

Development of a framework to assess preschool children's numeracy

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Abstract. Children numeracy refers to the ability to do basic arithmetic operations, understanding the simple mathematical ideas and applying the knowledge and skills in mathematics in daily life. It requires an understanding of the ability to process, interpret and communicate numerical in ways that are appropriate for a variety context. This paper will discuss research that was undertaken with the primary purpose of developing the children's numeracy framework in the following components: comparison, classification, one-to-one correspondence and seriation. The framework was developed based on the existing framework from other researchers and modified to suit with Malaysian preschool curriculum. Feedbacks were obtained from experts and preschool teachers on the suitability of the framework in relation to the National Preschool Standard Curriculum (2010). Six preschool children from 5 to 6 years old were interviewed to ascertain their representation (manipulative model, symbolic, static pictures, written language and spoken language) while answering the question given. The framework that was developed will be presented together with the pilot findings from the interviews.

1. Introduction

The importance of supporting preschool children to become numerate citizens is acknowledged worldwide. Researchers have demonstrated that children begin to think mathematically from an early age [1] and indicated a strong relationship between early experiences and later performance in mathematics [2]. Besides that, Geary, Hoard, Nugent and Bailey [3] found that students' basic math skills in numbers, counting and low-level arithmetic by first grade predict their success in math by the time they reach fifth grade and advised that educators should ensure that young students understand numerals and quantities. The Ministry of Education has over the years responded to the concern over Malaysian children's performance in mathematics through improving the understanding of numeracy which is seen as a foundation for understanding mathematics at a higher level.

Numeracy is seen as the ability to process, interpret and communicate numerical, quantitative, spatial, statistical, even mathematical information, in ways that are appropriate for a variety context [4]. According to the Ministry of Education, the programme of numeracy is defined as the ability to do basic arithmetic operations, understanding the simple mathematical ideas and applying mathematics knowledge and skills in daily life. In school education, numeracy is a fundamental component of learning, discourse and critique across all areas of the curriculum. Early numeracy experiences are critical because children who start school lacking in basic numeracy skills rarely catch up to their peers [5,6]. For preschool children, numeracy covers the ability to do a comparison, classification,



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one-to-one correspondence, seriation, number concept, and measurement. These early numeracy skills are the foundation of more complex numeracy work in later years [7].

Preschool teachers as children's first teachers may provide excellent opportunities for numeracy exposure and growth [8]. Furthermore, research has indicated a strong relationship between the frequency of early experiences and later performance in school mathematics [2,6,9]. The earliest stages of learning numeracy are foundational for future learning and attainment of mathematics across grades [10]. Therefore, this research proposes to develop a numeracy framework to assess preschool children numeracy. The purpose of this paper is to report on the development of an instrument to explore the children's understanding or acquisition of numeracy skills with respect to the different representations. The numeracy tasks were developed by reviewing relevant literature on young children's numeracy.

2. Method

The framework focused on the early mathematical concepts for preschool children: comparison, classification, one-to-one correspondence and seriation. The framework was refined after pilot interviews with selected preschool children.

The method used to come up with the framework followed several steps from the review of literature, securing the English version of the instrument 'Diagnostic Test for Basic Mathematical' by Ikaheimo [11] and the Dutch authors [12], proposing the framework and refining it through a series of workshops with experts consisting of teachers and university lecturers, and it was further refined after pilot interviews with three 5-year-old and three 6-year-old preschool children.

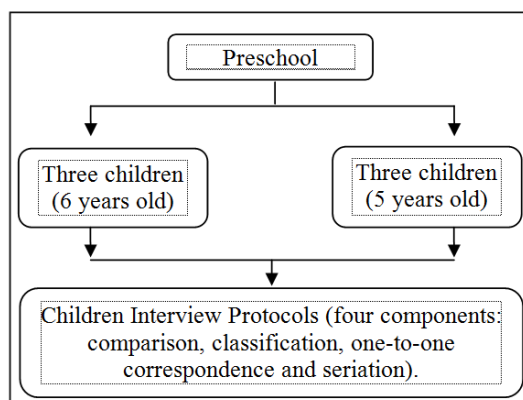


Figure 1. Research sample

3. Result and discussion

Referring to the existing similar frameworks from research done elsewhere in Netherlands and Australia and based on preliminary studies and relevant literature, this project came up with a draft framework which categorized the numeracy skills framework into four components namely, comparison, classification, one-to-one correspondence and seriation. In this project, the respective representations for each component were also discussed, such as manipulative model, symbolic, static pictures, written language and spoken language. This framework aims at describing children's representation in answering items in each component.

