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ABSTRACT

Ninety-one hearing-impaired students entering Gallaudet University received systematic cognitive instruction focusing on specific generalizable skills, in the contexts of their regular college classes. The students were given practice in skills of organization, comparisons, analysis, classification, following instructions, temporal relationships, sequencing, and logic, using a program called "Instrumental Enrichment." Pretest-posttest procedures for the experimental subjects and 91 control students indicated that the instruction produced significant improvement on Raven's Matrices and on the Reading Comprehension, Math Concepts, and Math Computation sections of the Stanford Achievement Test--Hearing-Impaired. No significant improvement was found on a writing sample, a University reading test, and a self-administered survey of the ways in which students saw themselves as thinkers. A formative evaluation of the project showed that administrative problems existed in conducting this type of intervention in a collegiate environment, but also showed some additional benefits of the cognitive instruction: students began to demand more elaboration, to become more careful in checking for error in their work, and to ask for verification from each other on points made during classroom discussion. Recommendations for expansion of the cognitive skills instruction program and recommendations for researchers are offered. (Author/JDD)

Improving Cognitive Skills of Hearing-Impaired College Students

Final Report

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Field-Initiated Research Project

IMPROVING COGNITIVE SKILLS OF HEARING-IMPAIRED UNDERGRADUATES

Final Report

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ABSTRACT

This project was built on the serious need for active programs in improving the cognitive skills of hearing-impaired college students. Ninety-one entering students at Gallaudet University were identified as experimental students, and were matched with 91 students as controls for the experiment. Experimental students received systematic cognitive instruction focusing on specific generalizable skills during the experimental period, several times per week, in the contexts of their regular college classes. Instructors of the experimental group were given special training over a two-year period in the methodology of the program, Instrumental Enrichment. Experimental students were given practice in skills of organization, . , comparisons, analysis, classification, following instructions, temporal relationships, sequencing, and logic. Experimental and control students were given pre- and post-testing with the Stanford Achievement Test Hearing-Impaired (SAT-HI), the Raven's Matrices, a systematically analyzed writing sample, a University reading test, and a self-administered survey of the ways in which students saw themselves as thinkers. Demographic data were collected on all subjects in relation to age of hearing loss, level of hearing loss, and gender.

Evaluation results indicated that cognitive instruction of this nature produced statistically significant improvement for experimental subjects in expected directions on the Raven's Matrices, and the SAT-HI test (Reading Comprehension, Math Concepts, and Math Computation). A relatively high rate of attrition was noted in the sample groups and may have prevented statistically significant differences on other measures.

A formative evaluation supported the administrative problems in conducting this type of intervention in a collegiate environment, but also showed some additional benefits of the cognitive instruction for students: a process analysis of interviews with individual experimental students and their instructors indicated that students began to demand more elaboration, to become more careful in checking for error in their work, and to ask for verification from each other on points made during classroom discussions.

Recommendations were made for the expansion of systematic cognitive skill instruction in universities; systematic training of college instructors was concluded to be a fundamental prerequisite for the implementation of such programs. It was further recommended that researchers investigating the effects of cognitive education in college settings must anticipate the problems of student attrition and mobility by seeking large sample sizes for their evaluation studies.

PURPOSE

Background

Results of recent National Assessment of Educational Progress Tests (NAEP) indicate that students on a national level are faltering in problem-solving skills. More specifically, instructors who work with hearing-impaired students at Gallaudet University frequently express deep concern and frustration about some of their students' serious deficiencies in problem-solving skills, and in understanding and manipulating higher order concepts and abstractions, as indicated in both classroom and written work. The concern often relates to difficulty with such critical cognitive skills as: manipulating more than one variable, conceptualizing what a textbook or journal author is saying, forming conclusions, dealing with hypothetical data, and spatial reasoning.

Yet, research with hearing-impaired persons has documented that no basic inherent malfunctions are present in the cognitive abilities of that population and that any inferiority in cognitive performance may be accounted for by experiential and linguistic deficits as well as by communication handicaps (Levine, 1976, 28). Compounding the problem, many instructors themselves have had little or no formal training in cognitive operational thinking, either as part of their own training or as a subject for teaching (Passow, 1980, 399).

During recent years, however, a specially developed program entitled Instrumental Enrichment (Feuerstein, 1978) has become available in the United States, developed by the Israeli Piagetian scholar, Reuven Feuerstein. This classroom intervention program for adolescents and adults uses content-free paper-and-pencil exercises to correct deficient cognitive functions and provide the prerequisites for learning and problem-solving. Specific skills enhanced through the program include: analytic perception, projection of virtual relationships, orientation in space, comparison, temporary relationships, hierarchical relationships, syllogistic thinking, categorization, synthesis, and sequential progression. Such a program such as this, stressing both concept formation and application, has enormous potential benefit for hearing-impaired students in college settings.

Review of the Literature

In the general field of special education, interest in "cognitive training" began to emerge in the late 1960's and early 1970's when researchers from several different orientations began to focus on self-control processes; a longer tradition exists in teaching exceptional children general and task-related strategies (Meichenbaum, 1980, 84). Among these relatively recent trends is attention to a technique called "cognitive behavior modification" (CBM), whereby the student acts in some way as his/her own trainer or teacher through self-control, self-verbalization, self-instruction, and self-reinforcement. CBM also often involves identifying a series of steps or strategies for problem-solving (Lloyd, 1980, 53). Another approach, called "strategy-training," teaches specific strategies for specific types of problems through a rote set of sub-skills and rules for combining them for a class of problems (Lloyd, 1980, 59).

A characteristic of some CBM programs is "metacognition," defined as one's cognition about cognitions, or the thinking about one's own thinking; processes involved here are: analyzing the problem, reflecting on what one knows that may be appropriate to a solution, devising a plan, and checking one's progress (Brown, 1978). Some handicapped learners have been considered to be deficient in metacognition as well as in certain academic areas.

Impulsivity is another characteristic of some learners who are achieving below their potential. Impulsive learners often lack well-developed habits of self-observation (Gutentag & Longfellow, 1977), which is related to the skill of metacognition already mentioned. Jerome Kagan's work has been significant in identifying impulsivity (versus reflectivity) as a learning style and the attendant problems that impulsivity brings. A number of teaching strategies [illegible] evolved for teaching the impulsive learner; among them, strategy-training (practice in using skills outside of a subject matter context) has been experimentally demonstrated to be effective in making the learner operate in a more reflective manner (McKinney & Haskins, 1980, 48).

Systematic intervention programs for working with the cognitive deficits of exceptional learners, then, are not new. Such techniques as those mentioned have had varying degrees of success, related to certain identified variables. For example, it has been shown that the child's concept of causal relationships influences his/her reaction to an intervention program (Henker, Whalen, & Hinshaw, 1980, 23). In addition, individual differences in language and cognitive maturity are also considered to be influences on the appropriateness and effectiveness of cognitive training interventions (Keogh & Glover, 1980, 79). One unresolved question is whether an intervention that is ineffective may be trying to <u>use</u> nonexistent prerequisite skills in the learner when it should be <u>developing</u> those prerequisites (Keogh & Glover, 1980, 81).

Intervention programs used until now have had limited success in the critical area of generalizability--the transfer and application of the skills learned through the program to other areas. One study suggests that generalizability may be limited by the strategies themselves; that is, transfer to a novel task with similar stimulus-and-response properties presents no problem, but transfer to one involving different materials and responses is often not obtained (McKinney & Haskins, 1980, 49). As the learner matures, on the other hand, generalization of training programs appears more likely, since older children are more aware of strategies available to them (Loper, 1980, 6). It appears that generalization can be enhanced if the training procedure ensures explicit feedback, and includes [illegible] in generalizing (Meichenbaum, 1980, 86).

