Young Children's Measurement Knowledge: Understandings about Comparison at the Commencement of Schooling

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This paper presents data gathered during a three-year study that explored the experiences with measurement that children have in prior-to-school and out-of-school contexts, and the ways in which children are able to represent these experiences. In this present investigation, examples of the children's responses to an open-ended drawing task, collected at the commencement of Kindergarten, are backward-mapped in relation to the draft Australian Curriculum's Measurement and Geometry strand for Kindergarten, with a focus on the Comparison sub-strand. This data demonstrates that most of the measurement skills described in the Comparison sub-strand of the Australian Curriculum are being exhibited by children at the commencement of schooling, prior to any formal teaching about measurement taking place.

In March 2010 the draft K-10 Australian Curriculum for Mathematics was released for comment and review. The newly framed curriculum has Measurement and Geometry as a strand that covers the notion of "measurement sense" (Joram, 2003). These two content areas have been combined in order to emphasise their interconnections and enhance their practical relevance (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2010). Within this strand, children learn to make meaningful measurements of quantities, choose appropriate metric units of measurement, understand connections between units, and calculate derived measures (ACARA, 2010). In relation to the Measurement and Geometry strand for Kindergarten, the measurement concepts focused on are those of Comparison and Time. This present investigation explores whether the Comparison sub-strand of the Australian Curriculum for Kindergarten reflects the measurement knowledge which children already posses as they commence school.

Background

In the past ten years there have been numerous studies that have examined children's measurement understanding (e.g. Clarke, Clarke, & Cheeseman, 2006; Curry & Outhred, 2005; Irwin, Vistro-Yu, & Ell, 2004; Stephan, Cobb, Gravemeijer, & Estes, 2001). Some of this work has considered, in particular, young children's understandings of measurement. Curry and Outhred's (2005) work on the links between the measurement of length, area and volume contributed the development of the *Count Me Into Measurement* [CMIM] program, designed to assess children's knowledge of these three measurement concepts. Findings from this study suggest that the order in which certain measurement concepts are addressed in the curriculum may need to be readdressed. Clarke, Clarke and Cheeseman (2006) have similarly worked to develop strategies for assessing the children's knowledge, with the development of the Early Numeracy Research Project's [ENRP] task-based interview. While the ENRP interview addressed numeracy more broadly, some measurement tasks were included. Results to the tasks found that most of the children were arriving at school "with considerable skills and understandings in areas that have been traditional mathematics content for that age…this means that expectations could be raised considerably in terms of what can be achieved in that first year" (Clarke et al., 2006, p. 97).

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Irwin et al. (2004) considered the importance of young children's informal experiences in the development of their understanding about length measurement in their cross-cultural study of children from New Zealand and the Philippines. Using a series of five tasks, Irwin et al. highlighted the important relationship between children's informal and formal measurement experiences. Their findings suggested that children's informal measurement experiences made a significant contribution to the children's learning of various measurement concepts. However, Irwin et al. suggested that, "the transition from informal to formal measurement needs much more time and care" (p. 22). Bobis, Mulligan and Lowrie (2009) have also emphasised the important role of children's informal understandings, describing these as "a crucial step towards understanding mathematics" (p. 14). Echoing the suggestion of Irwin et al., Bobis et al. highlighted that a significant concern for teachers is the ability to help children make connections between what they already know and the knowledge they will acquire in the classroom. Bobis et al. (2009) stated that:

> … the realisation that children already possess a great deal of knowledge before formal instruction occurs has caused many educators to reconsider their beliefs about how children learn mathematics and about the ability of children to individually construct their own knowledge. (p. 14)

In response to this body of research, this present investigation considers the informal understandings about measurement–in particular, the concept of comparison–which children possess as they commence school, and the alignment of these understandings with the curriculum content that they will be presented with in the formal classroom setting.

Research Design and Methods

This paper presents a selection of data gathered during a three-year study that explored the experiences with measurement that children have in prior-to-school and out-of-school contexts, and the ways in which children are able to represent these experiences. In this present investigation, examples of the children's responses to an open-ended drawing task, collected at the commencement of Kindergarten, are backward-mapped in relation to the draft Australian Curriculum's Comparison sub-strand for Kindergarten.

Participants

The data were collected at two schools in regional NSW, with the schools selected to represent the typical variance of the town's population. School A is what can be considered a low-SES school. To position the school within the current Australian educational climate, the 'My School' website states the school's Index of Community Socio-Educational Advantage (ICSEA) value as being 790. As an indication of the significance of this value, the average ICSEA score is between 900 and 1100. In addition, 70% of students are in the bottom quarter; that is, a significantly high proportion of students are educationally disadvantaged compared with the spread of students across Australia. Furthermore, the school has a dominance of Department of Housing residents in the suburb; approximately 45% of students coming from single-parent families; a highly mobile student population; and approximately 40% of students being of Aboriginal and Torres Strait Islander descent. By comparison, School B reflects the more middle-class sector of the population, with an ICSEA value of 994. The student population includes approximately 7% Indigenous students, and about 5% of students are from a non-English speaking background. School B represents a greater rate of educational advantage, with only 25% of students in the bottom quarter.

