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AN ASSESSMENT OF THE MATHEMAGENIC ACTIVITIES PROGRAMME*

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Cognitive developmental measures of role-taking ability and classification skills were administered to eighty two white children randomly selected from two Mathemagenic Activities Programme (MAP) classrooms and two non MAP classrooms at first second, and third grade Cartoons were used to measure role taking ability in the tradition of Flavell *et al* (5) Two measures of classification were used There was some support for the hypothesis that the classroom environment experienced in MAP facilitated role taking ability however classification skill was not affected at a statistically significant level

Different types of educational systems espouse different educational goals Evaluation of any such system will necessarily vary according to both the nature of these educational goals and the theoretical orientation of the evaluator The present study is part of the evaluation of the Mathemagenic Activities Programme (MAP), an educational programme designed at the University of Georgia and part of the Follow Through Programme funded by the United States Office of Education The MAP Follow Through model is based on a constructivist view of knowledge acquisition (6, 7) with special importance being attached to Piaget's theory of cognitive devel opment as a contemporary example of such an approach In Piaget's theory a child's rational understanding of his physical and social environment is defined in terms of existing cognitive structures (10) Advances in cognitive development come about when a child notices a discrepancy between his ongoing experience and his expectancies, and reorganizes his

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thinking because of this discrepancy. A child who has not learned to conserve weight, for example, will expect certain changes in the shape of a ball of plasticine to entail corresponding changes in weight. The opportunity to check on these expectancies will be given by a teacher who allows the non-conserving child to check his prediction with a weighing scales. Advances in knowledge are facilitated, according to the theory, by such opportunities for interactions which promote conflict between the way the child thinks and what he is experiencing.

In the MAP classrooms every effort is made to provide children with theoretically appropriate educational experiences through a curriculum process emphasizing both small group and individual learning tasks. The social interactions which occur in small groups provide more frequent opportunities for the experience of contradiction necessary to the development of cognitive structures. The recommended curriculum materials make it possible for the teacher to set up a learning environment consistent with the MAP principles of (a) *mismatch,* or appropriate structuring of the child's social and physical environment via learning units which are slightly above his present conceptual level; (b) *self-regulation* promoted by learning areas which encourage instructional strategies that provide for appropriate variation in modes of learning as well as a balance between highly structured and relatively low structured learning activities; and (c) *coordinated activities* by which children learn by active and thoughtful manipulation of their physical, social and symbolic environments. In addition, the interlocking nature of the different curriculum contents (e.g., overlap of Science, Art, and Language) creates possibilities for the development of intellectual processes and skills through a variety of media, activities and social situations. In its classrooms, MAP requires two instructional aides to provide a high level of social interaction in small group instruction.

Two sets of measures were selected with a view to evaluating the effects of MAP on children's intellectual processes. First, measures of classification were used to assess the structural development of the children's physical concepts; and second, measures of role-taking ability were used to assess the development of their social cognition. It was suggested in previous studies that the MAP schooling environment facilitated the development of concepts of physical invariants in children in kindergarten through third grade (e.g., 3, 9). The inclusion of measures of role-taking abilities in the present study is an innovation in the assessment of MAP classrooms.

The role-taking task used was one requiring a subject to distinguish his own thinking from that of another person. There are a number of studies in

the literature showing that children become capable of differentiating their understanding of a cartoon sequence (shown first) from another person's understanding of only part of the same sequence (e g , 1, 5) This capability develops during the concrete operational period Egocentric errors are defined as references to privileged information which only the subject knows because only he sees the entire cartoon sequence Chandler and Greenspan (1) reported that 85 percent of their six year old children were egocentric as compared to four percent of the thirteen-year olds

METHOD

Subjects

Ninety seven children from three schools in Lee County, Virginia, served as subjects Fifteen were in kindergarten, 26 in first, 28 in second, and 28 in third grade Children were randomly selected from four classrooms (two MAP Follow Through and two non Follow Through) at grade levels one, two and three The kindergarten children were not randomly selected, but could be divided into those who had received compensatory education

TABLE 1

NUMBER OF SUBJECTS BY GRADE SEX, SCHOOL PROGRAMME AND INCOME

	Follow Through		Non Follow Through		
Grade Level	Boys	Girls	Boys	Girls	Total
Kindergarten*	1(1)**	5(4)	6(1)	3(0)	15
First Grade	7(3)	7(5)	6(0)	6(5)	26
Second Grade	7(3)	7(4)	7(4)	7(5)	28
Third Grade	6(4)	8(4)	7(7)	7(6)	28

* The kindergarten children were divided into Follow Through and non Follow Through groups on the basis of whether or not they had Head Start experience

