South African Journal of Education

Vol 26(3)413–426

Evaluation of a number skills development programme

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A pre-test post-test correlated groups design was used to evaluate the effectiveness of the Shuttleworth/Rotary Number Skills Development Programme to enhance the numeracy of Grade 2 learners (N = 169) from five primary schools (a private school, a school of auditory impaired learners, and three rural schools). An unstructured questionnaire was employed to obtain teachers' views about the program (n = 5). The findings of the study showed that the programme was effective in developing the numeracy of the total sample, and of learners from the different types of schools. It was concluded that the use of concrete educational material should be central in the teaching of number skills in Grade 2. The teachers also indicated that the programme was beneficial to learners and to themselves. However differences in the improvement of the numeracy scores of the five classes were found (possibly due to difference in instructional quality). Therefore, it is recommended that teachers should be trained in the use of educational equipment and also to create an optimal learning environment. Further research, with more representative samples, is required to verify the effectiveness of (and broaden) the application of the programme, and to explore teacher-related variables that could limit numeracy development in learners.

Introduction

Overview

International studies have shown that South African pupils compare most unfavourably with pupils in other countries with regard to literacy and numeracy development (Heugh, 2001). Furthermore, research in South Africa has indicated that black children between the ages of five-and-a-half and seven are ill-prepared for formal education (Pretorius & Naude, 2000). Fortunately, Pretorius and Naude also found that black children are especially responsive to concrete learning experiences. This implies that manipulative learning activities should be included in the foundational learning phase for the development of the number skills of these children.

Number skills development

The aim of number skills development is to help learners open up their ability and inclination to solve numerical problems in a variety of situations (http://www.barnsley.org/barugh-green-primary/mathematics.htm). Numeracy is an essential part of being literate. Without adequate number skills a person cannot function effectively in society or in the workplace (Ananiadou, Jenkins & Wolf, 2003). Basic number skills are also important in formal education as most school subjects include a numerical component.

One important subject for which number skills are the underlying building blocks is mathematics. If children do not develop a grounded understanding of numbers during early childhood (birth to eight years of age), then they will most probably experience difficulties with the acquisition of mathematics skills in later childhood (Geary & Hamson, 2004; Van Luit, 2000). It is therefore of critical importance to intervene early to lay the foundation for further schooling (Kersaint & Chappell, 2001).

Number skills defined

The concept numeracy and the specific skills that are embedded in its use are not easy to define (Cohen, 1988). The exact meaning of the concept also changes over time and within specific social situations (Rose, 1998). A comprehensive description of numeracy should include the concepts number sense and number skills. Number sense, according to Reys, Reys, McIntosh, Emanuelsson, Johansson and Der (1999:61), refers to

> the general understanding of number and operations, along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful and efficient strategies for managing numerical situations.

Number skills include addition, estimating, sequencing, number shapes and patterns, measurement, two- and three-dimensional design, and time reading.

The following basic number skills need to be developed in early childhood (Frank, 1989; Gelman & Gallistel 1978; Ginsburg, 1977):

- The ability to manage and solve problems using measurements.
- Understanding space, data, and numbers in a variety of formats and for a variety of purposes.
- Counting. In order to count, children have to master the following skills (Fuson, 1988; Van de Rijt & Van Luit, 1998): ordering numbers in the correct sequence; establishing a one-to-one correspondence between number names and counted objects; understanding that the last number in the count represents the total number of counted objects; comparing (greater, most, and less); and classifying (arranging objects in a class or subclass).
- The ability to enumerate small sets of one to five or one to ten objects without counting them (Starkey & Cooper, 1995; Wynn, 1992).

To solve simple addition and subtraction problems in Grades 1, 2 and 3, children use predominantly three types of counting strategies (Fuson, Perry & Kwon, 1994): counting all (using actual objects); count on (keeping the first quantity/number in mind and proceeding from that point), and retrieving facts from memory.

