Jaworski, B. (Ed.) Proceedings of the British Society for Research into Learning Mathematics 20(1&2) February/May 2000

REVISITING THE 'MATERIALS OF PLAY': EFFECTIVE LEARNING IN SOME ASPECTS OF SHAPE AND SPACE.

Penny Coltman, Dinara Petyaeva, & Julia Anghileri.

Homerton College, Cambridge

With the current focus on the teaching and learning of number skills aspects of mathematics relating to shape and space have recently received rather less attention. This paper reports research into the role of a supporting adult in promoting effective learning relating to aspects of 3D shape in young children, using wooden blocks, in this case Poleidoblocs. Children in the study carried out problem solving tasks embedded within playful contexts. The study showed that under these conditions, structured adult intervention increased the effectiveness of learning and led to an enhanced development of secure and transferable concepts.

Introduction

Poleidoblocs are brightly coloured wooden blocks, in a range of inter-related geometric shapes, widely available in primary school classrooms. They were devised and described as 'materials of play' by Dr. Margaret Lowenfeld and are traditionally used for both free play, and as exemplar materials to support the teaching of early aspects of 3D geometry.

Anghileri and Baron (1999) established that children's self directed play with wooden building blocks provides valuable opportunities for extending learning related to three-dimensional shapes. Such findings reveal a greater potential for blocks as a classroom material than has been appreciated by many teachers.

The new National Curriculum for Mathematics, the National Numeracy Strategy and the Early Learning Goals contain objectives related to experiences and understandings of 3D shape. Reference is also made to the desirability of children becoming able to describe shapes which they can see or visualise. This therefore implies a clear pre-requisite for first hand experiences, exploring the features and properties of shapes through the manual exploration and experimentation typified in block play. In view of this, the effective use of blocks in developing learning invites investigation.

Anghileri and Baron (1999) carried out their observations primarily on children engaging in free play with Poleidoblocs. This study continued their work, looking more closely at the areas of learning which they had identified and investigating adult interaction as one of the conditions under which the effectiveness of this learning could be increased.

It is known that adult involvement in any learning activity with children increases the effectiveness of the learning process (Vygotsky 1978, Donaldson 1978, Wood 1986, Bruner 1991, Anning & Edwards 1999). The research concentrated on a level of adult involvement, which provides supportive interaction during the learning process itself. In exploring this within the context of shape and space, the

study aimed to extend the research evidence and to provide additional perspectives on the teaching of early mathematics and science.

Theoretical background.

The understanding of the role of play within the learning process of young children was highlighted by Vygotsky when he wrote that 'the child moves forward essentially through play activity' (1978 p. 103). This has subsequently been repeatedly supported by the findings of many researchers and educationalists, working within a number of theoretical perspectives (Bruner 1996, Anning & Edwards 1999). Closely linked to an acknowledgement of this fundamental role of play, is the requirement for a meaningful context within which the child sees both purpose and relevance (Donaldson 1978).

Whilst rooting our study within these principles, our research was primarily related to an additional identified condition, that effective learning will only take place within the zone of proximal development (ZPD) (Vygotsky 1978, Tharp & Gallimore 1998) . This zone contains the knowledge, skills and intellectual processes which children have not yet acquired, and which they *can* only acquire when supported by an adult or more experienced 'other'. The child is unable to complete tasks relating to these by himself. An understanding of the role of the ZPD in the learning process thus results, of necessity, in a recognition of the requirement for help. Developing the ideas of Vygotsky, Bruner (1991) presents a model of intervention described as 'scaffolding' in which the adult and child establish a 'co-construction' of meanings through a system of graded help.

Finally, adult interaction has a further benefit in helping children to become aware of, recognise, and appreciate the significance of the acts which they carried out in successfully completing a task. That means that they discover the solution to one particular task, and are likely to be able to transfer their method to new situations or to another task.

Purpose of the Study.

The main purpose of this research was to study the effect on children's learning of the provision of adult support for children undertaking problem solving tasks embedded in playful contexts. The hypothesis was that using wooden blocks with appropriate adult interaction would increase the effectiveness of the learning process and lead to an enhanced development of secure and transferable concepts related to shape and space.

Method

Materials The materials used were selected subsets from a set of Poleidoblocs. Additionally we used a range of simple props.