Studies in cognition in hearing-impaired persons have also been numerous in recent years. After an initial period of research focusing on I.Q., the center of attention now is on the processes involved in cognition and perception. It appears to be generally accepted that hearing-impaired persons have the normal range of intelligence when tested on the performance, rather than the verbal, subtests of various I.Q. instruments (Drever & Collins, 1928), with the exception of students who have neurological impairments resulting from an etiology of hearing loss that has multiple effects (Vernon, 1968, 8). In a more detailed examination of hearing-impaired subjects by specific etiology of loss, however, some differentiation in performance is also found; for example, the mean I.Q. for "genetically deaf" students was reported to be 114, while that for post-maternal rubella deaf students was 95 (Vernon, 1968, 7). We also know that when the influence of age is controlled, statistical data on hearing-impaired children indicate strong relationships between achievement test scores and variables such as age-of-onset of hearing loss, cause of loss, degree of loss, additional handicapping conditions, ethnic background, and type of special educational program (Jensema, 1975). While this project will not examine all of these variables in regard to the effects of the intervention program, several will be used in the analysis of the data. Thus, a rationale is clear for examining the effects of a new intervention program within identified etiological sub-groups of hearing-impaired learners.

The relationship between language and cognition is both essential and complex; this project will focus on an intervention program which makes regular use of language as a medium. We know, for example, that using language enables us to restructure mental schemata, perceive reality in new ways, and to redesign the strategies employed to solve problems (Klein, 1981, 449). A major body of research during the past 50 years indicates that language in social interaction is critical to effective cognitive development (Vygotsky, 1962, 1978; Wertsch, 1978). The work of Halliday (1973) and Tough (1977) has reinforced Vygotsky's work and given new insights into the degree of linguistic use by children in attacking cognitive problems. Thus, it is highly appropriate that an intervention program for hearing-impaired learners in the area of cognitive development should recognize and use language in a systematic manner since, as previously noted, the linguistic deficits of hearing-impaired learners are considered to be partly responsible for some of their difficulties in cognition.

The literature on the improvement of cognitive skills in the college-age learner strongly supports the efficacy of specific and planned training in those skills. Even minimal training in cognitive strategies has resulted in long-term benefits in college-level students (Dansereau, et al., 1975). Weinstein (1977) found that the more successful college-age learners use meaningful elaboration strategies, albeit often covertly. In addition, training *per se* was found to be superior to merely giving simple instructions to college students (Weinstein, et al., 1981). Hence, the merits of specific *training* in such skills is supported (Weinstein, et al., 1980).

If we accept the fact that certain specific cognitive deficiencies do exist for hearing-impaired persons but that no evidence suggests less than the normal range of intellectual potential among them as a general group, then it is apparent that a specific program of activity in an educational setting holds significant promise for improvement of these critically important generic skills. In addition, a program which was originally developed to ... performance of disadvantaged hearing learners who had some of the same deprivation of thinking skills opportunities as hearing-impaired learners, may well be specifically the type of program which is adaptable for this special purpose.

Importance of the Study

Thus, the importance of this project is that the results will enable all educators of hearing-impaired college-age students for the first time to incorporate significant cognitive skill improvement experiences into the subject matter of their courses, thus enabling the hearing-impaired college student to acquire and apply generalizable cognitive skills.

METHOD

The Intervention Program

Educators are currently expressing interest in improving thinking skills in the classroom. A recent issue of the Volta Review devoted two articles to encouraging teachers of hearing-impaired students to develop their own cognitive skill training programs and explains some guidelines for so doing (Cole, 1980, 344). Furth, after concluding from research that hearing-impaired students need practice in thinking and reasoning, wrote a book on "thinking games" based on Piagetian tasks and theory (Furth & Wachs, 1974). Other existing school programs such as the Peninsula Oral School approach have focused on sequences of cognitive strategies or tasks for hearing-impaired students, leading through concept formation, interpretation, inference, generalization, and application of principles (Levine, 1976, 54). With such clearly expressed need and interest, an already-formulated program which is thoroughly tested would seem most timely and would not require college instructors to develop their "own" products.

Such a program is Instrumental Enrichment, developed originally in Israel by Reuven Feuerstein, a student of Piaget, in response to the need for mediated learning experiences (MLE) for culturally disadvantaged groups emigrating to Israel. Mediation is that activity in which a person assists a learner in interpreting experience and in learning strategies for problem-solving. Feuerstein observed that a disproportionately large number of adolescents among certain immigrant groups (for example, Moroccan Jews) were being classified by the Israeli school system as "mentally retarded." In response to this observation, he developed the Learning Potential Assessment Device (LPAD) as a means of precisely identifying the potential of these students; this individualized instrument uses a "teach-test" method to assess the individual in great depth according to a number of specific cognitive skills.

That assessment indicated that many of those students were indeed not mentally retarded but were only lacking in mediated experiences in their own backgrounds. Feuerstein then realized the need for a specific intervention program which would provide mediated experience where it was lacking in these students. Thus, he developed the program known as Instrumental Enrichment (IE), a supplement to the regular curriculum in which students focus on paper-and-pencil exercises of increasing complexity designed to develop and enhance specific cognitive skills at the representational and symbolic levels of thinking.

Instrumental Enrichment provides an excellent mechanism in relation to the results of studies cited earlier for the following reasons:

1. It uses a "metacognition" approach in that students are given repeated opportunities to reflect on their own thinking processes.
2. Unlike those cognitive training programs focusing on impulsivity as a personality characteristic, IE assumes that impulsivity is a characteristic of the "retarded performer" due to his lack of adequate mediated learning experience. Thus, IE assumes that impulsivity may be reduced or eliminated, but for a different reason than other programs.
3. IE develops the prerequisites for learning and does not assume that those prerequisites already exist in the learner as has happened in several of the less than completely successful intervention programs.
4. IE recognizes that representational and symbolic levels of thinking are appropriate to expect from the adolescent and adult learner, nd mediates the learner in those modalities.

5. IE does not assume that generalization will automatically occur; rather, a critical element in the daily instructional sequence for IE is the "bridging" exercises in which the teacher overtly and actively promotes transfer by the student of cognitive skills to both real-life and curricular situations, through discussion for insight.

6. IE is based on the concept of cognitive modifiability in the sense that it is considered never too late in the individual's life for modification of cognitive structures to be made.

Thus, for all of the above-stated reasons, the IE program represents a highly logical intervention step in the history of cognitive intervention programs.

Prior Research Results

The results of using the IE program with hearing students have been positive. In an experiment in Toronto involving two groups of high school students, one using the IE program and the other not, the mean subtest scores on the Stanford Achievement Test for the IE group were higher in Reading Comprehension, Mathematical Computation, Mathematical Application, Spelling, and Language (Narrol, 1978, 49). Moreover, the principal of the school where IE was used reported that there were also markedly fewer behavioral problems and "remarkably" improved work habits of students (Narrol, 1978, 51) in those classes. In addition, the IE group had a significant mean increase in the number of correct answers on the Lorge-Thorndike Intelligence Test from pre- to post-test (35.8 versus 51.44). The behavioral and work-habits dimensions of these results may be explained by the intrinsically motivating nature of the exercises, which motivated students to stop competing with each other and stay tenaciously on the task until completion.

Follow-up studies of IE groups in Israel indicate that statistically significant structural changes in the cognitive processes of subjects (as measured by psychometric tests) actually increased over a period of two years after students completed the program (Feuerstein & Jensen, 1980, 422).

To date, IE has been used on a limited basis with hearing-impaired student populations. Prior experiments testing the Instrumental Enrichment program with hearing-impaired adolescents at the Model Secondary School for the Deaf at Gallaudet University have indicated that students measurably improve in the skills of reading comprehension, mathematical computation, systematic approach to problem-solving, organization of solutions to subject matter problems, and abstract thinking (Martin and Jonas, 1986). Another one-semester pilot study with Gallaudet undergraduate students in teacher preparation using the identical program showed similar improvement in precision, ability to compare, ability to explain, and diagnosis of errors in their written work (Martin, 1984).

The positive results from these separate implementations of the IE program indicate a strong rationale for a more widespread and systematic research project with hearing-impaired students of the scope described in the Experimental Procedures section.

Research Hypotheses

The following hypotheses were advanced as potential outcomes of using the Instrumental Enrichment Program with the experimental sample of hearing-impaired students:

> Hearing-impaired college students working on a regular and systematic basis with the exercises in the Instrumental Enrichment Program for a period of two years will:

1. Demonstrate significantly higher logical reasoning in comparison with a control group, as measured by results on the Raven's Progressive Matrices (Raven, 1960) at the end of the research period.