Findings on the effect of the use of manipulatives in the learning of children

Children have an innate need to explore and master the environment and to persist in goal-directed activities (Jennings, 1993; Morgan & Harmon, 1984; Yarrow, McQuiston, McTurk, McCarthy, Klein & Vietze, 1983). According to Piaget (1952), White (1959), Hunt (1965) and Popper (1993) children gain control over their environment and develop competence by engaging in exploratory and social activities, such as constructive play. Constructive play, allows children to experiment with objects, to find out combinations that work and don't work, and to learn basic knowledge about stacking, building, drawing and constructing (Fox, 2002; Stager, 1999). This implies that most learners in the elementary and middle grades learn best if they are involved in meaningful activities that require the use of concrete, manipulative materials such as educational equipment.

Piaget (1962) and Vygotsky (1978) were among the first to link play to cognitive development. Today, many educators believe that play is an important medium to develop foundational skills, such as numeracy, in early childhood (Bergen, 2002; Bodrova & Leong, 2003; Cristol, 2003; Van Luit, 2000) and that one of the best ways to develop a basic understanding and knowledge of numbers and their relationships in children is through the use of hands-on concrete objects or so called manipulatives (educational equipment). In other words basic understanding and the knowledge of numbers can be developed by promoting discovery

learning through exploration (Ball, 1993; Cobb, Wood, Yackel & McNeal, 1992; Conway, 1997; Damon, 2002; Lampert, 1986; Saxe, 2000). Fenton (2003), for example, describes an outreach programme for children in an impoverished school district in a rural African-American society. The idea of the project was to turn maths into play (hands-on fun). Fenton's findings show dramatic short and long-term results in the children's understanding and use of numbers. In another study, Van Luit and Van de Rijt (1995) developed a 3-month-long remedial maths programme for young children. The programme included learning by doing activities. Whereas the programme participants doubled their post-test scores on an early numeracy test, the numeracy skills of the control group improved very little. Van Luit (2000) also conducted a study (using a pre-post test research design) and found that an early numeracy programme, which included learning by doing, was effective to develop number skills in children.

It has been found that children who are comfortable manipulating objects and materials also become good at manipulating words, ideas, and concepts (Wardle, 2002). In this regard researchers have argued that the use of concrete materials with an emphasis on an understanding of the underlying concepts can bridge the gap between the concrete and the abstract (Beattie, 1986; Fennema, 1972; Ross & Kurtz, 1993; Sawada, 1985). By building on the child's experiences and providing moderately challenging tasks teachers can provide the intellectual scaffolding to help children learn and progress through different stages of development (Conway, 1997). Children go from counting concrete objects and concretely dealing with numbers to counting and dealing with numbers abstractly (Van Luit, 2000). This means that work with concrete materials should precede any introduction of symbolic abstractions. Van Luit (2000) stated that young children, with special educational needs, benefit from early maths instruction and practice at three levels, namely, manipulating concrete objects, using semi-concrete presentations of objects, and performing mental acts. These three levels correspond to the three stages of learning identified by Piaget (1952).

A major concern for educationists has to be the developmental appropriateness of educational equipment (Miller, 2002). Educational equipment varies in terms of complexity and the purpose for which it has been developed (Vlachou & Farrell, 2000). Some equipment is appropriate only for a specific stage of development whilst other types of manipulatives lack so-called functional fixedness. This means that they are useful in more than one developmental stage. A wide range of educational tools is available in the market for developing number skills (Consumer Reports, 1998). It is suggested that the growing availability of high quality educational equipment should inspire teachers to find ways to incorporate them in their classes (Stager, 1999).

Research findings on instructional quality

The choice of educational equipment alone cannot ensure the successful development of number skills in children. Much will depend on the quality of instruction provided by the teacher who uses the material. For example, research suggests that poor instructional quality is one of the main causes of mathematical and foundational number skill problems encountered by children with special educational needs (Fox, 2002; Miller & Mercer, 1997; Wilson & Sindelar, 1991). According to Fox teachers should be able to:

- Facilitate play in the classroom.
- Provide appropriate play environments.

