

Using Drawings and Discussion to gain Insights into Young Learners' Understanding of Mass

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Abstract

In this paper, we explore the possible value of an open-ended assessment task, *Impress Me*, and follow-up interview as ways to gain insights into children's learning of mathematics. Ten children in their first or second year of school recorded their understanding using drawing and/or writing after the period in which they were taught lessons on the measurement of mass. Later they met individually with an interviewer/researcher to discuss their drawing/writing and their learning. The *Impress Me* recording was found to be a useful prompt for the children to stimulate discussion about their learning.

Keywords : Measurement, mass, assessment, diagnostic interview, mathematics

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Introduction

Children begin school with an intuitive understanding of measurement and a range of relevant prior experiences. Schooling, in turn, provides an opportunity for children to further develop their understanding and interest (Sarama & Clements, 2009). Teacher knowledge of the understanding children develop from both prior-to-school and school experiences informs the provision of further learning opportunities. Assessment, a key element of teacher practice, is central to children's learning (Wiliam, 2010). Although there are various assessment techniques available to teachers (Santiago, Donaldson, Herman, & Shewbridge, 2011), there remains a need for suitable tools to gain insights into children's understandings of measurement (Smith, van den Heuvel-Panhuizen, & Teppo, 2011). Research on the use of such tools and the insights gained can contribute toward the limited but growing body of research on measurement (Sarama, Clements, Barrett, Van Dine, & McDonel, 2011; Smith et al., 2011).

In this paper we describe the use of a two-part process to explore young learners' understanding of mass measurement. We explore the use of student recording through drawing and/or writing (the *Impress Me* task, described in detail below), and follow-up discussion in an attempt to gain insights into young learners' understanding of mass measurement. We build on our experiences from previous research employing drawing and description (McDonough, 2002), and research on young children's learning of mass measurement (e.g., McDonough, Cheeseman, & Ferguson, 2013; Cheeseman, McDonough, & Ferguson, 2014), some of which involved children drawing to show understanding of mass measurement (McDonough & Cheeseman, 2014).

Research shows that children in Year 1 and 2 (6-8 years of age) respond well to the *Impress Me* task (McDonough & Cheeseman, 2014). In the study reported here, we investigate insights that this task and a follow-up discussion can provide into the understanding of younger children, those in composite Foundation/Year 1 classes (5-7 years of age). The second stage of our two-part process, the interview, is an extension of previous research and hence this paper includes reflection on the value of the prompts used during the interview for helping children articulate their understanding.

Our theoretical perspective

The key interest in our research is children's thinking, specifically, their mathematical understanding. In the study reported here, we focus on how we might gain insights into such understanding. We take a social constructivist view in that we hold "respect for each individual's ... sense-making ... [and children] ... are seen as active and enquiring makers of meaning and knowledge" (Ernest, 1991, p. 198). We acknowledge that, when learning mathematics, children construct understanding for which there may be some commonalities across individuals, but also differences that reflect a range in the depth and complexity of thinking. This includes the learning of the measurement of mass.

Gaining insights into student understanding

Student assessment can improve learning as it can assist teachers and their students to close the gap between their present understanding and what is desired (Black & William, 1998). The student assessment protocol reported here is open-ended in nature, providing opportunities not only for students to reflect on their learning, but also for researchers and teachers to learn about individual student understanding.

In this study, the *Impress Me* task was chosen to facilitate children's communication of their understanding about the measurement of mass. Although the terms *perceptions* and *beliefs* are sometimes used interchangeably (Pajares, 1992), the literature gives greater attention to beliefs. These are considered as generally stable in nature (Pajares, 1992) and can impact upon the action taken by learners to facilitate learning (Black & Wiliam, 1998). In line with the social constructivist perspective discussed above, it is recognised that children construct idiosyncratic beliefs, or perceptions, about mathematics and the learning of mathematics (e.g., Yackel & Cobb, 1996). We suggest that this applies equally to the learning of measurement as to other areas of mathematics.

The *Impress Me* task provides children with the choice of recording through drawing and/or writing to communicate their understanding. Woleck (2001) believes that "drawing brings ideas to the surface" (p. 215) and is a powerful way for young children to express

meaning. The use of drawings is one of many “projection techniques” (Patton, 2002, p. 394) that can prompt or provoke discussion. MacDonald (2010) asked 4 to 6 -year-old children to draw about concepts such as *heavy* and *light*, and she strongly encouraged researchers to talk to children about their drawings for more accurate interpretation.

When talking with young children about their pencil and paper recordings, as occurred in the second part of our data-collection process (the interview), we considered recommendations from the literature on techniques for effective interviewing. These included the following: taking care with asking *why* questions as they may suggest that the informant is not clear; use a variety of question types such as funnelling questions, descriptive questions, role play and simulation style questions, structural questions, and contrast questions to assist children in responding; use prompts such as “tell me more about that”, “please give me an example”, or “please tell me a little more”, to seek elaboration; and accept and value children’s responses (Burns, 2000; Patton, 2002; Spradley, 1979).