2. Demonstrate significantly better achievement in reading comprehension in comparison with a control group, as measured on the Stanford Achievement Test, Hearing-Impaired (SAT-HI) (Madden, 1972).

3. Demonstrate significantly better achievement in mathematics concepts in comparison with a control group, as measured on the SAT-HI.

4. Demonstrate significantly better achievement in mathematical computation in comparison with a control group, as measured on the SAT-HI.

5. Demonstrate improved organization in their production of a written essay as judged by a team of trained independent judges.

6. Demonstrate greater confidence in themselves in regard to approaching problem-solving situations in comparison with a control group, as measured by student written responses to a questionnaire at the end of the research period.

7. Within the experimental group, students whose hearing loss dates from age 2 or before will show significantly greater improvement in scores in logical reasoning as measured by the Raven's Matrices, when compared with students whose hearing loss dates after age 2.

In addition, other analyses deemed relevant to the comparison of IE groups were conducted.

General Procedures

The training procedure for instructors involved six full-days of instruction in the cognitive materials themselves, for each year of the two-year Project. Instructors representing a balance of several academic disciplines, received theoretical background in Feuerstein's cognitive theory, solved the cognitive problems themselves on an adult level as a way of creating insight into the cognitive modification process, and then developed a variety of techniques for integrating these exercises into their own particular subject matter areas. Thus, the instructors themselves experienced cognitive modification as they prepared to cognitively modify their own students. An example of the interaction behavior teacher and students, for which teachers were trained, was as follows:

1. Students in an English course carried out an IE task involving the comparison of pairs of words with somewhat similar meanings, and were asked to delineate the specific differences and similarities between the words.

2. The instructor then discussed with the students the mental processes which they used to solve these problems (looking at the entire problem first; fine discrimination between words that appear to have the same meaning; keeping in mind several sources of information; using what is known, what is seen, and what can be inferred; and checking for error). This discussion was considered metacognitive.

3. The instructor then discussed with students how that particular skill of comparison could be applied (or "bridged") to the subject matter of the course, e.g., in English--comparison of two characters in a narrative, comparison of two pieces of writing which are designed to communicate the same message, comparison of two modes of communication for the hearing-impaired learner.

4. Finally, the instructor later in the context of the English course referred back to the skills of comparison learned from these exercises, as a way of reinforcing the importance of the comparison process.

During the period October 1, 1985, through May 15, 1986, students had regular (at least 90 minutes per week) instruction in the Instrumental Enrichment program, focusing on the six cognitive skills of: projecting virtual relationships, orientation in space, analytic perception, comparison, creating and following instructions, and categorization.

During the academic year 1986-87, participating subjects had regular instruction in the cognitive skills of temporal and spatial relationships, numerical progressions, hierarchical relationships, synthesis, and logical reasoning. Intervention occurred in the context of regular course work by regular instructors who had special additional training in the IE program as discussed above.

Experimental Procedures

Groups

In the Fall of 1985 (Year One), 91 experimental subjects were identified in the classes of the seven experimental instructors who made a commitment to training in the methods of instrumental Enrichment--the experimental treatment. Ninety-one matched control subjects were also identified.

In the fall of 1986 (Year Two), identifications were made of those individuals in the original control group who had returned to college; a rather large number of control subjects did not return for their second year (reduction was noted from 91 to 55). The same assessment was made of the experimental subjects from the first year, and again, some considerable attrition occurred (from 91 to 75 for the reasons mentioned below under point number 2 in the section, Limitations of the Study).

However, in the classes in which experimental subjects were placed in their second year, a number of additional students who had not had prior exposure to the experimental treatment were able to have regular opportunities for cognitive skills instruction; because the unit of intervention was the classroom, rather than the individual, the investigator made a decision to include this latter group of new students as a second sub-group for the experimental condition (those exposed to the treatment for one year as opposed to two years).

In addition, a number of the experimental students were not able to re-enroll in experimental classes in their second year, and data was kept on them; this group was treated as a second sub-group who had had one year of exposure to the experimental treatment, but in this case for the first year only rather than the second year only.

Finally, still another sub-group was identified during the 1986-87 year in which the experimental students from the first year of the experiment had continued experiences in cognitive instruction for one more semester (Fall of 1986) before opting out of the program, thus enabling them to be treated as a three-semester experimental group.

As a result, the investigator is able to report on four different levels of experimental intervention groups rather than one--a four-semester experimental group, a three-semester experimental group, and two two-semester groups (1985-86 and 1986-87). Although these four levels within the experimental group were not previously planned, the fact of these sub-groups as an artifact of the problem of attrition and voluntary enrollment was seen by the investigator as also an opportunity for an assessment of the differential effects of the intervention according to a continuous variable of length of exposure, rather than a simple binary situation of either exposure or non-exposure.

The control group, of course, consisted of individuals who throughout the two-year period had no exposure to the experimental treatment.

Instructor Training

In 1985-86, experimental group instructors were trained in the methods of Instrumental Enrichment over a 30-hour span throughout the year. Each faculty training session lasted for a period of three hours and focused on faculty completion (on an adult level) of the particular cognitive exercises which they were asked to use with their college students, discussion for insight about the thinking processes, and development of specific classroom strategies

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Note: Acknowledgement is given to the important data analysis and research assistance provided by Dr. Bruce Jonas of the Walter Reed Army Medical Center and Ms. Sherry Craft of Gallaudet University.

for teaching cognitive skills. The training sessions were conducted by the project director (Principal Investigator), and covered the specific cognitive skill areas of: projection of virtual relationships, orientation in personal space, assuming other person's point of view, comparison and contrast, analytic perception, categorizations, following precise instructions, generation of precise instructions for another person, identification and explanation of absurdity in many different contexts. Applications of these skills to subject matter were developed for: writing, literature, grammar, biology, mathematics, and health education.

The investigator continued, as planned, with the training of a new group of instructors who would implement the experiment with the experimental group during the second year of the two-year experiment; all of these experimental instructors were members of the faculty in the Gallaudet University Department of English; English instructors were used because English as a required subject became administratively the most appropriate way of ensuring exposure to and implementation of the experiment with experimental subjects. The topics covered in the 30-hours of training in the second year included: temporal relationships, sequence, hierarchical relationships, symbolic logic, propositional logic, and synthesis.

Time Frame

Implementation of the Cognitive Skills Program took place within the framework of a special remedial program designed to enable the student to pass the university reading and writing tests in order to be admitted to full status in the liberal arts program. Thus, applications of the cognitive skills program frequently used examples in the area of the language arts. Incorporation of the methodology took place on an average of 45 minutes per week with a minimum of 30 minutes and a maximum of 60 minutes per week for experimental subjects.

Criterion Measures

As planned, demographic data were collected on all experimental and control subjects in the fall of 1985, including: age-of-onset of hearing loss, decibel loss in the better ear, and gender. Pre-tests were administered to both groups, including: Raven's Matrices, the Writing Sample, the Effective Study Skills Test[1], the Study Skills Survey[2], and the Self-Concept ... Survey (see Appendix); in addition, scores on entering students on the Stanford Achievement Test, Hearing-Impaired, (SATHI) were obtained for the subtests of Reading Comprehension, Math Concepts, and Math Computation.

Pre-tests using the SAT-HI and Raven's Tests (but not the Thinking Skills Survey, the Effective Study Skills Test, nor the Study Skills Survey) were given to the new one-year (1986-87) experimental group during the month of September, 1986; demographic data were also collected on this additional one-year experimental cohort. All post-testing took place during the first week of May, 1987. Post-test measures administered to both experimental and control subjects were: the Raven's Standard Progressive Matrices; and the Stanford Achievement Test (Hearing-Impaired) subtests on Reading Comprehension, Math Computation and Math Concepts; in addition, oral interviews of 20 randomly selected experimental students, and interviews with all experimental group instructors took place at the end of the experimental period. The Thinking Skills Survey was able to be administered as a post-test only to ten of the experimental students due to difficulties in scheduling; this measure had been given as a pre-test to the original experimental and control subjects, but the investigator eliminated it as a usable measure

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1 Brown, William F. (1964). Effective Study Test. San Marcos, TX: Effective Study Materials.