- Carefully consider age and developmental needs in the design and selection of learning materials.

One way to help teachers improve their instructional skills is to train them in the use of the educational equipment. This can be accomplished by allowing them to "play" with equipment in order to familiarize themselves with the world of kids (Stager, 1999).

The Shuttleworth/Rotary Number Skills Programme

The Shuttleworth Foundation and Rotary Tzaneen have identified a lack of number skills as one of the major shortcomings in learners of all ages in Limpopo province of South Africa. As a result, the Shuttleworth/Rotary Number Skills Development Programme was developed. The programme is outlined in Figure 1. The educational equipment used and the related learning to be achieved in the programme are listed in Figure 2.

The programme aims to take learners through a series of numeracy related learning activities to build their basic understanding of numbers. In order to achieve this aim educational equipment and assistance to improve their number skills were provided to primary school learners, and teachers were trained in the use of the educational equipment.

After the teachers had completed a two-day training workshop, they implemented the programme in their classrooms — where the learners used the educational equipment. The programme is scheduled for two hours per day, four days per week. During the implementation of the programme learners "played" with the learning equipment while a teacher supervised and observed their actions. When a number concept has been grasped, allowing a learner to use the appropriate learning tool to solve additional number problems reinforces their skills. These number problems were included in a Workbook.

Each learner was issued with the workbook that included a pre-programme evaluation test. The duration of the programme was 3 months. The learners wrote a post-programme evaluation test after completion of programme.

An educational specialist developed the workbooks for the learners. Utilization of workbooks was an innovative idea, as teachers in South Africa are not issued with workbooks to help them to teach basic number skills in the foundation phase of the school curriculum. They usually use verbal instructional methods and textbooks.

Problem statement and hypothesis

The purpose of the current investigation was to evaluate the success of the Shuttleworth/Rotary Number Skills Development Programme for the development of number skills in a group of primary school learners. More specifically, the following research question was addressed:

> How effective is the programme to develop the foundational phase number skills of Grade 2 learners?

Based on the aforementioned literature review and the research question, the following hypothesis was formulated:

> There is a significant difference between the mean numeracy test scores of the group of Grade 2 learners before and after completion of a three-month-long programme to develop their number skills.

Teachers' views about the Shuttleworth/Rotary Number Skills Development Programme were also explored.

1. STAGES OF LEARNING DEVELOPMENT
   - 1.1 Concrete: learning through senses: see/touch/taste/smell/hear actual objects before these objects have meaning
   - 1.2 Semi-concrete/semi-abstract: relate to a picture/model of the object – two-dimensional stage
   - 1.3 Abstract: understand symbolic representation of objects/pictures and cor to understand that letters and numbers have meaning and can be manipulated

2. REASONING AND PROBLEM SOLVING SKILLS
   - 2.1 Verbal reasoning: talking about problem while working through it with parent/teacher assistance
   - 2.2 Non-verbal reasoning: able to reason internally and find the solution(s)
   - 2.3 Spatial: see people and objects as they relate to the self and each other

3. LEVELS OF NUMBER DEVELOPMENT
   - 3.1 Count-all: using actual objects/substituting/abstract thinking
   - 3.2 Count-on: first quantity/number in mind -proceed from that point
   - 3.3 De-composition of number: break numbers into chunks according to ability and reasoning skills
   - 3.4 Tens and units: grouping/bundling for easy calculations

4. NUMBER SENSE AND DESIGN
   - 4.1 Counting; all mathematical processes/operations
   - 4.2 Estimating
   - 4.3 Sequencing
   - 4.4 Number shapes and patterns
   - 4.5 Measurement
   - 4.6 Design – 3dimensional
   - 4.7 Time reading

