DOCUMENT RESUME

ED 112 571 EC 073 765

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TITLE A Longitudinal and Comparative Look at Cognitive Development in EMH Children.
PUB DATE Mar 75
NOTE 23p.; Paper presented at the Annual Meeting of the American Educational Research Association (Washington, D.C., March 30-April 3, 1975)

EDRS PRICE MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS Child Development; *Cognitive Development; *Cognitive Processes; *Educable Mentally Handicapped; Exceptional Child Research; Longitudinal Studies; Maturation; Mentally Handicapped; Problem Solving; Secondary Education; *Student Evaluation
IDENTIFIERS Piaget (Jean)

ABSTRACT

Examined longitudinally were the rate and proportion by grade level of the cognitive development of 202 13- to 16-year-old educable mentally handicapped students. A 20-item written test composed of eight problem solving and 12 cognitive development items representing the concrete I, concrete II, and formal I operations levels of Piagetian theory, was used. Results over a 12 month period indicated that 68 percent of the Ss showed no change in developmental level, 92 percent of those making a gain increased by one level, and 6 percent demonstrated losses. Data suggested that curriculum materials should be appropriate to the student's level of cognitive development, and that measures of developmental level provide more educationally relevant information than IQ scores. (CL)

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A LONGITUDINAL AND COMPARATIVE LOOK AT COGNITIVE DEVELOPMENT IN EMH CHILDREN

by

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A Paper for Presentation at the 1975 Annual

Meeting of the American Educational Research Association

Washington, D. C.

March 31, 1975

Session 4.09

A LONGITUDINAL AND COMPARATIVE LOOK AT COGNITIVE DEVELOPMENT IN EMH CHILDREN

---What are appropriate and realistic educational expectations for educable mentally handicapped (EMH) children?

---What is the utility and relevance of various means of identifying and grouping EMH children?

These are the questions addressed by a series of longitudinal studies of teenage children in special classes. Placement of children in EMH classes has a number of implications for them:

A social stigma at school

The label "retarded"

A variety of assumptions about potential and general abilities

A different set of expectations and requirements

Separation (often permanent) from the regular school program

Separation from friends and age mates

Such serious consequences would argue for careful identification and frequent review of such placement, but previous studies (of this sample) indicate as many as 40% may be misplaced and retesting not done for intervals up to six years (Steele, 1973a).

The placement of children in EMH classes in many states entails the use of individualized intelligence tests, a costly procedure. Yet these scores provide information that has little meaning or relevance for instructional decisions in teaching. Indeed, in one of this series of studies, IQ explained little or none of the variance in performance of EMH students over a two-year period (Steele, 1973b; 1974).

Special educators have been actively struggling with the dual problems of placement and programming for students who are academically unsuccessful in regular classes. Various theoretical models of development have been applied but as yet none have emerged as generally useful. This series of studies suggests that Piaget's theory of cognitive development may provide meaningful ways to identify and group children as well as guidance in the design of curricula.. Earlier studies in the series have established that developmental level can be validly and economically assessed. Such measures do explain variance in performance. Using multiple regression techniques, developmental level was found to explain from 19-24% of the variance in performance in five out of six studies; IQ, age, sex, and ethnic background contributed no additional explained variance in performance in five out of six studies (Steele, 1974).

Piaget has done an enormous amount of research and extensively elaborated a theory. Substantial evidence is accumulating supporting the general postulates of this theory. However, little is known empirically about the rate of cognitive development or the proportion at each level of development for children at various grade levels. This paper explores both dimensions for a sample of 13- to 16-year-old EMH children. The proportions at each developmental level are compared with proportions found in a sample of 11- to 13-year-old children in regular classes.

METHOD

Subjects

Primary subjects were two hundred two 13- to 16-year-old educable mentally handicapped students in 17 classes participating in a field test of ME AND MY ENVIRONMENT, a life sciences program developed by the Biological

Sciences Curriculum Study. Most of these students were 13 or 14 years old (mean age = 13.4). Range in IQ scores was from 44 to 93, with two-thirds of the scores between 60 and 79 (mean IQ = 67.6).