** The number in parenthesis indicates the number of low income children in each group thus, the only kindergarten boy to have received Head Start was low income

(Head Start) and those who had not It was assumed that this would be comparable to the differences between MAP Follow Through and non Follow Through Low income level subjects, as defined by the United States Office of Equal Opportunity guidelines, were identified after data collection The Office of Equal Opportunity guidelines were based on factors such as

the size of family, ages of children and whether the family lived in a rural or an urban area. There was not a significant difference in the distribution of low income children in the Follow Through and non-Follow Through groups. The number of children tested by sex, income, grade level, and programme (MAP Follow Through versus non-Follow Through) are reported in Table 1.

The Follow Through Programme

Follow Through is a federally funded compensatory education programme for children in their first years in school. It finishes at the end of third grade. Under its auspices various educational programmes reflecting different theoretical bases were designed. Amongst the different programmes were educational models which could be described as being principally behaviourist, others which were primarily cognitive, and others which were more concerned with socio-emotional adjustment. While some programmes fell easily into this typology, many programmes were not readily classifiable.

The MAP Follow Through Programme, one which fits fairly cleanly into the cognitive category, has been in Lee County, Virginia, since the autumn of 1969. At the time of this study, teacher training was the primary responsibility of Project Resource Teachers. These community based teachers were trained by MAP staff and have been working with the programme since 1969. The function of the Resource Teachers is to organize training programmes for the MAP Follow Through teachers and to help facilitate implementation of the classroom process by frequent visits to each classroom. In addition, site visits by MAP classroom specialists (from the University of Georgia) were made five times during the academic year (1973-1974) in which this study was carried out. The site visits included discussions with each teacher which focused on the degree to which the classroom reflected MAP principles. In short, while many efforts were made to ensure the fidelity of the classroom environment to MAP principles, no objective measure of these teachers' effectiveness or of programme implementation in their classrooms, as defined by MAP, was available.

The classrooms from which the children were selected were randomly selected to be representative of Follow Through and non-Follow Through classrooms in the community. A post-hoc analysis indicated that the Follow Through classrooms were quite representative of the Follow Through classroom environments.

Experimental Tasks

Two Piagetian classification measures and seven social role taking cartoon tasks were used A full description of each task and the administrative procedures may be found in Gash and Smock (8)

Classification Tasks The two classification measures were tasks used by Smedslund (11) and by Nixon (reported in 2) These tasks were chosen to represent Groupings I and III of the concrete operational structures respectively (4) Grouping I (primary addition of classes) underlies the ability to understand the relation between a superordinate class and its subordinate components Grouping III (bi-univocal multiplication of classes) underlies the ability to reclassify a set of objects which can be classified in two ways The assessment procedure used on the Smedslund (grouping I) task and the Nixon (grouping III) task will make this clearer

On the Smedslund task subjects were required to answer a question about class inclusion Ten red squares (side 3/4") and three red triangles (side 3/4") were used Having established that there were more squares than triangles, the subjects were asked whether there were more squares or red pieces The subjects' responses could be divided into two groups operative responses were those which gave a correct answer *and* a justification for this answer, figurative responses were either those in which there was no justification of correct answer *or* were incorrect This task was essentially item one, class inclusion, described by Smedslund (11)

The Nixon task consists of five sets of painted wooden cylinders one white set, one red set, one yellow set, one green set, and one blue set

FIGURE 1

DISPLAY OF CYLINDERS IN NIXON TEST

	Two Groups of Cylinders in Each Item			Problem
Item 1	TRF SRF, TRN SRN	TWF SWF TWN, SWN		TRN, SRN
Item 2	TYF TGF TYN TGN	SYF, SGF SYN SGN		SYF, SGF
Item 3	TWF SWF TWN, SWN	TBF, SBF, TBN, SBN		TWF, TWN
Item 4	TRF, TYF, SRF SYF	TRN, TYN, SRN SYN		TRF TYF
Item 5	TGF TBF TGN, TBN	SGF SBF, SGN SBN		TGF TGN
Item 6	TRF, TBF SRF SBF	TRN, TBN, SRN SBN		TBF SBF

Key 1st letter (height) T = tall S = short
2nd letter (colour) R = red Y = yellow, W = white, G = green B = blue
3rd letter (thickness) F = fat, N = narrow

Each coloured set was made up of four pieces: a tall (2") fat (1") cylinder, a tall thin (5/8") cylinder, a short (1½") fat cylinder, and a short thin cylinder. The six items on this test are presented schematically in Figure 1. Subjects were classified as operational on each item of the Nixon test if they regrouped the cylinders on the first attempt and gave the correct reason for this arrangement. Other responses were considered figurative. Subjects who gave five or six operational responses to the six items on the Nixon test were considered operational.