The participant children had just commenced their first year of formal schooling, known as Kindergarten in NSW. Children in NSW commence Kindergarten in late January. They "must start school by the time they are 6 years old but they may start in the year that they turn 5, provided their fifth birthday is before July 31 of that year. Hence, it is possible for a new Kindergarten class to contain children aged between 4 years 6 months and 6 years" (Perry & Dockett, 2005a, p.65). 31 children from School A completed the task, as did 52 children from School B, giving a total of 83 participants in this present investigation.

Data Collection and Analysis

The data were collected in March 2009, at which time the children had been at school for approximately 6 weeks. It was confirmed by all of the Kindergarten teachers than no formal teaching about measurement had taken place in the classroom up to this point in time. The children were asked to draw a picture of something tall and something short, and then provide a description of their drawing. The task was deliberately designed to be open ended, allowing the children to reflect upon their own personal experiences with the concept, and represent these experiences in a rich manner. Although some children chose to complete more than one drawing, for the purpose of this investigation only one drawing per child was analysed. Analysis was based on the Comparison sub-strand of the draft Australian Curriculum, with the drawings and their accompanying descriptions being coded according to the sub-strand 'elaborations', these being:

1. Understanding that comparing is the most basic of measurement ideas and that the key idea is to compare like attributes;
2. Comparing objects directly, by placing one object against another to determine which one is longer or using pouring from one container to the other to see which one holds more;
3. Using suitable language associated with the measurement attributes, such as tall and taller, heavy and heavier, holds more and holds less; and
4. Ordering things by direct comparison such as saying which of the two children is taller by standing back to back or holding an object in each hand and saying 'this one is heavier than the other one'.

It should be noted, however, that only the first four of the five Comparison sub-strand elaborations have been utilised, as the fifth was not befitting the nature of the task given to the children.

Decisions were made as to which, if any, of these elaborations were represented by each drawing and its description. Once the drawings had been coded, counts per elaboration were made in order to determine the percentage distribution of results across the four elaborations, offering an overall picture of the children's understanding in relation to the Comparison sub-strand.

Results

The following tables (Table 1 to Table 4) show the proportion of students who were able to demonstrate each of the Comparison elaborations in their response to the drawing task. In addition, an example response has been provided for each elaboration.

Table 1
Elaboration 1

Elaboration	Proportion (N=83)	Example
Understanding that comparing is the most basic of measurement ideas and that the key idea is to compare like attributes.	93%	

Figure 1. "That's my Mum and she's tall. That's me and I'm short."

As can be drawn from Tables 1, 2 and 3, the majority of students were able to demonstrate an understanding of the first three elaborations of the Comparison sub-strand at the commencement of Kindergarten. With regard to the first elaboration, almost all of the students (93%) were able to represent a comparison of two objects according to the attribute of height, and could identify which object was 'tall' and which was 'short'. As shown in Figure 1, Chloe was able to represent herself standing next to her mother, and identify that her mother is tall and that she is short. Similarly, Luke drew "a tall tower and a short tower", while Dulce drew a house and a person, explaining, "the house is tall and the person is short."

Table 2
Elaboration 2

Elaboration	Proportion (N=83)	Example
Comparing objects directly, by placing one object against another to determine which one is longer or using pouring from one container to the other to see which one holds more.	89%	

Figure 2. "That's when I went and saw an Australian flag and that's me. The flag's taller than me."

The second elaboration refers to the ability to compare objects directly, and, in the case of this specific task, ascertain which object is taller or shorter. As this was a drawing task,

direct comparison could be evidenced by the positioning of the objects along a common baseline. As shown in Table 2, 89% of the children were able to represent objects in this manner and state which was the taller/shorter of the two, as did Brody in his drawing of himself next to a flagpole (Figure 2). Other examples included Sarah, who drew a tree next to a volcano and stated, "the tree is taller", and Tobias, who described his drawing as "Me and Mum. My Mum's the tallest."

Table 3
Elaboration 3

Elaboration	Proportion (N=83)	Example
Using suitable language associated with the measurement attributes, such as tall and taller, heavy and heavier, holds more and holds less.	90%	 *Figure 3*. "The person is short and the skyscraper is tall. The monster is shorter than the skyscraper but taller than the person."

The third elaboration requires that children use suitable language associated with measurement attributes, and, as shown in Table 3, 90% of the children in this investigation were able to do so despite having received no formal teaching about measurement at this point in time. Indeed, some children were able to use the appropriate language in quite a complex manner, such as Blake, who offered the following description of his drawing: "The person is short and the sky scraper is tall. The monster is shorter than the skyscraper but taller than the person" (Figure 3). Those children who were not classified among the 90% generally did not use *incorrect* terms, but rather terms, which were not the *most suitable* given the task, explicitly focused on height. Examples of these less-suitable words included "big" and "little", "giant" and "tiny", etc.