Subjects from regular classes used for comparative purposes were six hundred twenty-two 11- to 13-year-old students in 28 classes participating in field tests of Human Sciences, a program under development by the Biological Sciences Curriculum Study. In this sample, 42% were eleven years old and 49% were twelve (mean age = 12.1).

Instrument

A twenty-item written test consisting of eight problem-solving and twelve cognitive development items was used. Two items were "completion" type, while the remaining eighteen were multiple choice with four or five alternatives per question. Fifteen items included drawings for concrete reference. Each cognitive development item reflected the logic of a specific developmental level and was derived from previous work by Gray (1973a, 1973b). The cognitive developmental level of problem-solving items was determined *ex post facto*. Item distribution included the following levels:

Concrete I = beginning inconsistent concrete operations

Concrete II = established consistent concrete operations

Formal I = beginning inconsistent formal operations

Five item types were included:

Transformation = conservation of liquid quantity

Seriation = serial ordering by size or in time; combinatorial thinking

Combination = Co-univocal multiplication of classes;
Bi-univocal multiplication of classes;
Combinatorial thinking

Proportion = Bi-univocal multiplication of relations including direct and inverse correspondence

Exclusion = Addition of asymmetrical relations (increasing)

Table I shows the distribution of items by level and type. Appendix A provides examples illustrating each type of item as well as all of the items included in the formal operations score.

TABLE 1

Distribution of Items 1 through 20 by Level and Type

	Developmental Level		
Item Type	Concrete 1	Concrete 2	Formal 1
Transformation	1, 20		
Seriation	3		15
Combination	5	9	11
Proportion	8	4	14
Exclusion*	10, 17 2, 6, 7, 12, 13, 19	16, 18	

*Items 2, 6, 7, 12, 13, and 19 were developed as problem-solving items but can be categorized as Concrete 1 Exclusion type bi-univocal (one-to-one) correspondence. Items 16 and 18 were also problem-solving items and have a hybrid structure but generally can be considered exclusion type problems at the Concrete 2 level.

The instrument has been validated in several ways. Using ordering theory (Bart, 1973), a measurement model that can assess all multilinear prerequisite relationships within a set of data, an hierarchical analysis was conducted on a sample of 375 EMH students, ages 13-16. This analysis provided substantial support for the differentiation between concrete and formal levels of cognitive development and for the relationships within the various item types. Logical prerequisites were shown to exist among all items (Gray, 1974). This analysis has been replicated several times with like results. Appendix B illustrates this hierarchical relationship for the instrument based on administrations in 1973 and 1974 to the sample used in this study. Comparison of test item responses with student responses and explanations derived from individual interviews also supports the validity of the instrument (Steele, 1973b).

Procedure

Students were tested in their respective classrooms as a group. Each student received a copy of the test and read silently as their teacher read each item aloud twice. Students marked the option they felt best answered each question. They were not questioned as to the "why" of their choice. Items were scored correct or incorrect and two variables were constructed to derive a judgment of developmental level. The concrete operational variable included items 1-8, 10, 12-13, 16-17, 19-20, each with a weight of one (1), for a total possible score of 15. The formal operational variable included items 15 and 18, each with a weight of two (2); item 9 with a weight of three (3); and items 11 and 14, each with a weight of four (4). The total possible score again was 15.

The basis for selection of items for the concrete operational variable was their hypothesized developmental level, supported by the hierarchical analysis. The items included in the formal operational variable were selected on the basis of their difficulty and their hypothesized developmental level. Items 15 and 18, although apparently concrete in structure were substantially more difficult than other concrete items and were consequently considered transitional items and given more weight than other concrete items. These two items also appear to occupy pivotal positions in the hierarchical analysis. Item 9 was a concrete operational item of extreme difficulty, patterning with the formal operational items and consequently received a weight of 3. Items 11 and 14 were formal operational items of extreme difficulty and were given a weight of 4.