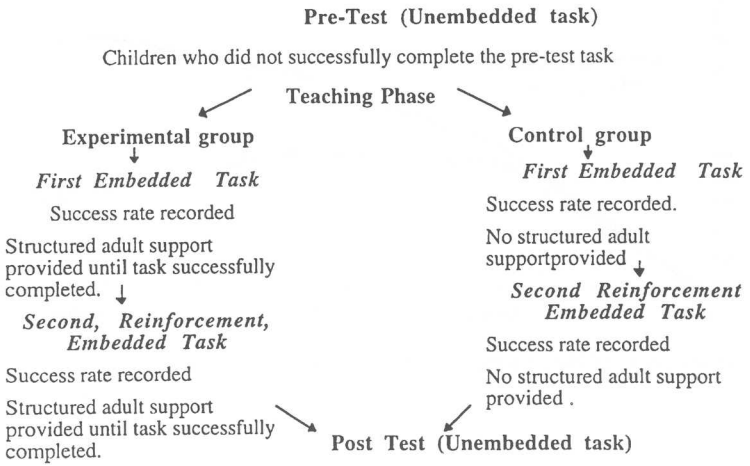
Participants The project consisted of two phases - a pilot and experimental phase, and involved 90 children from two schools, aged 4-6 years, in the spring and summer terms of their reception year. The pilot phase involved 30 children from the reception class of one primary school and the experimental phase involved 60 children comprising two reception classes from a second primary school. In both phases children were observed individually and field notes were taken. Some children were also videotaped. Each session was of 10 to 20 minutes in duration.

Pilot phase During the pilot phase a number of activities were trialled and the responses of children were analysed to inform the design of the tasks to be used in the experimental phase.

Throughout the remaining phases of the research, all the tasks related to the following aspects of shape and space: matching 2D outlines to the faces of 3D blocks; recognising and using alternative orientations of 3D shapes; developing an awareness of aspects of balance; characterising and classifying 3D shapes; recognising equivalence in shape and size; and constructing a reflection (using reflective symmetry).

The model of graded support which was also developed through the pilot activities, was a form of scaffolding, which provided cues and prompts of an increasingly explicit nature and consisted of the following three levels: the researcher encouraging the child to handle the blocks, examining the shapes of different faces both visually and manually; demonstrating the actions necessary to solve the task, using an equivalent but different set of blocks; and finally researcher showing the child how to complete the task.

Experimental Phases



The experimental procedure was designed to encompass both motivational and cognitive aspects when working within the zone of proximal development. A source of motivation was provided in the use of embedded tasks with contexts meaningful to young children. The cognitive aspect was supported by the provision of the three levels of adult help, and also by the presentation of both the task and the adult help in a material form so that there was hands on activity and an external form of support in finding the solutions to problems.

Results and discussion

Pre-test. The pre-test included 6 adult-directed, unembedded tasks presented in a material form. Each task required children to work within one of the 6 areas of learning related to shape and space. The purpose of the pre-test was to select children who were as yet unable to complete one or more of the tasks. Inability to complete tasks showed that the relevant concepts were not, at this stage, within the capability (the zone of actual develoment), but could be within the zone of proximal development. These children were thus selected as subjects for the study which focussed on the forming of these concepts, working within the zone of proximal development. After the pre-test the children were divided into 3 groups, each of them including children who had not performed the same two tasks from the 6 offered. Each of these three groups was then further divided into control and experimental groups, taking into account the gender, age, teacher and baseline assessment scores of the children, to maximise equivalence between the groups.

Teaching phase. The children in both control and experimental groups were presented with the same first embedded task (Task A). In both groups the children tried to solve the tasks on their own with no adult intervention (see Fig.1).

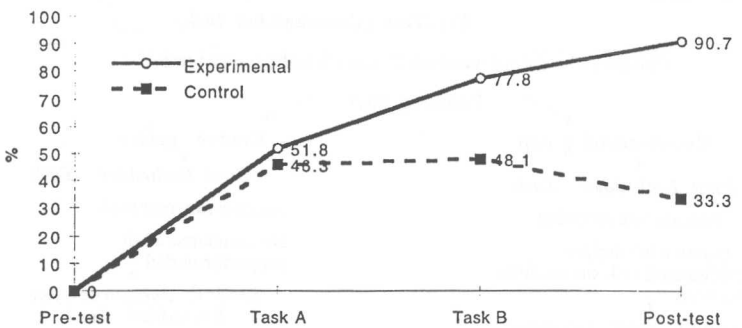


Fig 1. Percentages of children sucessfully completing tasks.