Figure 1 Shuttleworth/Rotary Number Skills Development Programme

Scales	Using beads and hooks: • One to one correspondence (6 = 6) • Estimating: What if we put stones on the left side and coins on the right side? • Basic concepts: empty/full; something/nothing; more than/less than etc. • Quantity concepts: 3 = 1 + 1 + 1 • Decomposition of numbers: 9 = 2 + 3 + 4 • Number bonds: 7 = 3 + ? • Adding: 5 + 2 = ? • Subtraction: 7 – 2 = ? • Mathematical symbols: = / > / < / +,etc. • Multiplication: 3 x 4 (adding in groups = multiplication) • Division: Half of 10 = ? • Advanced maths: (3 x 10) + (6 – 4) – (2 x 3) = ? • Using the mass disks: 10g + 5g = 15g • Comparing the mass of commercial products: sugar x Rice Crispies, etc. • Fractions, decimals and percentages (Specific labels to be used included)
Counters	Counters fit into one another • Colour discrimination • One to one correspondence • Sorting • Sequencing • Counting • Eye-hand co-ordination • Fine motor skills • Basic calculations: adding/subtracting/multiplication/division
Number Builders	• Notation of number: singles/tens/hundreds/thousands etc. • Decomposition of numbers • Place value of numbers • Even/uneven numbers
Shapes	• Eye-hand co-ordination • Fine motor skills • One to one correspondence • Position/place and direction • Shape, colour and sequencing • Spatial relations • Sorting and fitting • Memory skills development • Shape consistency • Visual discrimination • Logical thinking • Problem solving

Figure 2 Shuttleworth/Rotary Number Skills Development Programme — educational equipment and the related learning

Method

Research design

A field experimental research design strategy was used to assess learners before and after programme implementation. This type of design is commonly used to evaluate the effectiveness of interventions and to determine whether the performance (test scores) of a tar-

get group has improved (Greenwood & Terry, 1994). The strength of the design is that it provides actual baseline (pre-test) information that can be compared to post-test data. For this design to work, a test should be administered before intervention. After the intervention the same test or an equivalent test should be administered in the same way.

According to Eisner (1991) the narrative method is one of the most typical approaches used to obtain and interpret qualitative information on educational phenomena. This research strategy was therefore used to capture the first-order descriptions of the views of the teachers involved in the programme. It provided an indispensable means to understand the phenomenon from their point of view.

Participants

One hundred and sixty-nine Grade 2 learners from primary schools in the Letaba area in Limpopo province, South Africa, were selected for the study. Due to practical considerations, such as accessibility and travelling costs, a convenient sample of five (out of 18 primary schools) was selected for the study. School A is a school of auditory impaired learners. School C is a private school. The other three schools are in rural villages in the target area. The numerical characteristics of the research sample are outlined in Table 1. Table 1 shows a fairly even spread of the number of learners across the participating schools. Most of the learners (24.3%) were from school C and the smallest Grade 2 class (16%) in the sample was from school A.

Table 1 Sample characteristics of Grade 2 learners

School	Frequencies	Percentages
A	27	16.0
B	33	19.5
C	41	24.3
D	31	18.3
E	37	21.9
Total	169	100

Five teachers (one from each of the above schools) implemented the programme in their respective schools, and provided a written description of their views about the programme.

Assessment instruments

An educational specialist developed the assessment instruments (one-hour-long pencil and paper tests) for the learners. The pre- and post-tests were designed using a pool of 100 test items. The test (100 items) was split into equivalent halves: a pre-test (50 questions) and a post-test (50 questions).

Additionally, an open-ended questionnaire to gather qualitative data on the views of the teachers was developed in co-operation with the researcher (who was not otherwise involved with the programme). They were asked to provide a written answer to the following question: "What is your view about the programme"?

Procedure

Two afternoon training sessions were organized to train teachers in the use of educational equipment. The educational specialist who designed the assessment instruments was responsible for these sessions. They then implemented the programme in their classrooms.

Each learner was issued with a workbook that included the pre-test. They completed the pre-test before at the start of the programme. They then participated in the programme. After completion of the 3-month-long programme the learners wrote the post-test. The educational specialist (who trained the teachers) administered the post-test in each of the classes.