2 Brown, William F. (1983). Study Skills Survey. San Marcos, TX: Effective Study Materials.

except to give a sampling of post-experimental attitudes among experimental subjects due to several factors: (1) the significant attrition from the original group, (2) the fact that this measure is a non-standard instrument which requires only self-reporting, and (3) the fact that this instrument was not able to be given as a pre-test to the new experimental sub-group (one-year 1986-87).

Because of a major and uncontrollable problem with the scheduling of student time for post-testing, neither the Effective Study Skills Test nor the Study Skills Survey were able to be given as post-tests to control nor experimental groups; pre-test results on these measures, therefore, are reported as measures of the characteristics of the two entering groups to show their similarity as groups for purposes of the experiment--no significant difference was found between experimental and control groups in either measure on its September 1985 administration.

Intervention, Year One

Experimental subjects beginning with the Fall of 1985 received instruction in the Instrumental Enrichment program for an average of 2½ hours per week with a specially trained instructor. Intervention took place during a regularly scheduled course for all experimental subjects.

Intervention, Year Two

In order to synchronize the teaching of the cognitive skills material for the experimental classes which had in some cases a mixture of new one-year students and those who had already had one year of previous exposure, all experimental students in September 1986 were given a brief (four-week) overview or review of the first-year skills from the Instrumental Enrichment Program before moving on to new cognitive skill materials.

Interviews

As planned, interviews of randomly selected experimental students took place and are reported in this report, as are the results of the planned interviews with all faculty who had responsibility for teaching in the experimental groups.

Data Treatment

Student data on the Stanford Achievement Tests and the Raven's Matrices were analyzed by comparing the pre-test scores from the Fall of 1985 with the post-test scores from the Spring of 1987. Mean scores on criterion measures were obtained and analyzed using an analysis of covariance in which the covariates were pre-test scores, sex, age-of-onset of hearing loss, degree of hearing loss, and Instrumental Enrichment group (length of exposure). Aptitude-treatment interactions were then analyzed by examining sub-group means of selected covariate combinations (IE females, IE males, control males, control females) when significant interactions were present. Results of student writing samples and student questionnaires on self-concept as a thinker were used for interpretation of standardized results and for analysis of effects not shown by the standardized measures. Finally, a series of composite case studies were developed so as to describe the characteristics of students who tended to do well with IE instruction.

Limitations of the Study

Most educational experiments which take place in the collegiate environment are constrained by several limitations imposed by the nature of the relatively high flexibility allowed to the college student, by comparison with the student in the elementary or secondary school. The present investigation was no exception to that generalization.

A number of specific limitations or obstacles were noted by the investigator, which may have had some depressive effect on the eventual outcomes of the study. Those limitations include the following:

1. The training of the instructors for the experimental group took place parallel to, rather than prior to, their implementation of the experimental treatment. This simultaneity meant that instructors were as new to the methodology as were the students.
2. A large proportion of the students--all students were hearing-impaired--had experienced years of frustration in the area of the use of the English language. At the point of this particular experiment, these students were at the last possible point of being able to pass a university language test which would determine whether they could continue their liberal arts college education. The methodology for the experiment required that the thinking skills content be incorporated within, not separate from, the regular content of the curriculum. This inclusion which was considered by the investigator to be essential to enable the students to make proper and immediate connections between the cognitive skills and their application, at the same time produced a negative attitude on the part of some students who for some time during the intervention period did not accept the relevancy of the cognitive skills to their eventual chances of passing that college test. As a result, some experimental subjects tended to regard the experimental materials and time to be a distraction from, rather than an aid to, their work in English. Thus, this attitude could very easily have affected their receptivity toward the cognitive training.

3. Some of the professors involved in teaching the experimental group also felt the same pressure as the students in order to "cover the material" as opposed to incorporate the teaching of thinking with their other teaching; although their attitudes improved, it is clear that implementation was at first affected negatively, with the result that the exposure of some students in the experimental group to cognitive instruction was less frequent in the early weeks of the semester in each case than the investigator had planned.
4. The university in general and the investigator in particular had no way of legally enforcing the enrollment of experimental students from the first year into continuing experimental sections in the second year of the experiment in which they would have more instruction in the cognitive skills program. In fact, a number of the students regarded that opportunity as one which they actually wanted to avoid because they did not perceive that the cognitive training would help them with their academic achievement. As a result, there was considerable attrition of students in the original experimental group from the first year into the second year. Regular attrition (because of students not returning to college) also affected the size of the experimental group that was able to have the exposure to the experimental treatment for two full years.
5. Attrition between the first and second years of college also negatively affected the size of the continuing control group.
6. A final acknowledged limitation is the use of a quasi-experimental design in which subjects were not able to be assigned randomly to treatment groups.

RESULTS

As has been previously mentioned, one limitation of the present study turned out to be the mobility of this college-age population which allowed little control by the investigator over how many students would comprise the final study sample size for the post measures administered. Consequently, it was important to measure the degree to which the control versus IE groups remained comparable on the original set of factors thought to be important for matching characteristics between these two groups. Table 1 presents the series of characteristics for the final study sample. For all variables listed in this table as well as most variables in subsequent tables, group sample sizes representing non-missing data are presented. This point is important since these values sometimes change markedly, thus affecting interpretation of the results presented.

Table 1 presents two hearing-loss measures (specifically age-at-onset and dB loss in the better ear), the participant's gender, and three measures of the student's study and thinking skills. For all measures presented, there were no significant initial differences found between the control and IE groups. The largest group variations were found in the age-of-onset of hearing-loss measure--which showed a 5% discrepancy in the IE versus control group comparison and in the gender variable which showed a 10% discrepancy. In either case, these variations were deemed acceptable by the fact that Chi-Square tests were non-significant, as well as the fact that there was still ample representation of all sub-categories of variables in both groups. We therefore concluded that the final study sample size was an adequate representation of the original sample and that matching between the IE and control groups remained intact.

Table 1.

Selected background Characteristics of the Final Cognition Study Sample – Statistics Presented for the Overall Sample and Broken Down by Control versus IE Group Participation* (Group Sample Sizes with Non-Missing Data)

	Overall Sample N=130	IE Group N=75	Control Group N=55
Age-at-Onset of [illegible]			
before 2 yrs.	69.3 (70)	67.2 (41)	72.5 (29)
before 2 yrs.	30.7 (31)	32.8 (20)	27.5 (11)
dB Loss in Better Ear			
less than 70 dB	25.8 (15)	24.4 (10)	29.4 (5)
less than 70-90 dB	27.6 (16)	29.3 (12)	23.5 (4)
more than 90 dB	46.6 (27)	46.3 (19)	47.1 (8)
Sex – % Males	50.4 (63)	55.7 (39)	43.6 (24)
% Females	49.6 (62)	41.3 (31)	56.4 (31)
Study Skills Survey Score--Pretest Mean	27.4 (93)	28.5 (46)	26.3 (47)
Effective Study Test Score--Pretest Mean	63.4 (93)	63.4 (46)	63.4 (47)
Thinking Skills Survey Score--Pretest Mean	25.7 (99)	25.9 (51)	25.4 (48)

* No significant differences were found comparing IE to control group statistics

Table 2 presents the pre, post, and difference score means for the Raven's Progressive Matrices. The two comparisons of most interest for this table and the following Tables 3 through 7 are: (1) comparing controls to all IE students combined, and (2) comparing length of exposure to IE instruction (two versus four semesters of instruction). The results show that for the first comparison, IE students significantly gained more than control students averaging 1.9 points to the control's 0.7 points. These gains, however, are lower than previous research conducted (Martin & Jonas, 1986), where two-year gains were around 8 points. Control of the sample was somewhat greater in this previous research since that population was in a high school. The second comparison revealed no trend between two and four semester IE groups. Hence, Hypothesis One is supported that gains for the IE students are significantly greater than that for the controls in logical reasoning, although, the magnitude of the gain is not as high as previously-reported results.

Table 2.