To establish cutoff points for determining developmental level, the closest score to 75% of the items correct was used as the criterion, a level Piaget tends to favor. Consequently, an individual's developmental level was determined in accordance with the following table:

TABLE 2

Scoring Algorithm for Determining Developmental Level

Score	Variable	Level
10 or less	Concrete	Preoperational
11-15 7 or less	Concrete Formal	Concrete Operational
11 or more 8-10	Concrete Formal	Transitional (Concrete-Formal)
11 or more 11 or more	Concrete Formal	Formal Operational

For the sample of students from regular classes a modified version of the instrument was used that did not include seven of the problem-solving items (item 18 was retained). Items 1 and 3 were also deleted from this version. In their place were substituted revised or alternative items of various types at each developmental level. Ten new items at the Formal 1 level were added, and four items at the Formal 2 level (established consistent formal operations) were added.

For purposes of this comparison only those items common to the form used by the EMH sample were scored. As the formal items were all retained, the formal operational variable of the scoring procedure remained the same. A cutoff point of 7 or more of the 11 items was used for the concrete operational variable.

Results and Discussion

Table 3 reports the degree to which changes seem to occur over a twelve-month period for this sample of 202 teenagers in special classes. Table 4 summarizes the percentage of students in each sample classified at each of four developmental levels. Over the year, 68% showed no change in developmental level, as measured by the instrument. Of the 26% showing gains, 24% gained one developmental level. That is to say, 92% of those making a gain increased by one level. Gains of more than one level most likely reflect measurement error or misclassification of students as retarded. There were 6% who showed losses, 4% moving from the concrete to the preoperational level. It would seem likely that the 12 students who showed losses reflect error of measurement or perhaps a transitional stage in the student. The pattern is one of very slow change, almost arrested at the concrete operational stage. Of the six students who appear to be at the formal operational

TABLE 3

Degree of Stability or Change in Measured Developmental Level Over One Year

Percentage Showing No Change or Moving	Preoperational	Concrete	Transitional	Formal
From Preoperational to	33%	19%	0	0.5%
From Concrete to	4%	33%	4%	1.5%
From Transitional to	0	1%	1.5%	0.5%
From Formal to	0	0.5%	0.5%	0.5%

TABLE 4

Percentage of Students Per Development Level

	Mean Age	N	Preoperational	Concrete	Transitional	Formal
EMH Sample 1973	(13.4)	202	52%	43%	3%	1%
EMH Sample 1974	(14.4)	202	37%	54%	6%	3%
Normal Sample 1974	(12.1)	622	15%	40%	22%	23%*

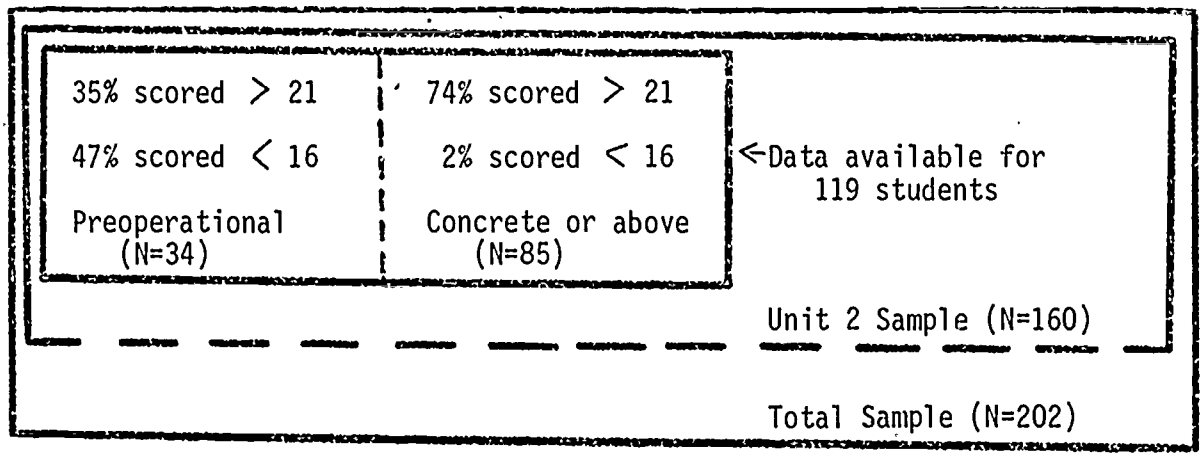
*Analysis using the additional items administered to regular classes indicates that 20% would be classified Formal 1 (beginning inconsistent formal operations) and 3% would be classified as Formal 2 (established consistent formal operations).