The teachers were then invited to a meeting and during this meeting they completed the unstructured questionnaire.

Data analysis

Pre- and post-test data for learners were statistically analysed by means of the Statistical Package for the Social Sciences (SPSS).

- Descriptive statistics (means, modes, medians and standard deviations) were calculated.
- The scores of each group of Grade 2 learners from the five schools were explored to determine appropriate statistical analysis. For this purpose the skewness of pre- and post-test scores were computed. The exploratory data analysis showed that the skewness for some of the groups was larger than 1, indicating asymmetry and thus (together with the relatively small sample sizes) rendered the use of non-parametric statistics appropriate. The skewness figures are presented in Table 2.
- The non-parametric alternative to the *t* test for correlated groups, the Wilcoxon Signed Ranks Test, was employed to assess the difference between pre- and post-test scores.
- In order to identify underlying themes the teachers' written accounts were transcribed. The transcriptions were divided into natural meaning units and the natural meaning units were collapsed into themes.

Table 2 Skewness of pre- and post-tests

School	Pre-test	Post-test
A	0.295	0.314
B	1.325	0.293
C	0.476	–1.711
D	–0.567	–0.951
E	–0.523	–1.352

Results

Results for each school

The pre- and post-test means and standard deviations for each of the five Grade 2 classes in the sample are given in Table 3. It is evident from the table that the mean numeracy scores for all the classes increased after completion of the programme. The standard deviation for each class decreased. These results appear to indicate that on average the groups of learners performed better on the post-test than on the pre-test, irrespective of the type of school in which they were enrolled.

Table 3 Pre- and post-test scores for each Grade 2 class

School		Pre-test	Post-test
A	Mean	13.78	17.48
	N	27	27
	Standard deviation	9.784	9.175
B	Mean	10.39	12.76
	N	33	33
	Standard deviation	6.139	3.580
C	Mean	16.12	36.54
	N	41	41
	Standard deviation	9.493	8.787
D	Mean	35.00	35.74
	N	31	31
	Standard deviation	11.381	9.201
E	Mean	34.38	41.46
	N	37	37
	Standard deviation	8.509	6.735
Total	Mean	22.09	29.78
	N	169	169
	Standard deviation	13.884	13.699

However, it is also evident that the differences between the mean pre- and post- test scores of some of the classes were larger than for others. School C (the private school) learners showed the most improvement. Learners from school D (a rural school) had the highest pre-test scores and showed the least improvement.

It is difficult to account for these findings. However, it is possible that the quality of teachers' teaching skills could account for these differences.

Overall results: Grade 2 learners

Table 4 displays the overall means, medians, modes, and standard deviations of the distributions of pre- and post-test scores for the Grade 2 learners in the sample.

Table 4 Pre- and post-test descriptives

Descriptive statistic	Pre-test	Post-test
Mean	22.09	29.78
Median	20.00	34.00
Mode	9.00	38.00
Standard deviation	13.884	13.699

From Table 4 it is evident that the learners' mean score on the post-test was higher than their mean score on the pre-test. This showed that, on average, learners performed better on the post-test.

Using the Wilcoxon Signed Ranks Test, a highly significant difference between the mean scores of the Grade 2 learners on the pre- and post-tests was found ($p < 0.01$), indicating a marked improvement in the numeracy scores of learners after completion of the programme. The results are shown in Table 5. An encouraging reliability coefficient of 0.8251 (Spearman-Brown) was obtained.

Table 5 Wilcoxon Signed Ranks test

Test statistic	Post-test – Pre-test
Z	–7.845
Asymp. Sig.	0.000
Based on negative ranks	

Results: Teachers

The following four themes were extracted from the written accounts provided by the teachers. Sections in *italics* are the respondents' own words.

