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ABSTRACT

The performance of children on problem-solving tasks 8 years after their participation in an early education intervention was compared with that of children who did not receive the intervention. At the time of the outcome assessment, all subjects (n=60) were in middle school. One group of the subjects was selected from the middle school students in a school system in a northeastern industrial city who had attended the school system since kindergarten; the other subject group had been selected when in kindergarten to receive an intervention based on a task analysis of curricula into steps necessary for mastery of the activity. It had previously been shown that the treatment group scored at a significantly higher level on standardized achievement tests than did a comparison group drawn from the same pool of at-risk kindergarten students. Three problem-solving tasks from Piagetian and mathematics curriculum research were administered. The performance of both groups was comparable with age-related results in the literature, but the treatment group surpassed the other cohort on two of the three tasks. Every subject in the treatment group solved at least one task; 11 of the cohort group solved none. Implications for the teaching of learning strategies are discussed. The instructions for the tasks, some task diagrams, and four tables of results are included. (SLD)

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Long Term Outcomes of an early Intervention: Performance on Three Problem-solving Tasks

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This study presents and discusses one portion of the results of a long term outcome study that assessed the effects of an early education intervention. The intervention, based on the task-analysis of kindergarten curricula, was designed for children who were identified as at-risk for learning problems. There were two general purposes of this study. The first was to assess the degree to which children in the task analysis intervention group made normal progress over eight years in school, as measured by standardized tests, in comparison with a contrast group of at-risk kindergarten children (cohort I) and a randomly sampled middle-school group (cohort II) who did not receive the intervention. The second purpose was to examine the performance of children in the task analysis group on three problem-solving tasks, eight years after the intervention, in comparison with Cohort II and with results of previous research studies with similar tasks. It is the second purpose that is the focus here.

Subjects:

Three groups of subjects (N = 77) from a Northeastern industrial city (Pop. 70,000) were selected for the study, two at kindergarten age and one sample at middle school age for another sample treatment with the outcome study. Two of the subject groups had been initially selected from an at-risk kindergarten population identified by The Jansky Screening Index as follows: a treatment sample drawn from two schools, and Cohort I, randomly selected from the remainder of the at-risk pool. In order to assess treatment sample functioning in middle school in comparison with their peers, the third group, Cohort II, was randomly selected from the entire pool of middle school students who had attended the school system since kindergarten. At the time of the outcome assessment all were middle school students (grades 6-8). Scores of Cohort II were comparable with the treatment group on the Metropolitan Reading Readiness Test and the Gates-MacGinitie Reading Test following kindergarten and first grade. There were no significant single variable differences among all three groups with respect to background variables (age, sex, ethnicity race,parental marital status, group IQ score - CAT).

Procedures:

The kindergarten intervention was based on task analysis of curricula into steps necessary for mastery of the activities. Classroom and special education teachers together developed instructional strategies stemming from these analyses. In the post-treatment, first, third, fifth, and seventh grade outcome assessments, the treatment group scored at a significantly higher level ($p<.01$) on all standardized achievement tests than the cohort I group.

In the long term project, A specific problem-solving study was carried out when the **treatment** subjects were in seventh and eighth grade. Three problem-solving tasks from the Piagetian and mathematics curriculum research literature were individually administered in random order to both the **treatment** and **cohort II** groups (N=60). Each of the tasks requires the subject to select the variable that solves the problem, make judgments about it, and to exclude other variables. The Plants Task and the Sick and Healthy Man Task were originally designed to be less academic types of adaptations of the Inhelder-Piaget (1958) tasks which resembled chemistry and physics experiments (Kuhn et al, 1977; Neimark, 1975). The Topology Task was taken from sixth grade enrichment mathematics curricula (See the attached problems and instructions.) Although both subject groups' performance were comparable with age-related results in the literature, the **treatment** group surpassed the **cohort II** group on two of three problem-solving tasks, (chi square association $p<.05$). Every individual in the treatment group solved at least one problem, whereas eleven of the cohort group solved none.

Discussion: Learning strategies and task context

Although postulating long term relationships among factors from the time of kindergarten to the middle school must be speculative, several points about the effectiveness of this intervention are nevertheless notable. The influences of specific learning strategies and context on children's problem-solving have been of particular interest to psychologists and educators. Research in recent years with students having learning disabilities has indicated that many do not use efficient or thoughtful strategies in educational tasks (Torgeson, 1982; Wong, 1982). Such children have also been described as less actively involved in their own learning processes (Kavale & Forness, 1986). Students receiving the intervention repeatedly progressed through numerous task sequences that essentially were problems-to-be-solved. Although it would be difficult to determine whether or not those kindergartners learned to approach tasks with a step-by-step strategy, the consistent and active approach to tasks in the classroom in itself may have helped the students to learn task-mastery and learning strategies.