level at the end of the year, two were placed in the special class not because of evidence of retardation, but because of being "disadvantaged." Two more were Chicano, coming from bilingual homes. One of these children was moved to a regular classroom late in the year. The other two children cannot be accounted for, but some suspicion must be held that they are not retarded and are misplaced in an EMH classroom. Even the placement of the 12 children at the Transitional level is questionable. Six of them were placed in special classes primarily for other reasons than retardation. For example, one child had cerebral palsy, two were classified as emotionally disturbed, and three were labeled "disadvantaged." Two of the six remaining students had IQ scores of 84-93, technically above the range for classification as EMH.

Previous studies, based on total scores on the instrument rather than classification by developmental level, indicated a substantial positive relationship between cognitive level and performance. Based on this refinement in scoring procedures the relationship increases strikingly. One example, shown graphically in Table 5, serves to illustrate.

TABLE 5

Reduction in Sample Size and Results of Unit 2 Performance by Developmental Level



Unit 2 Standards: 75% of students score 16 points or more
Unit 2 Test: 6 items, each scored 0, 3, or 5; total possible: 30 points.

Statistics:	mean	s.d.
Total group (N=119)	22	6
Preoperational (N=34)	17	7
Concrete + (N=85)	24	4

Of the 202 children in the sample, 160 were in a field test group testing Unit 2 of ME AND MY ENVIRONMENT, and data are available on 119 of these students.* Six items, each scored 0, 3, or 5, were used to assess understanding of Unit 2. The curriculum developers had set the minimum standard for successful performance as 75% of the students scoring 16 points or more (out of a maximum possible score) on the items. In the test, 85% earned 16 or more points; the mean for the total group was 22, standard deviation, 6. Eighteen of the total group of 119 (15%) scored below 16 points. Of these

*Because the curriculum was tested by two field test groups, performance data is available for only a portion of the sample of 202 students. As the data were collected periodically rather than all at one time, the sample was reduced further by absences and missing data.

18, 16 were classified as preoperational. It should also be noted that more than 50% of the students classified as preoperational evidenced successful performance, with 35% scoring at or above the total group mean. Only 2% of those students at concrete operational levels or above exhibited unsuccessful performance. The reader is reminded that IQ and age explained none of the variance in performance.

Beyond the implications for the utility of measures of developmental level, these results also suggest that the experimental curriculum was well designed for this population of children to understand.

Turning to the distribution of children at each cognitive developmental level (Table 4), how does this information and the comparison with normal children inform us? The existence of 2 1/2 times as many children at the preoperational level even two years later than normal children is not unexpected. If the data were available and the change in development constant, it would not be too surprising to find two-thirds of 12-year-old EMH children at the preoperational level. At the other extreme, finding almost no children in special classes at the formal operational level seems just what one would expect.

What is striking and gives pause for reflection is the proportion of children in both regular and special classes at the concrete operational level of development. There seem to be as many implications in this finding for grouping and instruction in regular classes as in special classes.

Implications

Let us return to our original questions and recast them in more general terms:

---What are appropriate and realistic educational expectations for children?

---What is the utility and relevance of various means of identifying and grouping children?

Regarding the first issue, the theoretical model for curriculum development that is least represented in curricula in use is a developmental model. Most curricula reflect the transmission-of-the-culture model which holds that there is an important body of content that all educated persons should know. Learning is equated primarily with knowing facts and the curriculum designer's task is primarily when and how such content should be presented. The expectations held about the cognitive operations that will be performed on this content at every grade level are heavily weighed with abstract logical thinking---formal operations. From first grade on in most curricula can be found demands to categorize, generalize, recognize and use multiple relationships, infer cause and effect, etc. Accumulating evidence suggests such expectations are inappropriate. Piaget's theory would have the curriculum developer's tasks be to study the cognitive operations children at various levels can perform and to design materials appropriate to these levels, structured to support and encourage each individual's development rather than mere information acquisition.