Raven's Progressive Matrices--Pre, Post, and Difference Score Means for Overall Sample, Controls, All IE Students and for Each IE Group (Sample Sizes with Non-Missing Data)

	Pre	Post	Difference
Overall Sample (N=73)	44.0	45.3	1.3
Controls (N=32)	42.8	43.5	0.7
All IE Students (N=41)	44.9	46.8	1.9
IE #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	43.9	47.2	3.3
IE #2 - 2 semesters (Fall 1985, Spring 1986) (N=14)	44.6	46.1	1.5
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	50.0	48.0	-2.0
IE #4 - 4 semesters (Fall 1985, Spring 1986, Fall 1986, Spring 1987) (N=11)	44.5	46.8	2.3

ANOVA comparing controls to all IE students on post-test

$F = 4.0377$ $p = .0483$

ANOVA comparing 2 semesters versus 4 semesters of IE exposure

$F = .0127$ $p = .9108$

Table 3 presents the SAT-HI Reading Comprehension results for the post-test administration. For this table and Tables 4 and 5, insufficient pre-test information was available. Based on our previous research we assumed that matched samples among hearing-impaired students are comparable among such standardized tests. The results indicated significantly higher scores for the IE group (634.9) versus the control group (621.4). The two- to four-semester comparison of IE exposure showed no significant pattern within the experimental sub-groups. Hypothesis Two is therefore supported in that the IE group does significantly better in reading comprehension than the control group.

Table 3.

SAT-HI Reading Comprehension Post-Test Means for Overall Sample, Controls, All IE Students and for Each IE Group (Sample Sizes with Non-Missing Data)

Overall Sample (N=69)	629.2
Controls (N=29)	621.4
All IE Students (N=40)	634.9
IE #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	633.6
IE #2 - 2 semesters (Fall 1985, Spring 1986 (N=13)	633.5
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	637.8
IE #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=11)	636.9

ANOVA comparing controls to all IE students

F = 4.3954 p = .0398

ANOVA comparing 2-semesters versus 4-semesters exposure

F = .0973 p = .7570

Table 4 presents the SAT-HI Math Concepts post-test means. The results show significances for both comparisons, that (1) IE students score significantly higher than control students (698.9 versus 678.1) and (2) that four-semester IE students score significantly higher than two-semester students (720.1 versus 690.5).

This result was expected since the contents of the Math Concepts test require the students to use principles of logic, and analogic activities occur repeatedly and more often as IE instruction moves into the second year. Hence, Hypothesis Three is strongly supported in that both the presence and duration of IE instruction have a significant impact on performance in Math Concepts.

Table 4.

SAT-HI Math Concept Post-Test Means for Overall Sample, Controls, All IE Students, and for Each IE Group (Sample Sizes with Non-Missing Data)

Overall Sample (N=70)	690.3
Controls (N=29)	678.1
All IE Students (N=41)	698.9
IE #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	689.9
IE #2 - 2 semesters (Fall 1985, Spring 1986 (N=14)	691.1
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	695.2
IE #4 - 4 semesters (Fall 1985, Spring 1986, Fall 1986, Spring 1987) (N=11)	720.1

ANOVA comparing controls to all IE students

$F = 6.6722$ $p = .0119$

ANOVA comparing 2 semesters versus 4 semesters exposure

$F = 5.7158$ $p = .0223$

Table 5 presents the SAT-HI Math Computation post-test means. The results show significantly higher scores for the IE group (711.7) as compared to the control group (689.0). The two-to-four semester comparison shows greater gain for the four-semester group (726.5), versus the two-semester group (707.5), but this comparison did not reach statistical significance due to the low sample sizes compared (11 four-semester students versus 26 two-semester students). Hence, Hypothesis Four was supported in that the IE group as a whole demonstrated significantly better performance in math computation in comparison with controls.

Table 5.

SAT-HI Math Computation Post-Test Means for Overall Sample, Controls, All IE Students, and for Each IE Group (Sample Sizes with Non-Missing Data)

Overall Sample (N=70)	702.3
Controls (N=29)	689.0
All IE Students (N=41)	711.7
. semesters (Fall 1986, Spring 1987) (N=12)	708.3
IE #2 - 2 semesters (Fall 1985, Spring 1986 (N=14)	706.9
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	697.5
IE #4 - 4 semesters (Fall 1985, Spring 1986, Fall 1986, Spring 1987) (N=11)	726.5

ANOVA comparing controls to all IE students

$F = 5.3293$ $p = .0240$

ANOVA comparing 2 semesters versus 4 semesters exposure

$F = 1.3275$ $p = .2571$

Table 6 presents the pre-, post-, and difference score means for Gallaudet University's Writing Placement test. The data do not show any significant differences between the IE and control groups. The comparison between two- and four-semester IE groups (3.7 versus 8.6) does approach statistical significances (p = .0891). Hence, Hypothesis Five is somewhat ambiguously supported; we cannot support an overall effect of the IE training but within the IE group, additional exposure does increase gain scores in writing.

Table 6.

Gallaudet University Writing Placement Test--Pre, Post, and Difference Means for Overall Sample, Controls, All IE Students, and for Each IE Group (Sample Sizes with Non-Missing Data)

	Pre	Post	Difference
Overall Sample (N=109)	46.1	52.5	6.4
Controls (N=48)	46.1	53.7	7.6
All IE Students (N=61)	46.0	51.5	5.5
IE #1 - 2 semesters (Fall 1986, Spring 1987) (N=5)	47.0	52.0	5.0
IE #2 - 2 semesters (Fall 1985, Spring 1986 (N=26)	45.2	48.7	3.5
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=12)	44.6	50.0	5.4
IE #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=18)	47.8	56.4	8.6

ANOVA comparing controls to all IE students

F = .3771 p = .5403

ANOVA comparing 2 semesters versus 4 semesters exposure

F = 3.0136 p = .0891

Table 7 presents the pre-, post-, and difference score means for Gallaudet University's Reading Placement Test. The data do not show any significant pattern for either comparison. Since these last two placement tests are locally produced and used at Gallaudet University, no validity or reliability study data are readily available. Hence, the extent to which test-retest measurement error influences the results is unknown. <u>Hypothesis [illegible] regard to improvement in self-concept as a thinker was not able to be supported in view of the absence of sufficient post-test data on the Thinking Skills Survey Test</u>.

Table 7.

Gallaudet University Reading Placement Test--Pre, Post, and Difference Means for Overall Sample, Controls, All IE Students, and for Each IE Group (Sample Sizes with Non-Missing Data)

	Pre	Post	Difference
Overall Sample (N=106)	37.8	40.4	2.6
Controls (N=49)	36.9	39.0	2.1
All IE Students (N=57)	38.6	41.6	3.0
IE #1 - 2 semesters (Fall 1986, Spring 1987) (N=2)	41.5	47.0	5.5
IE #2 - 2 semesters (Fall 1985, Spring 1986 (N=25)	37.5	40.8	3.3
IE #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=12)	37.4	41.8	4.4
IE #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=18)	40.7	41.9	1.2

ANOVA comparing controls to all IE student.

F = .4205 p = .5179

ANOVA comparing 2 semesters versus 4 semesters exposure

F = .0519 p = .8209

Table 8 presents a summary of data for six measures that include the Raven's Progressive Matrices, the SAT-HI Reading Comprehension, SAT-HI Math Concepts, SAT-HI Math Computation, and Gallaudet University's Reading and Writing Placement tests, broken down by age-at-onset of hearing loss. Statistics presented include the mean scores for the overall sample, less than two years of age-at-onset of hearing loss, and two years or more at age-of-onset of hearing loss. Further presented is the significance level comparing these latter two group means to the overall mean for each test measure presented. The table shows a lack of significant difference between these two hearing-onset loss groups except for the difference score on the Gallaudet Reading Placement test; here the group of two years or more at age-of-onset of hearing loss (postlingual) significantly outgained (5.3 versus 2.2) the prelingual or under-two-years age-of-onset group in reading.

Table 8.