In the study presented here, student self-assessment through drawing and/or writing, followed by individual discussions with a researcher/interviewer, contributed to the investigation of understanding the measurement of mass.

Research on children’s understanding of the measurement of mass

In learning to measure, children develop skills such as how to use a balance scale and develop understanding of foundational ideas including awareness of the attribute, comparison, unit iteration, the need for identical units, precision, and origin (e.g., Sarama & Clements, 2009; Lehrer, Jaslow, & Curtis, 2003). Research specifically on learning about the measurement of mass continues to be minimal even though mass is an element of the measurement curriculum in the primary school years (e.g., Australian Curriculum Assessment and Reporting Authority [ACARA], 2012). However, the limited research does provide insights, including findings showing that children encounter ideas of mass in their play from as early as 12 months (Lee, 2012), show awareness of the attribute in the first year of school (Cheeseman, McDonough, & Clarke, 2011; MacDonald, 2010), and can order objects by weight at 5-years (Brainerd, 1974). More recent research on the measurement of mass has

demonstrated complexity in young children's understanding (McDonough et al., 2013) and the ability of 6- to 8-year-olds to grapple with big ideas of mathematics, including equivalence, precision, and the lack of relationship between volume and mass (McDonough & Cheeseman, 2014).

The research reported here, which builds on our previous work, addressed the following research questions:

- What insights into children's understanding of mass measurement became apparent from the *Impress Me* task responses and follow-up discussion?
- What interview prompts were most helpful in facilitating children's articulation of their understanding?

Methodology

The data collection comprised two stages: completion of the *Impress Me* task by 61 children and a follow-up interview with 10 of these children. Three teachers and their Foundation/Year 1 students of 5 to 7 years of age participated in the first stage of data collection (drawing/writing), which occurred during a unit on the measurement of mass, and followed the teaching of a series of lessons. Each teacher administered the *Impress Me* task with their class by giving each child a blank piece of A3 paper and reading the following:

We have been doing lots of weighing lately. I want you to show me on this piece of paper all you know about mass and weighing. You can write or draw or do both! Take your time and show your ideas and thinking as best you can. I want you to *impress me* with all you know about mass and weighing.

Children could choose to draw, write, or combine the two. As researchers, we informed the teachers that we expected no two responses to be the same and that there was no one right answer. We wanted as much or as little as each child was individually able to give and we were happy to accept children's spelling. In consideration of the age of the children and the challenges some of them may have faced with writing, we informed the teachers that they could transcribe for the children should this prove necessary.

Ten children were chosen using convenience sampling for participation in individual follow-up interviews with a researcher. To enable the recording of the interview, the iPad application titled *Explain Everything* was used, with a photograph taken of the child's work and the conversation recorded in the same file for convenient analysis later.

The interviews were transcribed, and, in line with the research questions, key points were identified in relation to mathematics and the use of prompts during the interview.

Results

In this paper, findings are presented taking account of the two major themes which are related to mathematical concepts and the data collection process: namely, the ideas of comparison and equivalence. To illustrate these themes, excerpts were chosen from the interviews with Neena (pseudonym), a 6-year-old girl in her first year of school and Walter (pseudonym), a seven-year-old boy in his second year of school. The *Impress Me* responses varied within and across classes and provided insights into differences in children's thinking about measuring mass.

Neena

Like the other children, Neena completed her *Impress Me* recording (Figure 1) prior to the interview. She was keen to do well with her recording, starting the discussion with "I hope I did good". Neena reported that her recording was of an experience she had had earlier the same day. Her *Impress Me* portrayal, which she read as "I put a potato and an orange in the weigher. I love the weigher. It is lovely", was seemingly a recount of what had occurred during the lesson, with the addition of a statement indicating enjoyment.

In terms of the mathematics evident in this pencil and paper recording, Neena did not name a balance scale as such, but indicated awareness of it as a tool as well as the idea that weighing was involved in its use. We cannot be certain of what meaning she gave to weighing but the foundational measurement idea of comparison is perhaps suggested.