Impact of the programme

Apparently, the programme had a positive impact on the learners. In the words of one teacher: "*I saw a change in my learners since the project started*". The teachers believed that the concrete teaching aids helped the learners improve because they were "*... able to explore on their own*" and "*they understood much more when we worked with e.g. number builders, puzzles and other aids*". The teachers' observations not only supported the quantitative findings with regard to the effectiveness of the programme in the development of the learners' numerical skills ("*This project improved their abilities and their mathematical skills*" and "*their life skills and literacy* "), but also provided useful information about how learners' attitudes had changed toward numbers. For example, in the view of the teachers the learners enjoyed the experience; their understanding of numbers increased; they became more and more involved in the learning activities; and their enthusiasm for "*doing numbers*" increased. The teachers also indicated that the programme motivated learners to work independently and that it helped learners to develop their interpersonal skills.

The teachers also felt that the programme impacted positively on them and that it gave them the chance to see the value of alternative methods for teaching numerical skills.

Evaluation of programme and material

In general the teachers found the programme and learning material very useful and of a high standard. They also felt that the programme integrated all the necessary learning material for Grade 2 learners and that it covered all the relevant areas of numeracy. ("*The Grade 2 workbook that has been written covers every aspect of the curriculum for the whole year*" and "*everything which is dealing with numbers is found in this programme*"). They also indicated that the training to which they were exposed prepared them to implement the programme effectively.

Assessments

The written descriptions provided by the teachers showed that although the Grade 2 learners were able to complete the assessments in one hour, care should be taken not to place too strict a time limit on the assessment tests. Teachers should also help learners to relax and enjoy the experience. For example, one of the teachers wrote the following: "*One hour is not enough time for average Grade 2 pupil. The above average can cope. The children seize up and become stressed in this exam/test environment. Under normal circumstances they know everything*". It would seem that time limits and extra help are of special importance when the programme is implemented in schools with learners who have special needs. This point was emphasized by the teacher at school A: "... *learners* (with hearing disabilities) *are different from other learners, as they need a special attention and more time and even use sign language to let them understand the questions before they write*".

Future use of programme

All the teachers were very positive about the programme and its usefulness in enhancing the numeracy of learners. They also felt that the project provided support to teachers and that it was helpful to improve the quality of their instruction. They emphasized that the programme should be presented to as many learners as possible in the province and even farther afield. In the words of one teacher: "*I feel that maths in this country can benefit by this*". Another teacher wrote: "*I hope it is something that can be implemented at every school in future*".

Discussion

The hypothesis, that there is a significant difference between the mean numeracy test scores of the group of Grade 2 learners before and after completion of the three-month-long programme, was supported. The overall mean numeracy score of learners from all the schools increased significantly after completion of the programme. The teachers who participated in the study also perceived an improvement in their learners' numeracy. In their view their learners' attitudes toward numbers also changed dramatically. These findings and views provide support for previous research discussed in the literature on the effectiveness of concrete educational material to teach number skills to children.

The finding that the number skills of the sample improved significantly is also good news in view of the fact that different types of schools were included in the study. It implied that the educational material is appropriate for learners with and without special needs. The teachers who participated in the study also indicated that the programme should be implemented in other schools as well and that the use of concrete educational material should supplement the (conventional) use of textbooks. They also believed that the programme provides good coverage of the Grade 2 curriculum.

However, although encouraging results were obtained, further research with more representative samples is required in order to verify the effectiveness of (and broaden) the application of the programme for number skills development for Grade 2 learners and learners in other grades who lack basic number skills.

It should also be noted that previous research (as reported earlier) on instructional quality has shown that educational equipment alone cannot ensure the successful development of number skills in children. The quality of instruction provided by the teacher who uses the material plays a major role. Stager (1999) indicated that the instructional quality of teachers could be improved by training them in the use of educational equipment. This was done in the

present study. However, the differences between the pre- and post-test scores of some of the Grade 2 classes were larger than some of the others. It can be concluded that training in the use of educational equipment did enhance the instructional quality of teachers as well as their enthusiasm about the use of the programme, but that training alone does not ensure adequate development of numeracy in learners. Fox (2002), for example, indicated that the teacher should also be able to facilitate play in the classroom and structure an appropriate learning environment. In the present study teachers were not trained to do this. This could possibly account for the performance difference between the classes included in the present study. It is also possible that in an educational environment where there is a lack of teachers with adequate number skills, training in the use of educational equipment would not automatically enhance their instructional quality. It is therefore recommended that further research be done to explore these and other teacher related variables that could limit numeracy development in learners.