Raven's Progressive Matrices, SAT-HI-Reading Comprehension, Math Concepts, Math Computation, Gallaudet Writing and Reading Placement Test Means by Age-at-Onset of Hearing Loss--Overall Sample, Age-of-Onset at Less Than Two Years and Age-of-Onset at Two Years or Later (Group Sample Sizes with Non-Missing Data)

	Overall Sample	Hearing Loss Age-of-Onset Under 2 Years	Hearing Loss Age-of-Onset 2 Years or More	Between Groups ANOVA
Raven's - Pre	44.3 (61)	44.4 (37)	44.1 (24)	$p = .8899$
- Post	45.5 (61)	45.3 (37)	45.7 (24)	$p = .8528$
- Difference	1.2 (61)	1.0 (37)	1.6 (24)	$p = .6711$
SAT-HI Reading Comprehension	629.2 (56)	630.0 (34)	627.9 (22)	$p = .7872$
SAT-HI Math Concepts	693.9 (57)	693.4 (35)	694.7 (22)	$p = .8992$
SAT-HI Math Computation	706.3 (57)	705.5 (35)	707.5 (22)	$p = .8653$
Gallaudet Writing Test - Pre	45.9 (82)	46.1 (62)	45.3 (20)	$p = .7249$
- Post	54.4 (94)	54.0 (65)	55.3 (29)	$p = .6449$
- Difference	7.8 (82)	7.3 (62)	9.3 (20)	$p = .4855$
Gallaudet Reading Test - Pre	37.7 (79)	38.3 (63)	35.6 (16)	$p = .1398$
- Post	40.2 (94)	40.6 (66)	39.3 (28)	$p = .4788$
- Difference	2.8 (79)	2.2 (63)	5.3 (16)	$p = .0368$

Table 9 presents the same set of six outcome scores broken down by dB lo s in the better ear for the overall sample (less than 70 dB, 70-90 dB, and greater than 90 dB loss). The results show that there was no significant differences between these three groups of dB loss levels on the set of tests administered.

Table 9

Raven's Progressive Matrices, SAT-HI: Reading Comprehension, Math Concepts, Math Computation, Gallaudet Writing and Reading Placement Test Means by dB Loss in Better Ear - Overall Sample, Less Than 70 dB, 70-90 dB, Greater Than 90 dB (Group Sample Sizes with Non-Missing Data)

	Overall Sample	Less Than 70 dB Hearing Loss	70-90 dB Hearing Loss	Greater Than 90 dB Hearing Loss	Between Groups ANOVA
Raven's - Pre	44.4 (37)	42.3 (10)	44.8 (8)	45.4 (19)	p = .5956
- Post	46.1 (37)	42.3 (10)	47.9 (8)	47.3 (19)	p = .1932
- Difference	1.7 (37)	0.0 (10)	3.1 (8)	1.9 (19)	p = .3550
SAT-HI Reading Comprehension	634.4 (34)	638.6 (9)	644.7 (7)	628.3 (18)	p = .2394
SAT-HI Math Concepts	695.2 (34)	691.8 (9)	724.4 (7)	685.5 (18)	p = .0711
SAT-HI Math Computation	709.5 (34)	699.1 (9)	736.8 (7)	704.0 (18)	p = .2587
Gallaudet Writing Test - Pre	46.9 (42)	48.5 (13)	46.4 (11)	46.1 (18)	p = .7393
- Post	55.7 (53)	55.0 (14)	54.6 (14)	56.6 (25)	p = .8719
- Difference	8.1 (42)	5.4 (13)	9.5 (11)	9.2 (18)	p = .4918
Gallaudet Reading Test - Pre	38.8 (38)	40.8 (13)	37.8 (10)	37.7 (15)	p = .3041
- Post	41.3 (52)	42.1 (14)	40.3 (14)	41.4 (24)	p = .8349
- Difference	3.3 (38)	0.8 (13)	3.4 (10)	5.3 (15)	p = .1669

Table 10.

Raven's Progressive Matrices, SAT-HI-Reading Comprehension, Math Concepts, Math Computation, Gallaudet Writing and Reading Placement Test Means by Sex of Student--Overall Sample, Males and Females (Group Sample Sizes with Non-Missing Data)

	Overall Sample	Males	Females	Between Groups ANOVA
Raven's - Pre	43.9 (73)	45.6 (38)	42.1 (35)	$p = .0261$
- Post	45.3 (73)	47.0 (38)	43.5 (35)	$p = .0390$
- Difference	1.4 (73)	1.4 (38)	1.4 (35)	$p = .9439$
SAT-HI Reading Comprehension	628.9 (68)	629.7 (35)	628.0 (33)	$p = .8026$
SAT-HI Math Concepts	691.2 (69)	702.7 (36)	678.6 (33)	$p = .0027$
SAT-HI Math Computation	702.9 (69)	716.1 (36)	688.5 (33)	$p = .0050$
Gallaudet Writing Test - Pre	46.0 (105)	46.1 (52)	45.9 (53)	$p = .9209$
- Post	53.4 (118)	54.7 (58)	52.2 (60)	$p = .2889$
- Difference	6.5 (105)	7.3 (52)	5.8 (53)	$p = .5090$
Gallaudet Reading Test - Pre	37.7 (102)	38.1 (51)	37.3 (51)	$p = .5015$
- Post	40.1 (118)	39.3 (59)	40.9 (59)	$p = .2815$
- Difference	2.5 (102)	1.4 (51)	3.6 (51)	$p = .0815$

Table 1' presents selected two-way Analysis-of-Variance Models for the outcome measures that were found to be significantly different in Tables 8-10. As was mentioned, these Tables 8-10 did not distinguish between IE and control students. Table 11 further classifies test scores into treatment combination sub-groups, that is, IE students with age-of-onset of hearing loss under two years, etc. In this way Table 11 can further delineate where significance occurs and therefore the attributes of those students who tend to do significantly better or worse than the overall average. The first series in this table models the Raven's test for combinations of the IE group variable with age-of-onset of hearing loss, so as to address Hypothesis Seven. As shown, the table does not support this hypothesis, instead showing no significant differences between the four sub-group combinations listed in logical reasoning; thus. Thus, Hypothesis Seven in regard to greater improvement in logical reasoning by prelingually deaf experimental students compared with postlingually deaf experimental students cannot be supported. The second series in this table models the Gallaudet Reading Test for the same treatment combination. Here, the IE students whose hearing loss dates at two or more years out-perform the other groups. While significant, this result should be interpreted with caution since there were valid data for only two students in this group. The third series presents the Raven's test for the treatment combinations of IE males and females and control males and females. The table shows that IE males tended to out-perform the other three groups. The fourth and fifth series presents the same model for the SAT-HI Math Concepts and Math Computation tests. As before, the IE males tended to out-perform the other three groups listed.

Table 11.

Selected Two-Way Analysis of Variance Models (Group Sample Sizes with Non-Missing Data on All Variables in the Model)

IE Group Status by Age-at-Onset of Hearing Loss

	Overall Sample	IE Group Hearing Loss Under 2 Yrs.	IE Group Hearing Loss 2+ Years	Control Group Hearing Loss Under 2 Yrs.	Control Group Hearing Loss 2+ Yrs.
Raven's					
- Pre	44.9 (54)	46.1 (21)	44.8 (13)	42.9 (12)	45.4 (8)
- Post	46.5 (54)	47.4 (21)	47.6 (13)	44.0 (12)	46.5 (8)
- Difference	1.6 (54)	1.3 (21)	2.8 (13)	1.1 (12)	1.1 (8)
Gallaudet Reading Test - Pre	38.5 (41)	39.8 (19)	43.0 (2)	40.9 (12)	30.7 (8)
- Post	41.0 (41)	42.4 (19)	52.5 (2)	40.7 (12)	35.6 (8)
- Difference	2.5 (41)	2.6 (19)	9.5* (2)	-0.2 (12)	4.9 (8)

IE Group Status by Sex of Student

	Overall Sample	IE Group Males	IE Group Females	Control Males	Control Females
Raven's					
- Pre	44.5 (66)	45.9 (22)	44.3 (16)	47.3 (12)	40.6 (16)
- Post	46.2 (66)	48.2 (22)	46.0 (16)	48.0 (12)	42.3 (16)
- Difference	1.7 (66)	2.3* (22)	1.7 (16)	0.7 (12)	1.7 (16)
SAT-HI Math Concepts	690.3 (53)	709.6* (16)	694.3 (9)	690.5 (12)	668.7 (16)
Math Computation	705.0 (66)	725.7* (22)	701.4 (16)	707.1 (12)	678.4 (16)

* Denotes sub-group mean is significantly higher ($p < .05$) than overall mean.