Role-Taking Tasks. Five cartoons were modelled on a task (ID) used by Flavell, Botkin, Fry, Wright and Jarvis (5) and two have been used by Chandler and Greenspan (1). The major difference between the procedures used here and those used by Flavell *et al.* was that two types of questions were asked after the subject's description of the cartoon sequence. That is, both a *next* question and a *before* question were asked whereas Flavell *et al.* used only the *before* question. Questions were designed to require a subject to recognize that if a friend of his was shown part of the cartoon sequence, the friend would remain ignorant of details omitted from the story. On the *next question,* subjects were asked what a friend might say if he saw only the beginning of the sequence and was asked to state what happened next. The *before question* involved showing the subject pictures only from the end of the sequence and asking what his friend would think if he were shown these pictures and then asked what happened before. The types of stories limited the sorts of questions which could be legitimately asked: on only four of the seven cartoons could both the *next* and *before questions* be asked. Each role-taking question was scored as either egocentric or decentered.

In the first cartoon two children try to pick an apple from a tree, but the tree is too high. A giraffe appears and picks the apple for them. The role-taking question (a *next question*) involved removing the pictures showing the giraffe picking the apples and then asking the subject how a friend would think the children got the apple from the tree. Detailed descriptions of the cartoons may be found in Gash and Smock (8). Very briefly the other cartoons may be described as follows: the second cartoon involves a wolf who tries unsuccessfully to catch a pig; the third cartoon involves some boys who plan unsuccessfully to throw snowballs at a small girl; the fourth cartoon involves a pig who rescues another pig from being eaten by gorillas with the use of an air-balloon; and the fifth shows one of the pigs falling from an air-balloon into a snowdrift where he is found by some large bears. On these four cartoons (two to five) both *next* and

before questions were asked The last two cartoons, the lost coin story and the melting snowman story have been used by Chandler and Greenspan (1)

Procedure

The Smedslund and the Nixon tasks were administered in that order by two trained examiners with each examiner individually testing approximately one half of the subjects The data from the cartoon tasks were recorded on cassette tape recorders and specially prepared data sheets, organized so as to facilitate task administration (In the latter stages of data collection the first author wrote down the subjects' responses to the cartoon tasks because one tape recorder was malfunctioning) The first author and a trained research assistant administered the cartoon tasks All subjects received cartoon one first, then approximately half received the Chandler cartoons followed by cartoons 2, 3, 4, and 5, in this case, each of the latter cartoons was followed by a *next question* and then a *before question* The other subjects received the Chandler cartoons after the other cartoons and the *next* and *before questions* were reversed in order

The subjects' responses to the role taking questions were scored by the first author A research assistant scored a random sample of nine subjects' responses (approximately a ten percent sample) Only four disagreements occurred in the 99 responses scored by both examiners The disagreements were easily resolved in discussion

RESULTS

A preliminary question about the classification data is that of the relation of age (grade level) to classification performance These data, and those describing the relation between educational environment (Follow Through and non Follow Through) and classification ability, are summarized in Table 2 The degree of association between grade level (kindergarten, 1, 2, and 3) and level of performance (preoperational and operational) on classification was tested for significance using χ^2 analyses The association between grade level and performance on the Nixon task was not statistically significant, $\chi^2 = 5\ 16$, $df = 3$, $p < 0\ 25$ However there was a significant association between grade level and performance on the Smedslund task, $\chi^2 = 10\ 71$, $df = 3$, $p < 0\ 025$, and for the stricter criterion of operativity on both tasks, $\chi^2 = 11\ 30$, $df = 3$, $p < 0\ 02$

The effects of the Follow Through programme were investigated by constrasting type of classroom learning environment (Follow Through vs

TABLE 2

TYPES OF RESPONSES ON THE CLASSIFICATION TASKS BY FOLLOW THROUGH AND NON–FOLLOW THROUGH (NUMBERS OF SUBJECTS IN CELLS)