Acknowledgements

I thank the Shuttleworth Foundation and the Rotary Club, Tzaneen, for permission to use identifying information, Mrs G van Schalkwyk and Mrs M Lochner for initiating, developing and implementing the programme and gathering the data, and Prof HJ Pietersen for support and constructive criticism.

References

Ananiadou K, Jenkins A & Wolf A 2003. *The benefits to employers of raising workforce basic skills levels: A review of the literature.* London: Institute of Education, University of London.

Ball DL 1993. Halves, pieces, and twoths: Constructing representational contexts in teaching fractions. In: Carpenter T, Fennema E & Romberg T (eds). *Rational numbers: An integration of research.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Beattie ID 1986. Modeling operations and algorithms. *Arithmetic Teacher*, 336:23-28.

Bergen D 2002. The role of pretend play in children's cognitive development. *Early Childhood Research and Practice*, 4. Available at http://ecrp.uiuc.edu/v4n1/bergen.html

Bodrowa E. & Leong DJ 2003. The importance of being playful. *Educational Leadership*, 60:34-37.

Cobb P, Wood T, Yackel E & McNeal B 1992. Characteristics of classroom mathematics traditions: An interactional analysis. *American Educational Research Journal*, 29:573-604.

Cohen PC 1982. *A calculating people: The spread of numeracy in early America.* Chicago: The University of Chicago Press.

Conway J 1997. *Educational technology's effect on models of instruction.* Available at http://copland.udel.edu/~jconway/EDST666.htm#cogapp. Accessed 2 December 2004.

Consumer Reports 1998. Toys that teach, 63:76.

Cristol H 2003. Playful therapy. *Futurist*, 37:32-33.

Damon GD 2002. *Using everyday objects and materials to teach maths. Excelligence.* Learning Corporation: Earlychildhood.com

Eisner E 1991. *The enlightened eye: Qualitative inquiry and the enhancement of educational practices.* New York: MacMillan.

Fennema EH 1972. The relative effectiveness of a symbolic and a concrete model in learning a selected mathematical principle. *Journal for Research in Mathematics Education*, 3:233-238.

Fenton MM 2003. The Magic of Numbers. *Biography*, 71:21-31.

Fox JE 2002. *Back to basics: Play in early childhood.* Excelligence Learning Corporation: Earlychildhood.com

Frank AR 1989. Counting skills: A foundation for early mathematics. *Arithmetic Teacher*, 37:14-17.

Fuson KC 1988. *Children's counting and concepts of number.* New York: Springer-Verlag.

Fuson KC, Perry T & Kwon Y 1994. Latino, Anglo, and Korean children's finger addition methods. In: Van Luit JEH (ed.). *Research on learning and instruction of mathematics in kindergarten and*