Carryover Effect

The original grant proposal for this project indicated that the implementation would occur over a two-year period, first with a group of entering students and their instructors, and then with that same group of students in their second year and their instructors at that time.

The question arose, "What persisting change, if any, can be seen among the first-year instructors after they were no longer required to implement the thinking skills program?" That question is not easily answered. However, during 1986-87, while the experimental group was in their second year, the investigator examined the activity of first-year instructors (from 1985-86) as they began to teach a new entering group of students (who were not a part of this experiment). These instructors chose to continue their own training in IE in second-year instruments and also voluntarily implemented IE with their new group of entering students.

Analysis of pre- and post-test results in 1986-87 in first-year algebra--a subject taught by two of these instructors--in comparison with other algebra classes taught by non-IE instructors indicated a statistically significant difference ($p < .01$) in favor of the students in these two experienced IE instructors' classes.

Although detailed analysis was not carried out because it was beyond the required scope of this project, three conclusions may be drawn from these admittedly limited data:

1. Trained IE instructors tend to persist in their interest in implementing the teaching of thinking skills.
2. Students in the classes of experienced IE teachers show significant gains over these in other classes, even though the instructors are not required to implement IE.

3. IE as a method of teaching thinking skills has the clear potential to become institutionalized as a part of the college curriculum if instructors are appropriately trained and have continued access to needed materials.

This apparent potential for institutionalization is a critical element in the long-range thinking behind this project and is a truly encouraging indication for the improvement of cognitive skills.

Interview Data

As originally planned, the investigator also interviewed randomly selected experimental subjects as well as the instructors in the experimental group. These data are used to assist in the interpretation of the statistical findings and to broaden the base of information on the results of the experiment beyond paper-and-pencil instruments.

1. Students

The student interviews took place during Spring 1987, well into the final semester of the experimental treatment. Students were asked to respond to the question, "In what ways have you changed your thinking since you started to use Instrumental Enrichment?" Five students of the twenty randomly selected experimental subjects responded that they were not aware of any change; an additional two students expressed only that they were concerned with the amount of time that Instrumental Enrichment seemed to "take away" from learning English. The remaining students (13) all replied in some form that they believed that their thinking patterns had become more careful or systematic or less impulsive. A sampling of the responses of this latter sub-group are presented below to demonstrate the support for this latter interpretation:

Student	Statement
A.	"I found that I started to slow down before I guessed at an answer to a problem."
B.	"I think I started to look at the whole thing instead of the parts of a problem."
C.	"I think IE has been good for me--I can think better."
D.	"It takes me a little longer, but I think I get more right answers now."
E.	"I try to look for the reasons underneath the answers now before I write an answer."

2. Experimental Instructors

During the interviews with the experimental instructors, the key question was, "What types of responses to the program did you see happening in your students in the experimental group?" Instructor responses to this question helped to elaborate further on the above student responses. Among the instructors' observations was the clear trend that experimental students by the period of March 1987 began to demand that their instructors give them further verbal elaboration on any response, thus reflecting the same elaborative style that the instructor had been trying to model for them. For example, students were reported by experimental instructors to demand this reasoning both from each other and from the instructor with words such as:

A. "Explain it to me, please."

B. "Give me the evidence for that."

C. "Could I have another example, please?"

D. "I think I have the idea; let me give you an example and see if I know it now."

E. "How does that connect with what I already know?"

Instructors reported that no such demands were made by experimental students during the first semester of the experiment.

Students were also reported by experimental instructors to argue with one another over points during class, whereas previously they had merely accepted what the instructor had said or what each other said without question. It is clear from these sets of quotations that verbal elaboration behaviors were enhanced by the program; no such responses were reported from students in non-Instrumental Enrichment classes by experimental group instructors.

The second key question in the interviews of IE faculty was, "What overall changes do you see as a result of the experiment?" The following points were made by IE faculty interviewees:

A. Students in the experimental group began to feel the "strength" of their reasoning powers.

B. The students in the experimental group moved further ahead into higher level English and math than had been the case in previous years with similar groups that did not have Instrumental Enrichment.

C. Students demonstrated more confidence in themselves during examinations.

D. Students began to be able to use more than one piece of information at a time in activities requiring that behavior.

E. Test scores on teacher-made tests demonstrated that students had begun to "reason better."

F. Students stopped giving up on difficult academic problems or being depressed about their difficulty.

G. Students became better note-takers, they began to ask the instructor to stop and allow them to take notes instead of the instructor having to stop and remind them to take notes (this is an important issue in teaching deaf students, who are normally not able to take notes during a lecture because of the need for visual attending).

H. Students at first resented the non-verbal materials in the program because they felt that they were for younger students; but by the end of the third semester, they expressed that they saw the value of those and began to ask for more practice in the non-verbal instruments as well as in the verbal instruments.

I. Instructors said that they believed their own style of teaching had changed permanently as a result of the training in the direction of: using more "wait-time" for student responses in discussions, using more cognitive terms in their teaching, and demanding higher-level responses from their students during discussions.

Thus, these data also demonstrate that important changes were taking place beyond what was noted in the test scores reported earlier.

Thus, these data also demonstrate that important changes were taking place beyond what was noted in the test scores reported earlier.

COMPOSITE CASE STUDY ANALYSIS

Introduction

A further investigation of the data was undertaken to more specifically determine who among those students in the IE group did particularly well with the IE training. To answer this question, one method is to look at some percentage of the upper score distribution among those outcome test measures that were found to be significantly higher for the IE group as a whole. Since there is still considerable variance around the group mean of the IE group on these measures, this approach has the advantage of localizing those students who all did well on these measures and then reporting which attributes they possessed. For this analysis, the upper twenty-five percent of cases was selected in order to give approximately 10 to 15 students per outcome measure modeled. The outcome measures modeled were (1) Raven's Progressive Matrices Test, (2) SAT-HI Reading Comprehension, (3) SAT-HI Math Concepts, and (4) SAT-HI Math Computation. These represent the four outcome measures found significantly different for the IE group as a whole by comparison with control subjects (see Tables 2, 3, 4 and 5). The variables analyzed for each outcome measure included: (1) IE Group (e.g., 2 semesters 1986-87 academic year, etc.), (2) age-at-onset of hearing loss, (3) dB loss in better ear, (4) sex of student, (5) pre-test Study Skills Survey score, (6) pre-test Effective Study Test score, (7) pre-test Raven's score, (8) post-test Raven's score, and (9) pre-test Thinking Skills Survey score.

In order to be included in the profile of the composite for the successful IE student, he or she had to satisfy one or more of the following requirements: (1) score four or more on the Difference Score (Gain Score) on the Raven's, (2) score 651 or higher on the SAT-HI Reading Comprehension, (3) score 728 or higher on SAT-HI Math Concepts, and (4) score 729 or higher on the SAT-HI Math Computation test. Twenty-seven of the final forty-one IE group students scored high enough to meet these requirements. Of these, thirteen met one test cutoff requirement, nine met two requirements, four met three test requirements, and one student met all four test requirements. However, it is important to note also that various individuals do well enough with the IE training to extend it into different applications, and the influence of the training is therefore not limited to a few of students that did well on all tests. The following more detailed analysis will now help to answer the question, "What are the characteristics of the highly successful IE student?"