The interview resulted in further expression of understanding, including an indication of

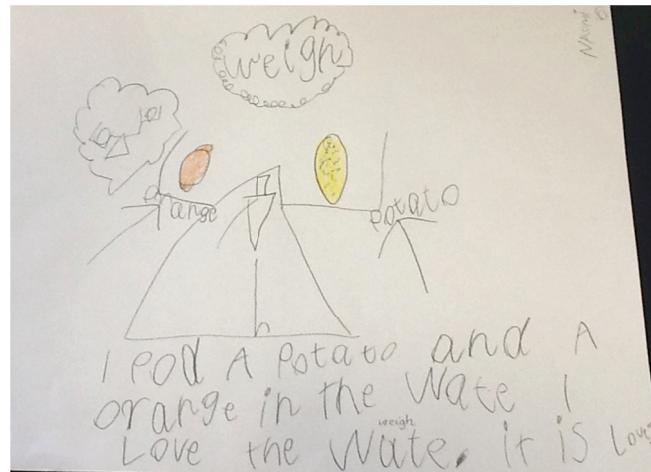


Figure 1. Neena's *Impress Me* recording

awareness of comparison of mass. This occurred partially through use of a technique called funnelling; that is, commencing with a broad, general question and progressively focusing onto the topic with more specific questions (Burns, 2000). The interviewer began with an open prompt, asking Neena to “tell me about it (her *Impress Me* recording)”. Neena stated, “I did an arrow and wrote orange. And then I wrote potato”. Following this, she read from her paper including mentioning “the weigher”. As a way of seeking further elaboration, she was then asked, “Tell me about the weigher that you’ve drawn”. As Neena described her picture, she noticed the arrow and excitedly stated “Oh, the arrow!” She was then asked, “So what does the arrow show you?” and replied, “That it is weighing”. She held her hands up, pretending to be a “weigher”. The conversation continued:

Neena: The two things in my hands they were weighing. And you know the arrow on them. You see the line, it goes on that line.

Interviewer: And what does it tell you if the arrow goes on that line?

Neena: It means that it is actually doing the right thing. It is, what’s that. It’s ah, it’s weighing. (Some hesitation; trying hard to find the right words). So it’s on the right spot where it should be.

Interviewer: It’s on the right spot where it should be. And what does it show you when it’s on that spot?

Neena: It shows you that they’re the same weight.

Like some of the other children, Neena appeared to have difficulty in finding the words to

articulate her ideas. This is perhaps not surprising as she was only six years of age and had had limited experiences learning about the measurement of mass at school. The interviewer valued Neena's ideas by repeating what she had stated. Burns (2000) has suggested that this parroting or mirroring can be an effective way of keeping an informant conversing. The interviewer then posed a further question, but rather than asking *why* there is an arrow on the scale, the interviewer followed the recommendation of Spradley (1979) and asked for a more descriptive response. This led to Neena identifying equivalence, a key idea in the measurement of mass and indeed in mathematics more broadly (Charles, 2005). Neena made reference to equivalence specifically in relation to mass, or weight as she called it, suggesting an emergent understanding of equivalence of mass (McDonough & Cheeseman, 2014). Notably this understanding was not evident in her *Impress Me* response but emerged during the interview. As the *Impress Me* drawing was the initial prompt for the discussion, it appears that the first element of the data collection process supported the second.

Walter

The *Impress Me* response from Walter, a Year 1 child, was mainly in writing, with two small drawings that appeared to represent balance scales but that were not detailed. Once again the interviewer commenced with an open-ended prompt.

Interviewer: Remind me about what is happening here. Tell me about your drawing.

Walter: This is me and Mac weighing a shoe. And that was me and Mac playing with vegetables and MAB flats. I also wrote "This is the best day of life, having a really good time with my friends".

Through recounting what had occurred during a lesson, Walter showed awareness of the term weighing; he also recalled materials that had been used but did not make explicit reference to scales. The mention of friends led Walter to talk about playing in the playground. The researcher brought the focus back to the measurement of mass.

Interviewer: Tell me more about the weighing that you were doing,

Walter: We were kind of weighing vegetables. I got a carrot and some shapes or like an MAB flat. I found out 20 shapes and a potato weighed the same.

In terms of the mathematics, Walter's interview discussion showed further understanding than that apparent in his pencil and paper recording. That is, he made reference to the idea of equivalence, as had Neena, but also went further. He provided a number (20) and appeared to be referring to the shapes as an informal unit of measure.

When the interviewer asked, "How did you know they weighed the same?" Walter referred to the scales but only briefly: "I found it out with the scales". The interviewer then encouraged him to elaborate.

Interviewer: Tell me a bit more about how the scales told you that

Walter: Like I kind of saw with the scales. Like I saw it had to, like do it. Then it just came up.

Interviewer: So if I was to look at the scales how would they have to look for me to know the two things were the same?

Walter: The top would have to be kind of balanced (Walter hesitated) with those circles on it

Interviewer: The top would have to be kind of balanced

Walter: Like with that yellow thing

Interviewer: Do you do something with that yellow thing?