	Nixon				Nixon and Smedslund				Smedslund			
	Figurative		Operative		Figurative		Operative		Figurative		Operative	
Grade Level	FT	NFT	FT	NFT	FT	NFT	FT	NFT	FT	NFT	FT	NFT
Kindergarten	6	5	0	3	6	7	0	1	4	6	2	2
Grade 1	9	10	5	2	11	12	3	0	7	5	7	7
Grade 2	5	10	9	4	6	11	8	3	4	4	10	10
Grade 3	6	8	8	6	8	8	6	6	3	2	11	12

non-Follow Through) with level of response (operational vs preoperational). On the Nixon test, 46 percent of the Follow Through sample were operational as compared to 31 percent of the non-Follow Through sample; this difference though suggestive, is not statistically significant, $\chi^2 = 1.58$, $df = 1; p < 0.10$. (It was hypothesized that the type of social environment and learning opportunities created in MAP Follow Through classrooms would facilitate Follow Through children's classification abilities. For this reason one-tailed tests are used in assessing the significance of the χ^2 values.) When the strict criterion of operational responding on both tasks was employed, the Follow Through subjects were again superior to the non-Follow Through subjects at a non-significant level, $\chi^2 = 2.34; df = 1; p < 0.10$.

Five of the cartoon tasks used to assess role-taking ability were constructed for this study. Preliminary analyses, performed to determine the suitability of the measures, showed that there were no significant order effects, and the measures of role-taking were homogeneous (8). The influence of grade level, programme, and sex on the number of egocentric responses elicited by all eleven role-taking questions was assessed using a 3 (grade) x 2 (programme) x 2 (sex) analysis of variance. The relevant means and standard deviations are reported in Table 3 and a summary of the analysis of variance is presented in Table 4.

Significant differences between grade levels (F (2,68) = 5.59, $p < 0.01$) were found. The origins of the significant grade x sex x programme interaction (F (2,68) = 3.47, $p < 0.05$) may be examined in Table 3. The mean number of egocentric responses on the role-taking tasks is greater, for

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR THE NUMBER OF EGOCENTRIC RESPONSES ON THE ROLE TAKING TASKS FOR GRADE, SEX AND PROGRAMME*

		Follow Through		Non Follow Through	
		Male	Female	Male	Female
Grade 1	M	7 00	4 33	5 33	7 00
	SD	3 79	2 16	4 46	1 27
Grade 2	M	5 57	4 14	4 57	8 00
	SD	4 65	3 02	3 69	2 31
Grade 3	M	1 50	4 14	4 00	3 43
	SD	1 38	2 41	2 71	3 36

* Cell numbers are identical with those in Table 1 with the exception of two Follow Through girls one at grade one and another at grade three who did not complete this test

TABLE 4

ANALYSIS OF VARIANCE OF NUMBER OF EGOCENTRIC RESPONSES TO ROLE TAKING TASKS

Source	df	MS	F
Grade	2	55 18	5 59**
Programme	1	15 90	1 61
Sex	1	4 84	0 49
Grade x Programme	2	1 85	0 19
Grade x Sex	1	20 15	0 50
Programme x Sex	2	4 89	2 04
Grade x Programme x Sex	2	34 21	3 47*
Residual	68	9 87	

* $p < 05$
** $p < 01$

example, for non-Follow Through girls than for Follow Through girls A post hoc ANOVA showed that this difference was significant (F (1,32) = 5 56, $p < 0$ 025) In the case of boys, however, at grades one and two, non Follow Through boys had slightly fewer egocentric responses than Follow Through boys on this measure, while at grade three Follow Through boys had fewer egocentric responses The over-all post hoc comparison of non Follow Through and Follow Through boys showed that there was not a significant difference between these groups on this measure

DISCUSSION

There was an indication that the Follow Through subjects were superior to the non-Follow Through subjects on the measures of social decentration. The initial evidence for this was found in the significant grade by sex by programme interaction. Inspection of the means indicated that there was a Follow Through by grade interaction for males and females separately. That is, Follow Through females were shown to be significantly superior to non-Follow Through females across grade levels. Third grade non-Follow Through females, however, were slightly less egocentric than their Follow Through peers. In the case of male subjects, the third grade Follow Through sample had the fewest number of egocentric responses to this task in comparison to any group within grade and sex. The first and second grade Follow Through subjects had, however, a slightly greater number of egocentric responses than their non-Follow Through peers.

When a strict criterion for operational classificatory thinking was applied (operational responses on both tasks), the Follow Through subjects were more advanced than the non-Follow Through subjects. However, this difference was not statistically significant. When the tasks were analysed individually a similar trend was found for the Nixon task, but not for the Smedslund task. Thus the present study fails to replicate the findings of earlier studies (3, 9).

Our findings do not provide clear evidence of the effects of the MAP Follow Through programme on children's role-taking abilities or classification skills. It should be borne in mind, however, that we were unable to monitor the level of cognitive development of the subjects when they entered the programme. Further, MAP teachers had experienced different amounts of training for MAP procedures – a variable which may be associated with the varying levels of teacher effectiveness reported by MAP field staff.

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