The final elaboration that was addressed in this investigation required children to order objects based on direct comparison. Similar to the second elaboration, it was expected that the children represent their chosen objects in order along a common baseline, identifying which was the tallest and/or shortest. While only 33% of children's responses demonstrated this, it must be acknowledged that the task *did* only ask the children to draw something tall and something short, so the representation of more than two objects took some initiative on the child's behalf. Chelsea achieved this with her drawing of four flowers shown in order of height, and in her description she identified which was the tallest and which was the shortest (Figure 4). Similarly, Nathan drew the members of his family and explained "Dad's the tallest. Bonnie's the shortest."

Table 4
Elaboration 4

Elaboration	Proportion (N=83)	Example
Ordering things by direct comparison such as saying which of two children is taller by standing them back to back or holding an object in each hand and saying 'this one is heavier than the other one'.	33%	

Figure 4. "This flower's the tallest. This is the shortest."

Discussion

The elaborations of the Comparison sub-strand for Kindergarten are organised to reflect a progression in understanding about measurement concepts. To summarise this progression, children's understanding develops from the notion of comparing like attributes through to ordering objects as a result of direct comparison. However, implicit in this progression are a number of specific skills which children exhibit as they develop more sophisticated understandings of comparison.

When considering the notions of 'tall' and 'short', a starting point for young children is often the idea of using themselves as a benchmark – that is, deciding whether they are taller than or shorter than the object being considered. As Bobis et al. (2009) explain, children's natural baseline is their body. Interestingly, very few children in this investigation actually did use themselves as a benchmark, and those who did usually compared themselves to a familiar adult, such as their mother or father. In doing so, these children are also showing a more advanced understanding of comparison by demonstrating an ability to compare two similar objects. Often this involved the comparison of familiar people, not always including themselves. For example, Rhys described his drawing as, "My Dad is a little bit tall. Mummy is a little bit shorter than Dad", while Leteasha drew a series of people and said "Mum is tall. The baby is shortest." Other children chose to draw more generic objects, such as Luke who drew "A tall tower and a short tower", or Brodie who similarly drew "A short box and a tall box." However, the majority of children were able to extend the notion of comparison beyond comparing *same* objects to comparing *different* objects. In some cases, the children did indeed use themselves as the basis for comparison, such as Kyle, who drew a picture of himself and a monster and stated that, "the monster is taller than me", or Lara who drew herself standing next to a tree showing the difference in their heights. But more frequently, children drew two different objects and considered their varied heights.

When considering progression in understanding about comparison, at the most sophisticated level children demonstrate an ability to compare more than two objects. As stated earlier, the task given to the children did not explicitly ask them to draw more than two objects, however many children indeed chose to do so. As with the comparison of two

objects, the comparing and ordering of three or more objects can be considered at two levels: the comparing of *same* objects, and the comparing of *different* objects. The children in this investigation demonstrated both. For example, Wayne chose to draw "a big rope, a short rope, and a middle-sized rope", whereas Ethan drew "a building, a giant, a lady beetle and a speck of dirt" in descending order of height.

Woven throughout this progression in understanding about comparison is the ability to use the language of measurement in an appropriate manner. With only a small exception, the children in this investigation were able to use language appropriate to length measurement in both a dichotomous manner (i.e. "tall" and "short"), as well as in a comparative manner (i.e. "taller than" and "shorter than"). As noted earlier, the children demonstrated this ability to appropriately use measurement language prior to any formal teaching about measurement taking place. Thus, it can reasonably be assumed that the ability to use such language has evolved out of children's own informal, personal engagements with measurement. As was evidenced in the drawings, the children have drawn upon a range of rich and personally significant experiences in order to demonstrate their measurement understanding.

Conclusions and Implications

As the data presented in this paper has shown, the children in this investigation demonstrated the comparison skills described in the draft Australian Curriculum for Kindergarten at the commencement of school, prior to any formal teaching about measurement taking place. Of significance is the fact that these skills were exhibited despite the rate of educational disadvantage experienced by many of the participant children.

The fact that children are coming to school with these skills is a positive outcome because it means that the children will be confident with the curriculum material they will encounter in the classroom setting, and their familiarity with the content will enable them to achieve success in their formal learning. However, it must also be considered how these children can be extended beyond their existing understandings so that their classroom engagements will be stimulating and developmental. As Perry and Dockett (2005b) advocate, current learning must be recognised and used so that children are challenged by their mathematics learning and find that mathematics can be an exciting subject. By utilising tasks such as the one described in this paper, educators can not only elicit the prior experiences and understandings of children, but also extend children's learning in a rich and meaningful manner.

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