Two likely notions concerning the teaching of learning strategies and problem-solving arise in consideration of the task sequences from the intervention. The overriding notion could have been the daily instruction and emphasis in the task-analysis program on attention to the task. Teaching step-wise and recording observations required teachers and students to stay with the task at hand, whatever the content. If the task-analysis students learned this strategy, the process could have been reinforced continuously through the grades with each task mastered by the students. Attention to the problem-solving tasks in this study was probably the primary component in solving them. In retrospect, and in light of the results, a specific measure of attention to task would have been useful for this study.

The other notion concerns the emphasis that was placed on sorting and categorizing in the intervention. These activities involve a constant process of testing the logical possibilities of combining and changing sets and categories of sets, as well as a growing acculturation to what comprises a set of X in one's portion of a culture. The students were also required to justify their categories, to consider verbally why certain items might go together. As cited earlier from Winocur (1981), developing sets and trying- out categories are basic early tenets of logical thinking. Specific tasks in these areas may not have continued for the task-analysis group after the intervention, and the question arises of whether the skills persisted or transferred onto others which were practiced and reinforced. Conceivably, mathematics instruction provided such transfer and practice for these students, beginning with combining sets ard then subtracting sets.

Another explanation, more exploratory and hypothetical, for the positive performance of the task-analysis group is that they are particularly able to do logical thinking tasks in the <u>context of an individually administered task</u>. One of the lowest students in standardized test achievement received the highest possible rating on two out of three of the tasks. She has worked individually with a special education teacher for eight years, while also attending her regular classes. Although she scored just over the lowest quartile in reading, her response to the Plants Task was easily verbal (note that the tasks did not require any reading). The subject looked closely at the tray of materials for about 20 seconds:

> Oh yeah, it's this dark-colored plant food because these two had it and they are healthier. Easy.

Experimenter: Did the leaf lotion have anything to do with it?

Subject: It could (pause). I don't know. No? No, because otherwise this one (unhealthy plant with leaf lotion) would look better. Right? This is fun.

This subject was correct in including the correct variable and excluding incorrect variables. On the Sick and Healthy Men Task she said:

Maybe the healthy ones with germs are going to feel sick and these (sick men with germs) did have the germs, but they're getting better.

Experimenter: How do you think this happened?

Sub.: It can't be a cold because they are germs. It could be something they (sick men without germs) ate or maybe they got too much sun.

Experimenter: What happened here (healthy with germs)? Why do they still have germs?

S: That's hard. Maybe they already took medicine to feel better but the germs are still there.

The subject understood and used cause and effect, here, realized germs cause disease (Ss were asked about this if they did not volunteer the knowledge) and tried out plausible hypotheses. This subject stayed directly with the parameters of the tasks, whereas many subjects brought in extraneous ideas to try for solutions. Several subjects suggested that the experimenter jostled or bumped the two unhealthy plants, or the soil was different to begin with, or that a doctor did an incorrect blood test on the Sick & Healthy Men task. Such responses were categorized as pre-formal operational thinking.

Another student with learning disabilities, who is achieving at average levels, also responded correctly. She was among the youngest of the subjects at 149 months.

S: Obviously, it's the dark-colored food.

Exp.: Why do you say that?

S: You gave to these two healthy ones and the others with the other food don't look so great.

Exp: What about the water? Is that important?

S: No, it's different sizes for the healthy ones.

Exp: And the leaf lotion?

S: No.

Cole and his colleagues (Sharp, Cole, and Lave, 1979) continually have challenged the traditional views of measures of achievement and development in education and elsewhere. One of the basic questions they have asked is: "How is the measurement affected by the context?" If they observe subjects performing the same task in different settings, they try to uncover the overriding validity of the task. Although most often working in cultures other than the U.S., they recently took this process of task examination to study adolescents with learning disabilities, in an attempt to try to present similar tasks in different settings (Cole & Traupman, 1981). Cole and Traupman observed adolescents proceeding through a recipe (a quintessential task analysis) and compared that performance with other modes of task performance. They found that some characteristics (word recognition and reproduction) were difficult for these subjects, but others (reading the recipe, measuring amounts of flour and milk) were performed correctly, better than other students in the class. Something about the context of the task allowed for their comparative success.