primary school. Doetinchem, The Netherlands: Graviant.
Geary DC & Hamson CO 2004. *Improving mathematics and science achievement of American children: Psychology's role*. Available at http://www.apa.org/ed/geary.html. Accessed 3 December 2004.
Gelman R & Gallistel CR 1978. *The child's understanding of number*. Cambridge, MA: Harvard University Press.
Ginsburg H 1977. *Children's arithmetic: The learning process*. New York: Van Nostrand.
Greenwood CR & Terry B 1994. Confirming a performance-based instructional model. *School Psychology Review*, 23:16-26.
Heugh K 2001. Many languages in education. Perspectives in Education, 19:117.
Hunt JMcV 1965. Intrinsic motivation and its role in psychological development In: Levine D (ed.). *Nebraska Symposium on Motivation*. Lincoln, Nebraska: University of Nebraska Press.
Jennings KD 1993 Mastery motivation and the formation of self-concept from infancy through early childhood In: Messer DJ (ed.). *Mastery motivation in early childhood: development, measurement and social processes*. London: Routledge.
Kersaint G & Chappell MF 2001. Helping teachers promote problem solving with at-risk children. *Early Childhood Education Journal*, 29:11-13.
Lampert M 1986. Knowing, doing, and teaching multiplication. *Cognition and Instruction*, 3:305-342.
Miller LG 2002. *Toy selection*. Excelligence Learning Corporation: Earlychildhood.com
Miller SP & Mercer CD 1997. Educational aspects of mathematics disabilities. *Journal of Learning Disabilities*, 30:47-56.
Morgan GA & Harmon RJ 1984 Developmental transformations in mastery motivation: measurement and validation. In: Emde R & Harmon RJ (eds.). *Continuities and discontinuities in development*. New York: Plenum Press.
Piaget J 1952. *The origins of intelligence in children*. New York: International University Press.
Piaget J 1962. *Play, dreams, and imitation in childhood*. New York: Norton.
Popper S 1993 Social and object mastery play in 12-month-olds with depressed and non-depressed mothers: Developmental changes and correlates. Paper presented at the *Biennial Meeting of the Society for Research in Child Development*, New Orleans, LA.
Pretorius E & Naude B 2002. A culture in transition: Poor reading and writing abilities among children in South African townships. *Early Child Development and Care*, 172:439-449.
Reys R, Reys B, McIntosh A, Emanuelsson G, Johansson B & Der CY 1999. Assessing number sense of students in Australia, Sweden, Taiwan, and the United States. *School Science and Mathematics*, 99:61-70.
Rose AD 1998. Expanding the scope of mathematical instruction. *Adult Learning*, 9:71-78.
Ross R & Kurtz R 1993. Making manipulatives work: A strategy for success. *Arithmetic Teacher*, 40:254-257.
Sawada D 1985. Mathematical symbols: Insight through invention. *Arithmetic Teacher*, 32:20-22.
Saxe GB 2000. Children's developing mathematics in collective practices: A framework for analysis. *Journal of the Learning Sciences*, 11:15-31.
Stager GS 1999. Teaching with toys. *Curriculum Administrator*, 35:73.
Starkey P & Cooper RG 1995. The development of subitizing in young children. *British Journal of Developmental Psychology*, 13:399-420.
Van de Rijt BAM & Van Luit JEH 1998. Effectiveness of the AEM program for teaching children early mathematics. *Instructional Science*, 26:337-358.
Van Luit JEH 2000. Improving early numeracy of young children with special educational needs. *Remedial and Special Education*, 21:61-78.
Van Luit JEH & Van de Rijt BAM 1995. *Rekenhulp voor kleuters* [*Remedial math for children at kindergarten age*]. Doetinchem, The Netherlands: Graviant.
Vlachou M & Farrell P 2000. Object mastery motivation in pre-school children with and without disabilities. *Educational Psychology*, 20:59.
Vygotsky L 1978. *Mind in society: The development of higher psychological processes*. Cambridge,

MA: Harvard University Press.
Wardle F 2002. *Play as curriculum*. Excelligence Learning Corporation: Earlychildhood.com
White RW 1959. Motivation reconsidered: the concept of competence. *Psychological Review*, 66:297-333.
Wilson CL & Sindelar PT 1991. Direct instruction in math word problems: Students with learning disabilities. *Exceptional Children*, 57:512-519.
Wynn K 1992. Children's acquisition of the number words and the counting system. *Cognitive Psychology*, 24:220-251.
Yarrow LS, McQuiston S, McTurk RH, McCarthy ME, Klein RP & Vietze PM 1983. Assessment of mastery motivation during the first year of life: contemporaneous and cross-age relationships. *Developmental Psychology*, 19:159-171.

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