Regarding the second issue, current means of identifying and grouping children utilize a static model (IQ) that assumes little or no change in a child and a relatively constant rate of development. Thus, a low IQ is forever and implies a slow rate of learning and low level of understanding. Piaget's theory involves a dynamic model in which all children develop and change at varying rates and times. Level of understanding is tied to the developmental level rather than reflecting the maximum potential the individual has. There are definite activities which are appropriate for specific stages of development, but a variety of content can serve as a vehicle.

The recent trend toward "mainstreaming"---placing academically unsuccessful children back in regular classes and attempting to meet their needs through the regular teacher and resource teachers---ignores grouping as a solution. In light of large differences in cognitive level in regular and special classes, this solution seems to be no solution at all.

The finds of this study and the series of studies which preceded it suggest the following implications:

(1) Measures of developmental level seem a more appropriate basis than IQ for a variety of educational programming decisions.

(a) Developmental level measures might prove to be a more effective means of grouping children than IQ.

(b) Developmental level measures might direct instructional programming to enhance learning, or at a minimum indicate which are realistic versus inappropriate activities and expectations for particular children.

(c) Developmental level measures might remove or at least reduce the stigma of labels such as retarded, by emphasizing that development is still expected to occur, albeit at a slower than normal rate.

(2) Children currently placed in special classes for the retarded are there for a variety of reasons. Evidence from this series of studies suggests that up to 40% of these children may be inappropriately placed. Even those aptly identified as mentally retarded exhibit a variety of functional abilities and disabilities not adequately assessed by any instrument. The sorting of children first by developmental level, a focus on cognitive functioning

overriding age, IQ, and information acquisition (achievement test scores), should benefit gifted as well as marginally retarded students. Programming could reflect the nature of activities taught, rather than merely pace or level. It appears that a sizeable proportion of "normal" children could also profit from such programming.

(3) The most far-reaching implications of this series of studies have to do with curriculum development and teaching strategies. It is entirely possible that most existing curricula make unwarranted assumptions about what children at a particular grade level can be expected to understand---even if they can "successfully" parrot the desired responses on tests. Certainly, almost no curricula have been designed on a developmental model---they are based on an information transmission model. Given a reportoire of activities appropriate to various developmental levels, it is an open question whether teachers could respond to students' performance in appropriate ways, as their teaching is also a reflection of the information transmission model.

As Piaget has pointed out in To Understand is to Invent, the concept of development entails much more than the cognitive domain. It includes social and moral development and blossoming of the total personality. An understanding teacher as well as an enlightened pedagogy guided by theory is necessary for encouraging such development to the fullest. The present series of studies should not be misinterpreted merely to advocate the substitution of one means of measuring and labeling children for another. Such measures are needed to learn more about children and instructional efforts. The next step in this avenue of exploration might be to answer these questions:

How do the content and type of performance assessed relate to measures of developmental level? How does successful performance in various subject areas utilizing various instructional approaches relate to measures of developmental level?

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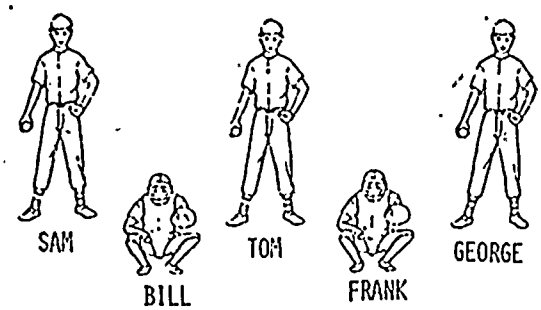
APPENDIX A

9. COMBINATION (CONCRETE 2; INCLUDED IN FORMAL VARIABLE)

A BASEBALL MANAGER HAS THREE PITCHERS (SAM, TOM, AND GEORGE) AND TWO CATCHERS (BILL AND FRANK). THE MANAGER WANTS TO FIND THE BEST PAIR OF PITCHER AND CATCHER.



IF EACH PITCHER AND EACH CATCHER IS TO BE GIVEN AN EQUAL CHANCE, HOW MANY PAIRS OF PITCHER AND CATCHER MUST THE MANAGER FORM?