While the students with learning disabilities were doing the problem-solving tasks they appeared to be comfortable with the experimenter and the tasks, by and large, and undertook the process with concentrated focus on the tasks. Their attending capability could be an artifact of the years of individual work with a special education teacher [one student, clearly accustomed to special education service patterns, asked the experimenter if he was now supposed to see her every day at the same time].

Qualitatively, this immediate attending was not as true of some other subjects. One potential reason for this behavior is that the task-analysis intervention students had become accustomed to success with individual task performance, even if they were less successful with group tests or classroom group performance. Neither the cohort II subjects nor treatment subjects who were not later individually taught necessarily had developed an effective capability to use an individual-experimenter situation. In fact, these latter subjects may have felt more at ease with school-type tasks or tests than with the problem-solving tasks. It would be interesting to test the effect of task context in both individual and group administration to see if this is a performance factor on such tasks.

The Problem-Solving Tasks and Cognitive Development

In the case of putting together all the problem-solving tasks in this study, the percentage of the total sample that showed evidence of using the isolation of variables thought process was consistent with a broader developmental trend. The early adolescent subjects were at the same age range at which other studies had found transitions to aspects of hypothetico-deductive thought, "formal operational" aspects in Piagetian terms (Kuhn et al, 1977, 1979; Neimark, 1975).

As in the studies from which these two tasks were taken, there is evidence in the total task-analysis intervention group and cohort II of developing cognitive capabilities. Over 60 % of the total treatment and cohort II group were displaying formal operational thought on these tasks, where previous research studies ranged from 50% - 75% for subjects on these and similar tasks.

The discussion of problem-solving presented here is intended to be suggestive, to stimulate future study in the teaching of learning strategies to children, early in their school careers. The conclusion must also be cautionary concerning task context and validity. Research should learn more about the effects of context and situation in their many dimensions, and to begin to describe these effects in detail. This is an ideal notion for research in practice: studying learners within the context of everyday learning.

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Instructions for Tasks

1. Materials for the Plant Task

a. four live plants, two healthy-looking and two unhealthy looking;

b. two dishes of dark-colored plant food and two dishes of light-colored plant food;

c. two small and two large glasses of water;

d. two bottles labelled "leaf lotion".

The variables are the following: two amounts of water applied; two types of plant food (dark and light); and presence or absence of leaf lotion. The presentation is verbal, without a training session. The subject is asked to determine what causes the conditions of health or lack of health in the plants. All conditions are mixed except the plant food. Dark plant food is next to the healthy plants, and light food is next to the unhealthy plants. To solve the problem, the subject must include the plant food variable as the solution, and the other variables must be excluded.

2. Sick and Healthy men task

The intention of this task is to determine whether the individual is able to isolate one logical solution to a presented problem. In this case, the subject is presented with sixteen similar drawings of men's faces, eight of whom are obviously healthy, and the other eight obviously unhealthy. On the back of the pictures, a representative blood sample of each of the men is depicted. Six of the sick men indicate a blood sample with germs and two indicate nothing (blank cards). The subjects are asked to explain the situations. If subjects do not volunteer, the experimenter first asks questions concerning general causes of disease and health and then becomes more specific if the subject does not produce evidence of a possible solution.

Initially this task was introduced as a reliability check for the plants task. The topology task's reliability was checked by an althernate form, another series of designs. The sick and healthy men task was incorporated into the experimental procedure because, while the inter-task reliability was high (.88), the task also provided more information about the subjects' performance. Also, overall the subjects found the task interesting.

3. Topology task

Essentially, topology is the study of properties that are not structurally changed by rotating, shrinking, enlarging, or stretching (as different from changing the size of angles). The problem to solved is whether the path of a plan can be followed without going back over any one path. However, to solve the problems of a series of designs, including those for which the path cannot be successfully followed, the number of paths converging at each intersection of paths must be counted. For a path to be followed, and not returned upon, there may be no more than two odd intersections. Two pre-tests are given to ensure that training has been accomplished, or to provide for subject-exit (all subjects in this experiment passed the pre-tests). A series of ten networks are then presented to each subject. Each is instructed to follow the path of the networks and count the intersecting lines at each intersection. The subjects' observations on each network are recorded for the subject's use. These records are kept as data by the experimenter. The experimenter gives a maximum of one helping prompt for each incorrect count of intersecting lines (N.B. the object of the problem-solving is not to determine a counting skill), The correct solution to this problem requires both the subjects' observations and their recorded data concerning the number of odd and even intersections at each network's vertices. If they have not volunteered their observations, the subjects are asked to conjecture about wny the path of a network can or cannot be followed.

