

## **Mathematics games: Time wasters or time well spent?**

Paul Swan and Linda Marshall

Faculty of Education and Arts, Edith Cowan University, Joondalup, Western Australia, 6027

[p.swan@ecu.edu.au](mailto:p.swan@ecu.edu.au)

[l.marshall@ecu.edu.au](mailto:l.marshall@ecu.edu.au)

### **Abstract:**

Globally education authorities are placing increasing emphasis on the development of literacy and numeracy in primary schools. This paper reports on research designed to assist teachers to improve the numeracy of their students by making the use of mathematics games a more focused aspect of the teaching and learning experience in mathematics. Classroom experience and anecdotal evidence suggest that games are often used without really focussing on the mathematics involved in playing the game, and are justified simply on the basis of children having 'fun'. In this paper we report on the use of one game, Numero and how teachers made use of the game and the impact on the children's learning when using the game.

### **Introduction**

The use of mathematics games is often cited as an effective strategy for teaching mathematics. However, the researchers were unsure whether games are being used as supplementary activities for children who finish their 'real' work early, as busy work, or used with a real purpose. Although children may be having 'fun', the belief is that this is not sufficient reason for their inclusion in a mathematics program.

The ECU team, in collaboration with Industry Partners The Association of Independent Schools of WA (AISWA) and R.I.C. Publications, were awarded a grant to investigate the use of mathematics games in primary schools in Western Australia. This investigation involved offering extensive Professional Development to a group of teachers from a variety of independent schools, with follow up in-school support. As part of this process, the teachers were expected to conduct some aspect of action research on the topic, and report back their findings to the group.

### **Literature Review**

While it may be assumed that the use of games in the teaching of mathematics has been researched, a brief literature review revealed that surprisingly little empirical research into the use of games has been carried out. Often teachers assume that the use of games is an effective teaching tool. This may not be the case (Bragg, 2006).

Many authors have presented the use of games as a beneficial tool in the mathematics classroom (Bragg, 2006; Booker, 2000; Gough, 1999; Ainly, 1990). Also numerous authors assert that games should not just be restricted to practice and that they can be an effective vehicle for teaching new concepts to children (Bright, Harvey & Wheeler, 1985, Kamii & De Clark, 1985; Thomas & Grows, 1984; Burnett, 1992; Booker, 2000)

Clearly, what is important is the structure of the games used (Ainley, 1990; Badham, 1997) and the literature does highlight that if this structure is not provided learning does not always take place (Onslow, 1990; Burnett, 1992).

### **Connecting School and the Home with Games**

Games are used worldwide as a means of developing mathematics concepts. Often parents purchase educational games as a means of supporting learning in the home. There is a large educational games industry referred to as "Edutainment" that is designed to tap into the parent market. The games used in this research tended to be more 'classroom games', although games such as Battleships that cross over the school/home market were explored. Numero is a game that crosses the school/home divide. There are many games of educational value played in the classroom that help make some topics less onerous; however, children would not choose to play at home. If a game has proven educational value and children choose to play them out of school, then the children would be spending more time on task and it could be assumed become better at the task or in this case the embedded mathematics. The fact that Numero is played both at school and home as of interest to the researchers.

The researchers consider Numero to be more than a simple practice game as it includes elements of problem solving when children make use of strategies to maximise their point score. For detailed explanation of the card game Numero see <http://www.ricgroup.com.au/bookshtml2/Numero.pdf>.

Asplin (2003) noted in her study that simply playing Numero as a time-filler or casually was not sufficient to improve mental computation skills. The authors argue that if a game is deemed worthy of playing then it should be elevated from the status of a time filler or activity for early finishers but rather be an integral part of a teaching sequence. Asplin went on to note that in the class where the teacher encouraged students to describe orally their moves, and where the children were grouped according to ability, gains in mental computation ability were much higher. However, Bragg (2006) who studied the use of two games in the teaching of mathematics, raised questions about grouping children according to ability when playing games. In this research the children within classes were not grouped according to ability but, in at least one case, the class had been formed because the children were less able. The larger research project explored, in some depth, the use of games in the teaching of mathematics, in particular number, and aimed to develop guidelines for maximising the effectiveness of games in the teaching of mathematics. These guidelines are noted using Numero as an example.

### **Research Framework**

This research employed a mixed-method design.