- [ ] 2
- [ ] 3
- [ ] 5
- [ ] 6

1973 EMH	11%
1974 EMH	12%
REGULAR CLASS	38%

NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

11. COMBINATION (FORMAL 1)

FOUR GIRLS ARE GOING TO PLAY CHECKERS WITH EACH OTHER. IN ORDER TO FIND THE BEST PLAYER, EACH GIRL WILL PLAY EVERY OTHER GIRL.

HOW MANY GAMES MUST BE PLAYED IF EACH GIRL IS TO PLAY EVERY OTHER GIRL?

- [ ] 1
- [ ] 4
- [ ] 6
- [ ] 8

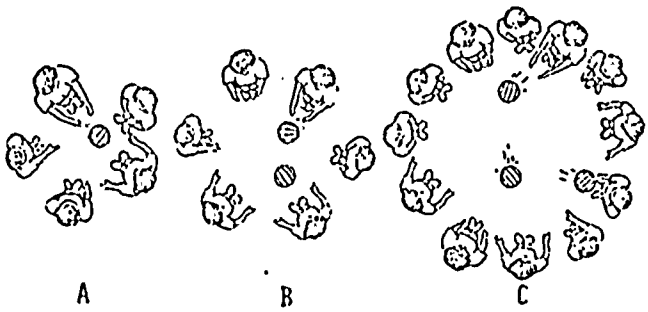
1973 EMH	11%
1974 EMH	11%
REGULAR CLASS	35%

NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

14. PROPORTION (FORMAL 1)

DURING RECESS, THREE SEPARATE GROUPS OF CHILDREN WERE FORMED TO PLAY BALL, AS THE PICTURES SHOW. GROUP A WAS MADE UP OF 5 CHILDREN AND 1 BALL. GROUP B WAS MADE UP OF 6 CHILDREN AND 2 BALLS. GROUP C WAS MADE UP OF 12 CHILDREN AND 3 BALLS.



WHICH GROUP OF CHILDREN WOULD IT BE BEST TO JOIN IF ONE WISHED TO CATCH THE BALL MOST OFTEN?

- [ ] GROUP A
- [ ] GROUP B
- [ ] GROUP C

1973 EMH	12%
1974 EMH	17%
REGULAR CLASS	38%

THERE IS THE SAME CHANCE OF CATCHING THE BALL IN EACH GROUP.

NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

15. SERIATION (FORMAL 1)

OCTOBER 23

1973 EMH	28%
1974 EMH	41%
REGULAR CLASS	64%

3 WEEKS LATER

JOE PLANTED A FLOWER ON OCTOBER 23. HE MEASURED HOW TALL IT WAS. THREE WEEKS LATER HE MEASURED IT AGAIN TO SEE HOW MUCH IT HAD GROWN. WHAT DATE WAS IT AT THE END OF THREE WEEKS?

CIRCLE THAT DATE ON THE CALENDAR.

OCTOBER

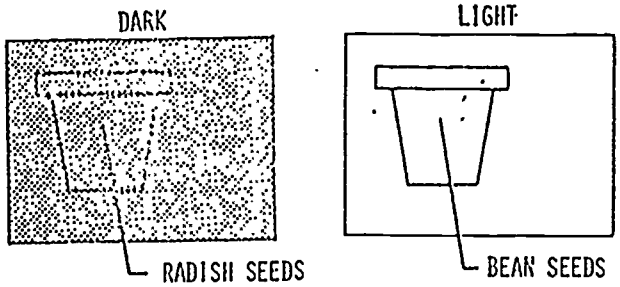
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

NOVEMBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

1B. EXCLUSION (CONCRETE 2; INCLUDED IN FORMAL VARIABLE)

TOM WANTED TO FIND OUT WHETHER PLANTS CAN GROW BETTER IN THE DARK OR IN THE LIGHT. HE PUT A POT WITH 6 RADISH SEEDS IN A DARK ROOM AND A POT WITH 6 BEAN SEEDS IN THE LIGHT ON THE WINDOW SILL.