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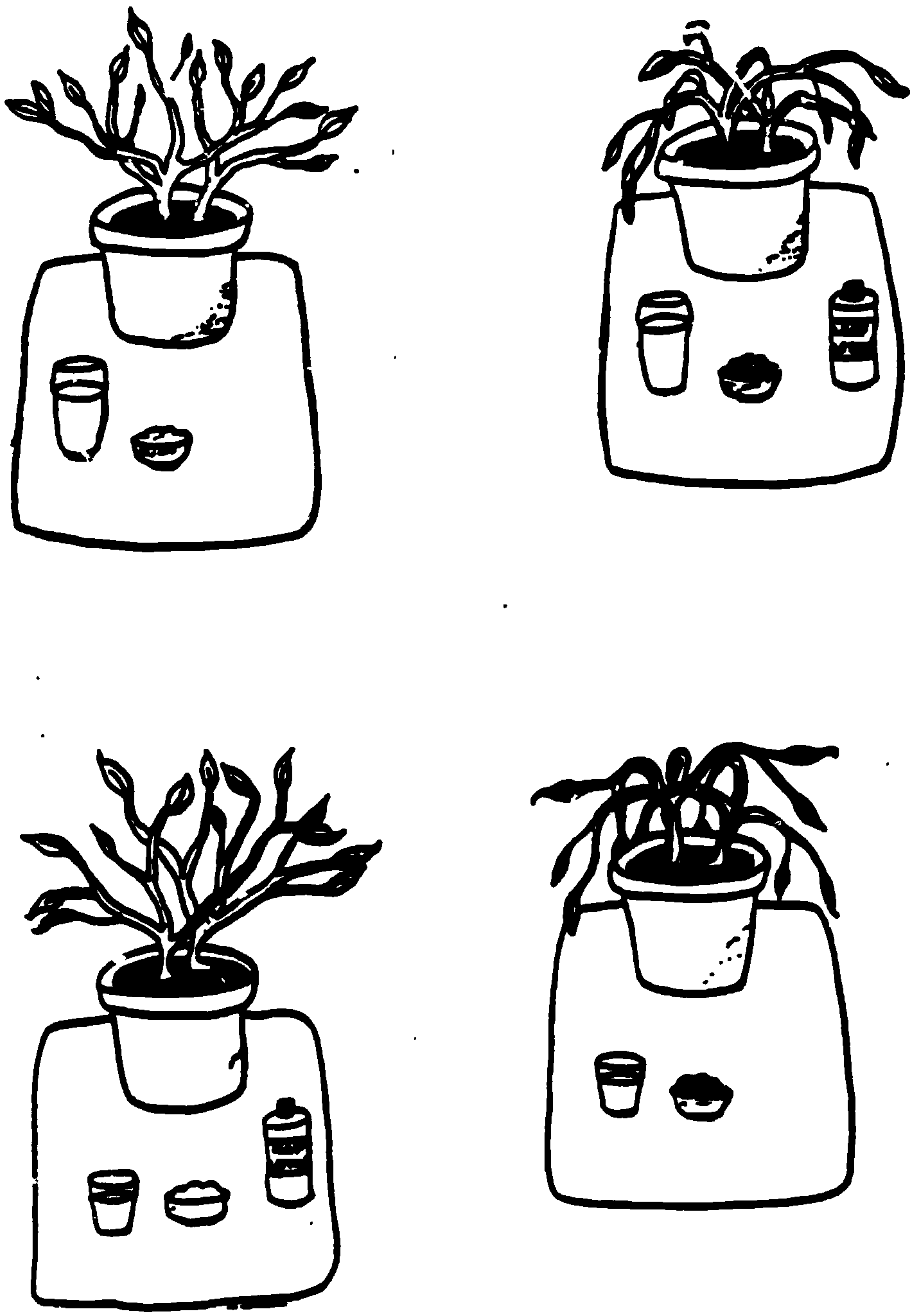

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LONGTERM RESULTS

Differences among means were significant ($p < .05$ at post 1st grade and $p < .01$ at all others) at every data collection point between the task analysis intervention group and the original contrast group: kindergarten, first grade, third grade, and fifth grade.