Walter: You put it in the right spot then when you do it like they balance

It seems reasonable that Walter would refer to the top, or beam, of the balance scales. But he appeared to be having some difficulty expressing his ideas; that is, like Neena, he seemed to be looking for the words to express his understanding. Seeking clarification, the interviewer asked how the scales would look. Spradley (1979) pointed out that asking a descriptive question like this "is like offering informants a frame and canvas and asking them to paint a word-picture of their experience" (p. 85). However, Walter still seemed to have some difficulty. In the case of working with young children, it may be advisable to use a more concrete approach such as a role play or simulation-style prompt, as discussed by Patton (2002). In this case, the introduction of a balance scale may have enabled Walter to more clearly illustrate and explain his thinking.

It was noted that Walter referred to "that yellow thing" at the top of the scale. Balance scales are designed so that the user can move this piece to ensure the beam is balanced before weighing. However, in our earlier work we have noted that occasionally children in early years classrooms have adjusted this once the materials were in the buckets, perhaps because they *wanted* them to be equal in mass and/or believed that their materials were now equal in

mass. Such an approach suggests a focus on an important mathematical idea, equivalence, but with only an emerging understanding of the scales and what they show. Although the conversation with Walter continued, and he knew that the balance could be set before weighing, it seemed he also believed the “yellow thing” could be moved after objects were placed in the pans of the scale. Once again, having scales on hand for Walter to demonstrate with an example may have provided clarification.

Although the data presented here come from two children only, they provide insights into the nature of the data collection process, particularly regarding useful prompts, and also, into young children’s thinking about the measurement of mass. The following discussion, which is structured around the two themes related to the research questions, also makes brief mention of some other children’s responses, as relevant and as space allows.

Discussion

In the discussion of the first theme, mathematics, the focus is on understanding related to the measurement of mass, as this was the context of the study.

Mathematics

The first research question asked about insights into children’s understanding of the measurement of mass. Neena and Walter both made reference to comparison. So too did other children, using mathematical terms to explain. For example, Ben (7 years old, Year 1) stated that, “some counters are heavier than some icy-pole sticks”, Lily (6 years old, Foundation) stated that “If you put something heavy and something light, the heaviest thing will go down”, and Zoe (6 years old, Year 1) stated that “The carrot was up a little bit and the counters were up higher. The counters were heavier than the carrot”, indicating that she had not yet developed correct understanding of the terms *heavier* and *lighter*. We see that language is an important, and sometimes challenging aspect of learning and explaining mathematics and development is not necessarily by year level.

As illustrated above, data showed that making comparisons using balance scales led some

children to focus on equivalence and informal units of mass measurement. These are important in measurement (e.g., Lehrer et al., 2003), with comparison being identified in the Australian curriculum (ACARA, 2012) as appropriate for the Foundation level, and by inference for Year 1 also. In Year 2, comparison using balance scales is mentioned. It could be extrapolated from other measurement attributes in the Australian Curriculum that students are expected to use uniform informal units of mass measurement in Year 2. It seems then that some children in this study were showing a willingness and capacity to engage with ideas of mass beyond those expected for their level.

Notably the developed and emerging understanding portrayed by each child was different. This is perhaps not surprising, as we know that children make their own meaning of experiences, as discussed above. Each also gave direction to the initial focus of the interview through their selection of what to portray in their *Impress Me* response.

Prompts

The second research question asked about interview prompts that were helpful in facilitating children's articulation of their understanding. The first prompt was actually the *Impress Me* response completed by each child. This gave the interviewees a chance to talk about what was important to them, perhaps helping them feel comfortable in the interview and indicating that the researcher valued their perspectives. Asking children to describe or talk about their *Impress Me* recording was the first prompt in the use of a funnelling strategy where the questions became more focused as the interview progressed. The parroting or mirroring technique where the child's words were repeated, at least in some cases helped the interview to progress as intended. It was also used to communicate that the child's input was valued.

A finding from this research was not only that such prompts could be used to help young learners reflect on and articulate their learning of mathematics, but also that having relevant concrete materials ready in case they were needed might have been of value as young children have been shown to have difficulty describing situations or, as Spradley asserts (1979), painting word-pictures.

Conclusion

The *Impress Me* task is an assessment tool that gave children in their first and second year of school the opportunity to make a recording of their understanding, in this case regarding the measurement of mass. Most children recorded a recent experience at school, perhaps because the data collection occurred during the week in which lessons took place. This may have been a limitation of the research. However, it seems that the follow-up interview still provided insights into a range of emerging and developed understandings.

We suggest the use of the *Impress Me* prompt and follow-up interviews with conscious use of prompts such as those identified here can be of value to researchers working with learners, not only in relation to measurement but also potentially to other areas of mathematics and with older children. Interviewing can be time consuming but, nonetheless, the two-part approach described here may also be useful to classroom teachers, particularly when working with students for whom present assessment techniques are of limited value.

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