Thanks to the embedded nature of the task, some of the children could execute activities which they had not been able to do in the pre-test. Naturally, the results ofthe control and experimental groups showed no significant difference. In the control group 46.3 % of the children could find a solution and in the experimental group 51.8% ($p > 0.05$).

After that in the experimental group one or other of the following was conducted: The children who had executed the task were encouraged to check their findings, reinforcing the significance of their solution. The children who could not execute the task received graded help as previously described. An overwhelming majority of children (72%) managed to find a method of solution on receiving the second level of help. The first level of help appeared sufficient in 28 % of cases. No-one in fact required the third level.

In the control group no adult support was offered to the children.

Three days after the first presentation of these first embedded tasks the children in both the control and experimental groups were presented with second, reinforcement tasks (Task B) requiring the same kinds of activity but within a different meaningful context.

In the control group there was no significant improvement in the results. On the first presentation of tasks (Task A) 46.3 % obtained a correct solution and for the reinforcement tasks (Task B) 48.1% ($p > 0.05$). Thus, simply increasing the number of tasks appears not to be very effective.

In the experimental group 77.8% correctly solved Task B. Such a sharp increase (26 %) can be explained by the adult support supplied in completing Task A which enabled the children to acquire a method of action and use it in approaching another, similar problem (Task B) . The difference in success between the experimental and control groups was 29.7% ($p < 0.05$).

Post-test. The difference in the success rates between the control and experimental groups appeared even greater in the post-test which was conducted 3 days later. The post- test tasks were the same as the pre-test tasks. In the control group the success rate was less than it had been in the teaching phase, with only 33.3% of children finding a solution. In the experimental group, however, the results were improved with 90.8% of the children successfully completing the post -test.

Fig. 1 shows the progress of both groups throughout the experimental phase. In the control group the introduction of a meaningful context at the beginning of the teaching process led to a substantial improvement in the results compared to those of the pre-test. Reinforcement of such tasks did not add anything new to the learning situation and the results showed no significant improvement. In the post-test the success rate of children, working without the support of a meaningful context, decreased. Following Hughes (1986) we believe that an increase in the

number of concrete tasks does not advance the child to new stages of learning (levels of knowledge). In our case the children in the control group, whilst improving their solution of concrete tasks, did not realise the principle of their solution and could not transfer it to another situation.

In the experimental group the children, with the support of an adult, solved the teaching tasks and carried out a self-correction process which raised an appreciation of the actions carried out in order to achieve the successful solution. This, in turn, led to an enhanced ability to transfer the acquired activity to new circumstances and thus to further improvement in the results.

Conclusion

The results of the experiment support our hypothesis that the provision of appropriate adult support substantially improves the effectiveness of learning related to aspects of shape and space. Whilst understanding the importance of free play with wooden blocks, at the same time we see its insufficiency in facilitating the acquisition of early geometrical concepts. Children alone cannot reliably 'discover' all the important and necessary knowledge and methods of action solely through manipulating the blocks. They learn these more effectively through carefully structured joint activity with 'experienced others'.

References

Anghileri, J. & Baron, S. (1999) Playing with the Materials of Study: Poleidoblocs. *Education 3-13* , 27 (2), pp. 57-63.

Anning, A. & Edwards, A. (1999) *Promoting children's learning from birth to five: developing the new early years professional* (Buckingham, Open University Press).

Bruner, J.S. (1991) The Nature and Uses of Immaturity, in: M. Woodheard, R. Carr & P. Light (eds.) *Becoming a person* (London, Routledge/OUP).

Bruner, J. S. (1996) *The Culture of Education* (Cambridge MA, Harvard Unversity Press).

Donaldson, M. (1978) *Childrens' Minds* (London, Fontana).

Hughes, M. (1986) *Children and Number* (Oxford, Basil Blackwell).

Tharp, R. & Gallimore, R. (1998) A theory of learning as assisted performance, in D. Faulkner, K. Littletone & M. Woodhead (eds.) *Learning Relationships in the Classroom* (London, Routledge).

Vygotsky, L.S. (1978) *Mind in Society: The development of higher psychological processes,* edited by M.Cole, V. John-Steiner, S.Scribner and E.Souberman (Cambridge, MA: Harvard University Press).

Wood, D. J. (1986).Aspects of teaching and learning, in M.Richards and P. Light (eds.) *Children of Social Worlds* (Cambridge, Polity Press).