HE ADDED THE SAME AMOUNT OF WATER TO BOTH POTS. THE BEAN SEEDS GREW BETTER THAN THE RADISH SEEDS, SO TOM SAID HIS PLANTS GROW BEST IN THE LIGHT.

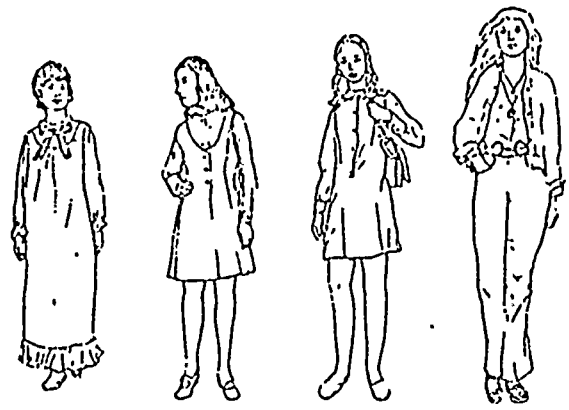
TO BE ABLE TO SAY THIS, TOM SHOULD HAVE DONE WHAT?

- WATERED BOTH POTS MORE.
- WATERED THE RADISH SEEDS MORE.
- PUT THE SAME KIND OF SEEDS IN BOTH POTS.
- GROWN THE SEEDS IN WATER INSTEAD OF SOIL.
- I DON'T KNOW.

MARK AN X ON YOUR CHOICE.

1973 EMH	42%
1974 EMH	48%
REGULAR CLASS	71%

17. EXCLUSION (CONCRETE 1)



MARY IS SHORTER THAN ANN.

ANN IS SHORTER THAN SUSAN.

SUSAN IS SHORTER THAN KATHY.

WHICH ANSWER IS CORRECT?

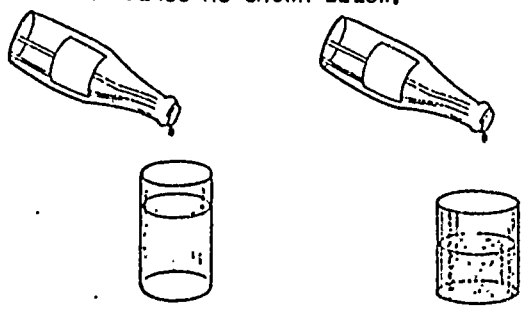
- MARY IS SHORTER THAN KATHY.
- KATHY IS SHORTER THAN ANN.
- SUSAN IS SHORTER THAN MARY.
- ANN IS SHORTER THAN MARY.
- NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

1973 EMH	48%
1974 EMH	59%
REGULAR CLASS	75%

20. TRANSFORMATION (CONCRETE 1)

SUE AND KAREN WANTED A BOTTLE OF ROOT BEER. THEIR MOTHER POURED ONE BOTTLE INTO A TALL SKINNY GLASS AND THE OTHER BOTTLE INTO A SHORT FAT GLASS AS SHOWN BELOW.



DOES ONE GLASS HAVE MORE ROOT BEER IN IT THAN THE OTHER?

- THE TALL GLASS HAS MORE IN IT.
- THE SHORT GLASS HAS MORE IN IT.
- THEY BOTH HAVE THE SAME AMOUNT.
- I DON'T KNOW.

MARK AN X ON YOUR CHOICE.

WHY DID YOU CHOOSE THE ANSWER YOU MARKED?

