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Assessing young children's mathematical abilities through games

Brian Doig^{a,*}, Connie Ompok^b

^a *Faculty of Arts and Education, Deakin University, Australia*

^b *Department of Educational Studies, Teachers Training Institute, Sabah, Malaysia*

Abstract

This paper outlines an innovative approach to the assessment of young children's informal mathematical abilities through the use of especially designed games. The range of games focus on a small number of critical aspects of mathematics identified in the research literature as being strong predictive factors of later success in mathematics at school. Examples of two of these games, and the results from a pilot study are presented. Children in the pilot phase were from Hungary, Australia and Malaysia, and were between two and six years of age. Two of the games, one for number and one for spatial sense, are presented here as examples of the approach taken by the researchers.

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1. Introduction

While the intellectual health of a country begins in the home, prior-to-school experiences play an essential rôle in ensuring that all children — particularly those regarded as being 'at risk' — have a sound beginning. This is especially true in mathematics, where recent research has revealed, and emphasizes, that a sound mathematical background before entering formal schooling is critical to future development (Jordan, 2010), not only in mathematics, but also in reading (Duncan, et al., 2007; Jordan, 2010). However, appropriate tools for assessing children's informal mathematical abilities, and tracking their development, are not readily found (Clements, Sarama, & Liu, 2008). Further, assessment instruments that are in the Mother tongue of the child, or that are culturally appropriate, are hard to find for non-mainstream children (see, de Lemos & Doig, 1999, for an exception to this).

Recent research into adult views of young children's mathematical development show that, while some prior-to-school educators expressed the view that children's mathematics started from birth, others agreed with the view of many parents (Doig, Mondon, & Nasrawi, 2008) that there is no mathematical thinking by young children before formal schooling (Hunting, et al., 2008; Thomson, Rowe, Underwood, & Peck, 2005). These findings prompted the first author to find a means of revealing and assessing the mathematical abilities of young children in a natural way, acceptable to parents and early childhood educators alike. Thus, while collaborating on research based on

* Corresponding author.

E-mail address: brian.doig@deakin.edu.au

using children's literature (van den Heuvel-Panhuizen, van den Boogaard, & Doig, 2009) Doig and van den Heuvel-Panhuizen started to devise a series of mathematical tasks that would enable young children to demonstrate their mathematical abilities in a non-threatening environment: namely, play.

This paper outlines this innovative approach to assessing young children's informal mathematical abilities through the use of games designed as instruments for assessment. These games focus on the handful of critical aspects of mathematics identified in the research, and assume that learning at the prior-to-school level is active, interest- and orally-based. As a consequence, the mathematical games are designed for use with individual children, although it is possible that observation of interactions in a small group would yield data on more than a single child at the same time. The games are accessible to, and engaging for, children over a range of abilities and ages found in prior-to-school settings.

2. Methodology

A review of the literature on children's informal mathematics learning revealed, surprisingly, that while prior-to-school mathematics ability was a key to later mathematical success at school, it was also a predictor of future success in reading as well (see, for example, Duncan, et al., 2007). Further, while counting was commonly found to be a strong factor in mathematical success at school, there were other aspects of mathematics that were strong factors as well. These included, for example, knowledge and understanding of counting (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004), numbers, ordinality, and measurement (Duncan, et al., 2007) and number sense (Jordan, Kaplan, Locuniak, & Ramineni, 2007).

In 2008, Doig and van den Heuvel-Panhuizen¹ constructed a series of games that were focussed on some basic ideas in number, geometry, measurement, and algebraic thinking, and logic. Following Freudenthal's (1973) approach these games were designed, where-ever possible, to start with a basic concept, with concrete materials for the child to use, and then develop through a series of iterations to an abstract version of the game, played mentally.

The purpose of the current research is to explore the viability of these games as a valid and useful approach to assessment of young children. We are particularly interested in this approach for cross-cultural research purposes.

a. *The Gumnut game*

Gumnuts are the seed-pods of the eucalyptus tree, and provide cheap and easily found 'counters': other suitable counting objects would be shells, buttons or pebbles, The game is played as described below in Figure 1. Note that after a few rounds, the child becomes the 'adult' and assumes responsibility for directing the game and correcting answers (See Part 3 of the game). We have reproduced the entire Gumnut Game, with its final embellishments, so that interested researchers may trial the game for themselves, and report to us on their experiences with it.

The Gumnut game has some interesting features. These are that:

1. The child can take on the lead rôle
2. The numbers can be adjusted to suit the child's skill level

And the Gumnut game also allows:

3. progression as far as the child can understand it
4. starting with the concrete and leading on to the abstract (mental)

The game is not merely counting, but involves:

5. general number sense
6. addition and subtraction specifically

We believe that points 1 and 2 are critical to engaging young children, and making the game truly 'play', while points 3 and 4 ensure that there is no 'ceiling' effect in the assessment. This allows for children with exceptional

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