Summary Statistics of Achievement Tests

First Grade to Seventh Grade

Ns, Xs, and Standard Deviations for the 3 Groups

First Grade Gates Macginitie Reading Test

	N	X	s.d.
Task analysis	25	50.77	8.3
Contrast	23	42.80	7.6
Current Cohort	30	49.83	7.2

Summary Statistics

Third Grade Iowa Tests of Basic Skills Composite

	N	X	s.d.
Task analysis	30	107.73	7.7
Contrast	14	98.64	10.23
Current Cohort	30	106.13	9.22

ITBS Reading: Third Grade Scores

	N	X	s.d.
Task analysis	30	106.73	8.73
Contrast	27	99.41	7.75
Cohort	30	105.67	8.76

Fifth Grade ITBS Composite

	N	X	s.d.
Task analysis	30	134.80	12.89
Contrast	22	122.27	12.00
Current Cohort	30	131.07	11.64

Seventh Grade ITBS Composite

	N	X	s.d.
Task analysis	30	160.23	17.37
Contrast	14	143.20	16.48
Current Cohort	30	156.63	23.26

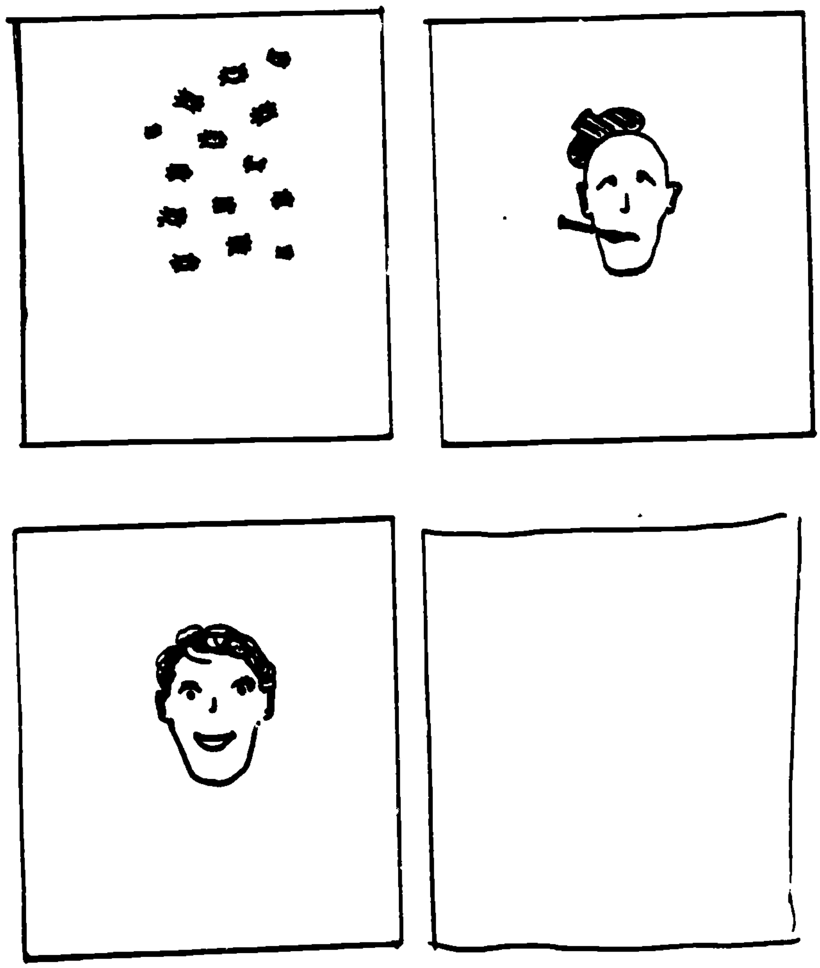
THE THREE GROUPS AT SEVENTH GRADE

Descriptive Statistics

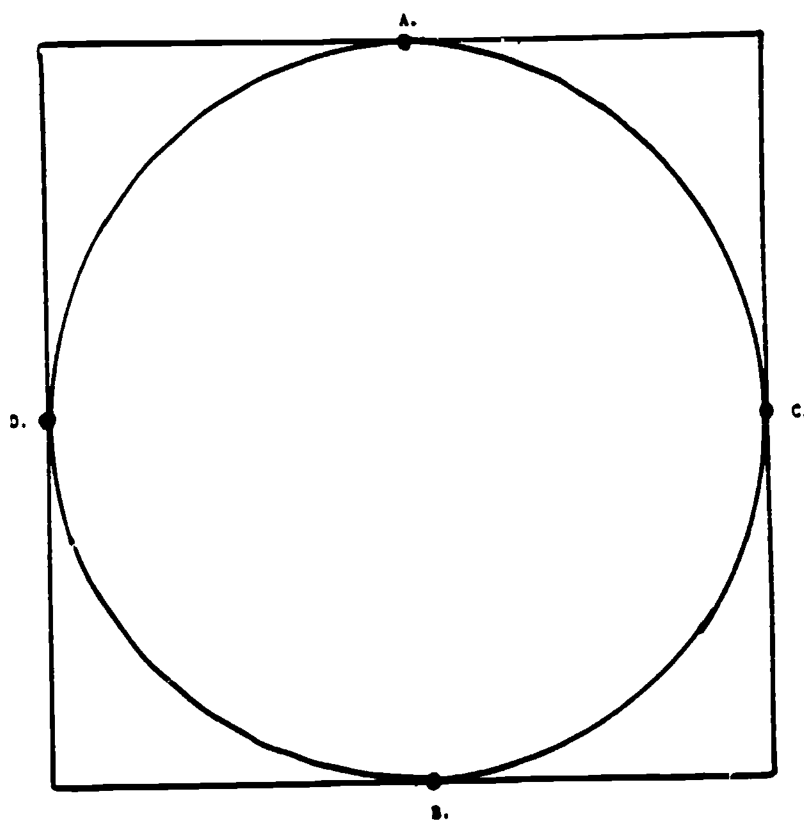