- Children were given a pre-test prior to the study and a post test after participating in playing the games over a period of time. As the selected game, Numero, is a 'skills' practice game, a pre-existing and validated basic number skills test was used. A test that reports on basic facts in the four operations was deemed the most appropriate tool to determine if any learning had taken place (Westwood, 2000). According to Westwood (2000), "the test-retest reliability of the One Minute Basic Number Facts Tests ranges from 0.88 to 0.94 according to age level" (p. 107).
- Classroom observations were made of the children playing the game.
- The teachers participating in the study were interviewed to determine their beliefs about the use of games as a pedagogical tool.

Action research (Kemmis & McTaggart, 1988) was undertaken by individual teachers and groups of teachers involved in this research. These multiple techniques were employed to ensure triangulation of data.

As the research methodology involved a mix of qualitative and quantitative methods, Miles and Huberman's (1994) processes of data reduction, data display and conclusion drawing provided the qualitative data analysis base for this project.

### **Sample**

A sample of 16 – 20 teachers were drawn from the Association of Independent Schools of Western Australia and asked to participate in a four-day professional learning program. This program highlighted the findings from the literature and introduced the teachers to a variety of different games. Participants were introduced to the action learning process and given the opportunity to explore an issue associated with the use of games, for example, the development of number skills through playing Numero. Not all of the participants elected to use the game Numero as their action research project, however those who chose to look at this particular game had a further meeting to examine preliminary data. Later, this sub-group met with the entire research team to share their findings.

### **Findings**

The card game Numero is a practice game involving mental computation that, at its simplest level, deals with addition of numbers from 1 to 15. This can be extended to include subtraction, multiplication, division, fractions, square and cube roots, square numbers and cubic numbers. In this study the teachers did not go beyond the four operations when playing the game.

After playing Numero on the second day of the Professional Development component of this project, teachers were asked to fill in a Review sheet on the game. The questions in the Review sheet were:

- Does this game support/reinforce a concept that I expect the children to understand? Why?
- Could this game be used to introduce a 'new' maths concept?
- Comment on the rules of the game. Is it appropriate that all children in the class need to know this game? If so, why? If not, why?
- Some people suggest that children learn by playing games. What might children learn from playing this game?

- Additional comments (for example, if you had the money, would you purchase this game for your classroom? Why?)

Four teachers believed that playing Numero was beneficial in *reinforcing previously taught concepts* such as the four operations and BODMAS (an acronym for remembering the order of operations), rather than using it to introduce new concepts. However, another teacher reported that he used it to introduce the concept of order of operations as well as to practise their basic facts. He believed that a big advantage of the game was that the rules are constant, but the level of difficulty could be adjusted according to the ability of the groups of children playing the game. One teacher stated that, “The rules are appropriate to all levels and the children are able to conceive numbers in abstract ways”; another said, “One child can teach another as their ability develops”.

### One Case

One teacher reported his results in detail. He taught students who were in Year 7 of a Middle School, so they turned 12 that year. The range of pre-game results was higher for the ‘critically low’ range than for the ‘average range’, according to the tests. He reported that addition and subtraction were generally the best operations, with division by far the worst. Table 1 below shows the comparative data.

*Table 1: results from Westwood One Minute Tests of Basic Facts*

| <b>Operation</b>      | <b>Initial Results</b> |                       | <b>Post –Game Results</b> |                       |
|-----------------------|------------------------|-----------------------|---------------------------|-----------------------|
|                       | <b>Average scores</b>  | <b>Critically low</b> | <b>Average scores</b>     | <b>Critically low</b> |
| <b>Addition</b>       | 12                     | 11                    | 19                        | 4                     |
| <b>Subtraction</b>    | 14                     | 9                     | 18                        | 5                     |
| <b>Multiplication</b> | 8                      | 15                    | 15                        | 8                     |
| <b>Division</b>       | 5                      | 18                    | 14                        | 9                     |

After playing Numero regularly, the critically low scores for addition dropped from 47.8% to 17.4%; subtraction from 39.1% to 21.7%; multiplication from 65.2% to 34.8% and division from 78.2% to 39.1%. These data are reported because the teacher chose to involve parents in the research. He took the unusual step of phoning each of the parents to share the results from the pre-test and urged them to come along to learn to play Numero. The researchers supplied a pack of Numero to parents who attended the training session.

The children played the game three times a week for around 15 minutes per session. Parents, with the exception of one who did not play the game at home, reported playing the game from at least once a week to playing most nights of the week. The researchers suspect that the children of parents who played the game regularly at home made the most gains but the data were such that direct matches to children could not be made.

A teacher from a different school reported that her students did not experience gains. This was possibly due to the conditions not being suitable to foster improvement. However, the teacher commented on the improvements in attitude towards the learning of mathematics when games were employed. In this case parents were not involved in playing the game. The teacher commented that she had not been able to motivate the children to play beyond set times during mathematics. Clearly, if children are motivated and engaged in mathematics they are more likely to benefit from participating in the game, task or activity.