This draft framework was further refined through a workshop with experts and researchers. The researchers discussed and prepared tasks for the four components of the framework. The task includes questions for each component and indications of expected representations. Afterwards, this draft framework was tested in a pre-pilot interview with four preschool children. Based on the results, further refinement was done to the framework, and a second draft was produced after discussing some errors and inadequacy. During this stage, the researchers clarified some excessive items of the framework, such as unnecessary elaboration of tasks, repetition of activities, and the number of items.

Amendments were made to the framework to ensure the tasks were efficient, systematic and more meaningful for preschool children.

A final framework was produced and will be used to interview preschool children with respect to numeracy in comparison, classification, one-to-one correspondence and seriation. The cycle of refinement of the framework allowed the researchers to shed some light on specific details of the interview sessions such as tackling children in answering questions, adding more representations into the framework and refining skills in asking questions and probing answers. Besides that, the researchers will observe the interview sessions to get hindsight for further improvement of the framework. Through a cycle of refinement, a final framework was developed, which will be used to interview 20 preschool children around peninsular Malaysia.

The final instrument consists of 21 items from four components (three items each) which are comparison, classification, one-to-one correspondence and seriation. The items in each component are categorized into five main representations: manipulative model, symbolic, static pictures, written language and spoken language. Some of these items require the use of concrete materials, flashcard and paper sheet. These components are briefly described as follows.

3.1. Comparison

- Requires children to compare two non-equivalent cardinal or ordinal situations.
- A sample item: Here are two boxes. Can you point out the box that has more butterflies than the one you see here?

3.2. Classification

- Requires children to distinguish between the objects and group them.
- A sample item: Here, you see twenty cubes. Please classify the cubes with the same colour.

3.3. One-to-one correspondence



- Requires children to ascertain whether the children are able to make a one-to-one relationship between different objects.
- A sample item: Here, you see number twelve. Point out the square where the buttons have the same value with number twelve.

3.4. Seriation:

- Requires children to recognize the correct rank order in the task.
- A sample item: Here are some numbers. Can you arrange the following numbers to descending order?

Table 1 gives a brief description of the instrument that was developed. Items 1 to 3 are based on comparison concept, Items 4 to 6 are based on classification concept, Items 7 and 8 are based on one-to-one correspondence concept, and Items 9 and 10 are based on seriation concept, as described briefly in Table 1. Some of the tasks given in the items require the use of concrete materials, flashcard and papers. The answers for each task can be categorized into three main representations: manipulative model, symbolic and static pictures.

Table 1. Brief description of children's numeracy task

Item	Numeracy Component	Feature: Requires children ...	Sample Task	Sample manipulative models used			
1 2 3	Comparison	to compare two non-equivalent cardinal or ordinal situations	Identify the group with least/most objects.				
4 5 6				Classification	to distinguish between objects and group them	Classify objects according to shapes/colour/size	
7 8							One-to-one correspondence
9 10	Seriation	to recognize the correct rank order in the task.	Arrange number cards/manipulative models in ascending/descending order				

4. Conclusion

The framework will focus on early mathematical concepts in preschool education, namely comparison, classification, one-to-one correspondence and seriation. The focus of the numeracy framework in this research is to investigate the preschool children's strategies when solving numeracy problems presented in multiple representations. The matrix would be able to seek out the advanced level of early mathematics as well as the normal band and also those lagging behind. This is imperative for preschool teachers to take the cue as to where improvements and innovations can be taken in children's numeracy so as to enhance the overall performance to a desired national level. The numeracy task was developed to measure preschool children's knowledge of learning numeracy. This instrument consists of 10 items from four components of numeracy that are based on the comparison, classification, one-to-one correspondence and seriation concepts. The answers for each task can be categorized into three main representations: manipulative model, symbolic and static pictures.

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