	T-A N=30	Contrast N=17	Cohort N=30
Age (Months)	158.2	157.4	161.4
Males	57%	53%	63%
Black	20%	29%	23%
Hispanic	13%	6%	7%
White	47%	65%	70%
Special Education[1]	27%	41%	17%
2-Parent Home	73%	65%	70%
Cognitive Abilities Tests			
CAT Verbal[2]	101.00	94.72	102.07
CAT Non-verbal	98.27	94.00	100.17
CAT Quantitative	101.37	90.83	100.43

[1] Does not include speech defects, gifted, or tutoring

[2] All single variable statistical differences non-significant (p<.05)



Pre-Test #1



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Pre-Test #2

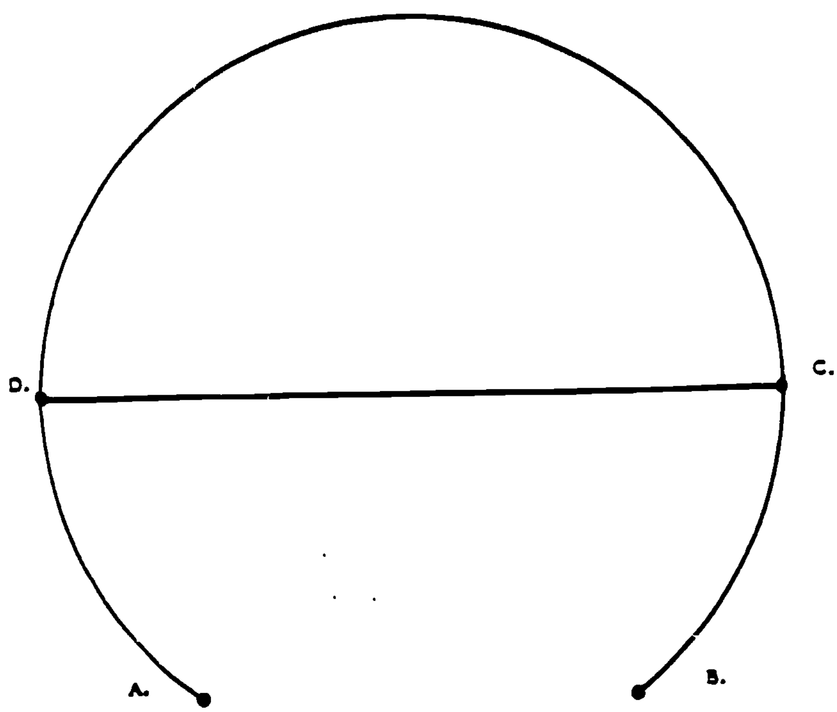

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Table 15

Percentage of Subjects with Isolation of Variable Process

	Grade	Sick/Healthy Task	Plants Task
Neimark (1975)	7 & 8	45-50%	——
	bright 7 & all 9	75%	
Kuhn & Brannock (1977)	5	——	50%
	6	——	75%
Rothenberg	7 & 8	63%[1]	65%[2]

[1]Task-analysis = 80%; Cohort = 47%

[2]Task-analysis = 77%; Cohort = 53%