### Criteria for Assessing Games

At the completion of the first day of Professional Development on games, all teachers involved in the project were interviewed. One of the questions they were asked involved describing the types of games they preferred. Table 2, below, shows the responses according to criteria of their choosing. These comments were provided before the teachers were shown the card game Numero.

Four main themes emerge from Table 2. These were illuminated by the comments made by teachers during the semi-structured interviews and in conversations during the workshops.

### Classroom management issues

The most common criteria for selecting games as reported by teachers in the study were concerned with classroom management issues. Some of the comments related to trivial issues about pieces going missing or taking too long to set up and pack away. However, the authors do not wish to trivialise the impact on the smooth running of a lesson and the associated loss of teaching time.

Table 2: Teachers' criteria for selecting games

| <i>Description</i>                                                     | <i>No. of responses</i> |
|------------------------------------------------------------------------|-------------------------|
| <i>Classroom management issues</i>                                     |                         |
| Simple, easy to explain                                                | 3                       |
| * Played in a small group                                              | 3                       |
| Not too noisy                                                          | 1                       |
| Quick and easy to set up                                               | 1                       |
| Not too many pieces                                                    | 1                       |
| Games that are quick to play                                           | 1                       |
| Games to make rather than buy                                          | 1                       |
| * Everyone participates at same time (not taking turns) ie whole class | 2                       |
| Games that the teacher can observe                                     | 1                       |
| <i>Types of games: Skills</i>                                          |                         |
| Relies on skill rather than luck                                       | 2                       |
| Practise a skill                                                       | 2                       |
| Mental practice                                                        | 2                       |
| Number games                                                           | 1                       |
| <i>Types of games: Concept</i>                                         |                         |
| Clear links to concepts                                                | 1                       |
| Place Value                                                            | 1                       |
| Strategy games                                                         | 2                       |
| Games that are relevant to children's stage of learning                | 1                       |
| <i>Motivation and engagement</i>                                       |                         |
| Interactive                                                            | 2                       |
| Challenging                                                            | 1                       |
| <i>Other</i>                                                           |                         |
| A variety – chance for children to experience them all                 | 2                       |
| Card games                                                             | 1                       |
| Board games                                                            | 2                       |
| Visual, spatial awareness games                                        | 1                       |
| Children use manipulatives alongside game                              | 2                       |
| Where children move around physically                                  | 2                       |

There were conflicting comments about number of players. In two cases the teachers preferred to play whole class games, while three teachers preferred playing games in small groups because it maximised the time children were thinking about the concepts embedded in the game.

Short games appeared to be favoured over longer ones. This allowed for more flexibility as to when and how games were used in the classroom. Simple rules were favoured as less time was spent introducing the game and sorting out conflicts based on misinterpretation of rules.

***Clear links to skills and concepts***

While the teachers liked the idea of using games from a motivational point of view, they preferred the game to be linked to a specific skill or concept. Several factors appear to affect this concern.

Teachers feel pressured to 'cover' a great deal of content and felt that devoting too much time to games without there being a direct link to specific content would erode their teaching time. The introduction of a National testing program during the conduct of this research weighed heavily on teachers' minds. The need to justify the use of games in terms of concept or skill learning was apparent. The teachers reported pressure from parents for their children to be seen to be completing some rigorous mathematics. In some cases, this translated to completing sets of algorithms on a page as evidence of

having 'worked hard' in the lesson. The extreme case is the reported pressure to complete all the pages in a textbook before the end of the year.

### **Motivation and Engagement**

Most teachers would choose to use games as motivators for engaging in mathematics. Games are often employed to make practice more pleasant. Difficult concepts such as fractions may be embedded in a game format to encourage deeper thinking about the concept. Bragg (2006) noted in her research that once the challenge of a game is lost, motivation wanes. Children are less inclined to engage with the game. For example, once you know how not to lose in Noughts and Crosses (Tic Tac Toe), it seems pointless to even begin a game.

### **Conclusion**

Preliminary data collected from recorded interviews with teachers in the sample suggested that the research evidence presented during the Professional Learning sessions was valuable in changing teacher attitudes toward the use of games. Prior to attending the Professional learning sessions and carrying out their own action research, some teachers did not use games while others had only used them as a reward or with children who finished their class work early. Those teachers now report that they would use games as an integrated part of their mathematics program.

This research has helped to show that, given the right conditions, games can achieve an increase in basic fact skills in a stimulating and enjoyable environment.

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