1973 EMH	32%
1974 EMH	32%
REGULAR CLASS (with conserving explanation)	53%

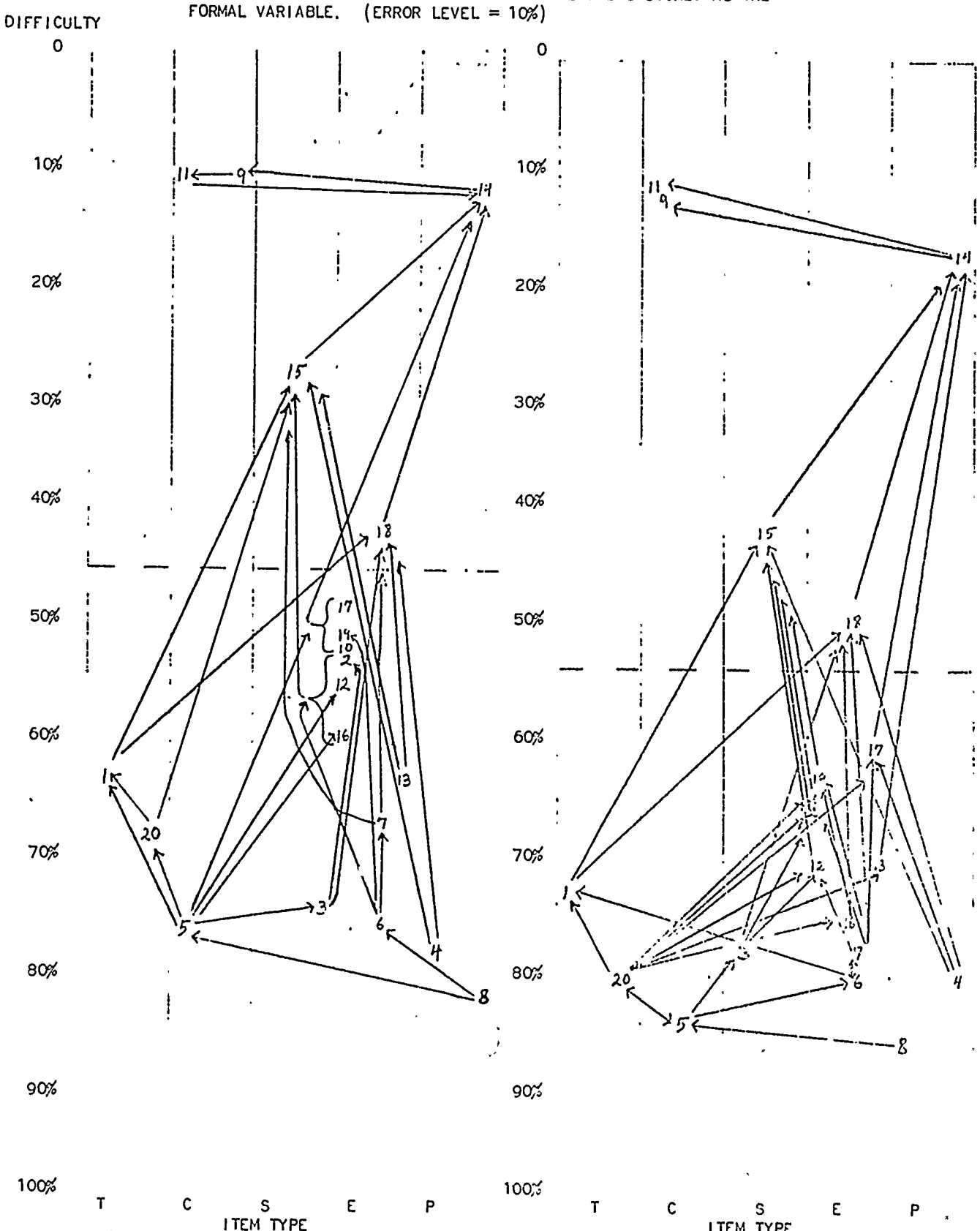
APPENDIX B

HIERARCHICAL ANALYSIS OF EMH STUDENT RESPONSES ON 1972-73 TEST*

NUMBER OF ITEMS: 20 NUMBER OF SUBJECTS: 202

GRAPHIC DISPLAY OF ITEM RELATIONSHIPS BY DIFFICULTY LEVEL AND ITEM TYPE. (T = TRANSFORMATION, C = COMBINATION, S = SERIATION, E = EXCLUSION, P = PROPORTION)

ITEMS ABOVE THE DASHED LINE ARE THE FIVE ITEMS SCORED AS THE FORMAL VARIABLE. (ERROR LEVEL = 10%)



*ORDEPING ANALYSIS PROGRAM BY WILLIAM M. GRAY, FOUNDATIONS OF EDUCATION, UNIVERSITY OF DAYTON.