Raven's Progressive Matrices

For the Raven's Progressive Matrices test, the average gain of the upper 25% far exceeded the gain for the overall IE group (7.8 versus 1.9 points gained). The pre-test score was lower (42.1 versus 44.9) and the post-test was higher (49.9 versus 46.8) than the overall IE group, though it is important to point out that students with low, medium, or high aptitude (as measured by the pre-test score on the Raven's) are represented in the upper 25%. The students came away from IE instruction with either four semesters of exposure (both 1985-86 and 1986-87 academic years) or from the more recent two-semester group (1986-87 academic year). While there were students with all ages of hearing-loss onset, there was a disproportionately larger group with 2+ years hearing-loss onset (70.0% versus 32.8%). All students in this upper 25% had at least a 70dB loss in the better ear. The proportions of males and females almost exactly matches that in the overall IE sample (54.5% versus 55.7% males and 45.5% versus 43.3% females). The score on the Study Skills Survey Test is higher than the overall IE group (38.0 versus 28.5), but the scores on both the Effective Study Test (65.4 versus 63.4) and the Thinking Skills Survey (27.4 versus 25.9) are comparable to the overall IE group.

The following two composite case studies will now portray the average findings for a male and a female that were in this upper 25% group. (In all cases for these as well as the later composites, the data do not reflect any one student.)

Upper 25% Raven's Male: He started IE training in the Freshman Year in September, 1985 and continued with IE the following year. His Raven's pre-test score was a 40, and his post-test score was a 50, giving him a ten-point gain. His age-at-onset of hearing loss was one year and his hearing loss was 75dB. His Study Skills Test score was average at the beginning of IE training.

Upper 25% Raven's Female: She started IE training at Gallaudet University in September, 1986. Her Raven's pre-test score was 44 and post-test score was 49, giving her a five-point gain. Her age at hearing-loss onset was two and her dB loss was 95. Her Study Skills Test score was above average.

SAT-HI Reading Comprehension

For the SAT-HI Reading Comprehension test, the average score of the upper 25% group was 660.9 as compared to 634.9 for the entire IE group. The pre-test Raven's score for this group was 45.0 and the average post-test score was 47.1. Thus, the average gain was 2.1. These Raven's scores and gain are comparable to the overall IE group. The students were also closely representative of all four IE groups (two-semester 1985-86, two-semester 1986-87, three-semester 1985-86 and Fall 1986, four-semester 1985-86 and 1986-87), with only a somewhat higher proportion of the two-semester 1986-87 group (28.6% versus 18.7%). In all other respects the upper 25% closely resembled the IE group as a whole.

Upper 25% SAT-HI Reading Comprehension Male: He scored a 651 on the SAT-HI Reading Comprehension test. He had four semesters of IE training, pre-testing at 45 on the Raven's and post-testing at 48, thus gaining three points. His age at hearing-loss onset was at birth and his dB loss was 97. His Study Skills Test score was below average.

Upper 25% SAT-HI Reading Comprehension Female: She scored a 686 on the SAT-HI Reading Comprehension test. She had two semesters of IE training at Gallaudet University (1986-87). Her Raven's pre- and post-test scores were 44 and 46 respectively, thus gaining two points. Her hearing loss wass 78 dB and her age-at-onset of hearing loss was four years. She reported her Study Skills as average.

SAT-HI Math Concepts

For the SAT-HI Math Concepts test, the average score of the upper 25% group was 743.6 as compared to 698.9 for the entire IE sample. The pre-test Raven's score was 47.9 (versus 44.9) and post-test was 52.1 (versus 46.8). Thus, the average gain of this upper 25% group was 4.2 (versus 1.9). In this group there was over-representation from the two-semester IE group (1986-87) who took IE training at Gallaudet (30.0 versus 18.7%) as well as from the four-semester group (50.0% versus 26.7%). There was a higher proportion of two or more years at age-of-onset (50.0% versus 32.8%), a dB loss of 70-90 (42.9% versus 29.3%), and a higher proportion of males (80.0% versus 55.7%). The scores on Study Skills were all comparable to the overall IE sample.

Upper 25% SAT-HI Math Concepts Male: He scored a 746 on the SAT-HI Math Concepts test. His pre- and post-test Raven's scores were 48 and 55, thus gaining seven points. He had three semesters of IE training, two in his

Freshman year and one in the Fall 1986 semester at Gallaudet. His age-at-onset of hearing loss was three years and his hearing loss was 92 dB. His self-reported Study Skills were well above average.

Upper 25% SAT-HI Math Concepts Female: She scored a 746 on the SAT-HI Math Concepts test. Her Raven's pre- and post-tests were 45 and 49, thus gaining four points. She had four semesters of IE training. Her age at hearing loss was three years, with a 101 dB loss. Her Study Skills Test score was well above average.

SAT-HI Math Computation

For the SAT-HI Computation test, the average score of the upper 25% was 761.8 as compared to 711.6 for the entire IE group. The pre- and post-test Raven's scores were 46.1 (versus 44.9) and 50.5 (versus 46.8); thus, the average gain of this upper 25% group was 4.4 (versus 1.9). So, similar to the Math Concepts test, scores on this test as well as the Raven's gain were higher for this group. This group had representatives from all but the three-semester IE group. Proportions found in regard to age-at-onset, dB loss variables, and Study Skills Test were similar to the overall IE group proportions. There were also males and females scoring in this upper 25% group, with a somewhat higher proportion of males as compared to the overall IE group (66.7% versus 55.7%).

Upper 25% SAT-HI Math Computation Male: He scored a 782 on the Math Computation test. His Raven's pre- and post-tests were 47 and 54, thus gaining seven points. He had two semesters of IE training in the Freshman year (1985-86). His age-at-onset of hearing loss was five years and his dB loss was 65. is Study Skills Test score was below average.

Upper 25% SAT-HI Math Computation Female: She scored a 735 on Math Computation. Her Raven's pre- and post-tests are 43 and 45, thus gaining two points. She had four semesters of IE training. Her age-at-onset was one year with a hearing loss of 60 dB; her Study Skills were average.

SUMMARY OF RESULTS

A brief series of summarized results is presented here for all tabular data plus the composite case study analyses:

1. The IE and control samples are comparable on all background and pre-test measures collected. (See Table 1.)
2. The gains on the Raven's Progressive Matrices are significantly higher for the IE group as compared to the control group. (See Table 2.)
3. The scores on the SAT-HI Reading Comprehension test are significantly higher for the IE group as compared to the control group. (See Table 3.)
4. The scores on the SAT-HI Math Concepts test are significantly higher for the IE group as compared to the control group. Also, the length of IE exposure (two versus four semesters) significantly favors longer exposure. (See Table 4.)
5. The scores on the SAT-HI Math Computation test are significantly higher for the IE group as compared to the control group. (See Table 5.)
6. The Gallaudet University Writing Placement test did not show any significant differences between IE and control groups. (See Table 6.)
7. The Gallaudet University Reading Placement test did not show any significant differences between IE and control groups. (See Table 7.)
8. In the entire group (both IE and control combined), males outperformed females on the Raven's pre- and post-test, but both sexes gained the same amount of points. Males also outscored females on Math Concepts and Computation. (See Table 10.)
9. Looking at the IE group only, males performed better than females on the gain score of the Raven's Progressive Matrices, the Math Concepts, and Math Computation tests. (See Table 11.)

10. Within the top 25% of the IE score distributions on the Raven's Progressive Matrices and the SAT-HI battery of tests, representatives of both sexes, and all levels of hearing loss did well enough to be included on one or more of these post-test measures. (See Composite Case Studies.)

11. Most often the high-achieving IE student did well on the Raven's Progressive Matrices (i.e., gained three or more points) and had four semesters of exposure to IE materials. (See Composite Case Studies.)

CONCLUSIONS

From the combination of the statistical and anecdotal data reported and analyzed above, a number of conclusions are drawn by the investigator as follows:

1. Two years of intervention with a systematic cognitive skills program is clearly more productive than a one-year intervention in terms of changes in cognitive behavior and academic achievement.
2. For the young adult learner in the collegiate environment, a systematic cognitive skills program places the student in situations where they can begin to feel that they can think, which is an important factor in their self-confidence as learners. This conclusion is especially critical in terms of the deaf college student, who frequently has a problem with self-confidence in comparing himself or herself with hearing students.
3. No significant alterations of sequence in cognitive skills instruction is needed for adapting cognitive-skill programs for hearing-impaired, as compared with hearing, college students.
4. This program of systematic cognitive instruction leads students to mediate for each other, to the point where this peer mediation gradually becomes a supplement to the mediation carried out by the instructor. Again, this conclusion is important in relation to the mutual-assistance goal of hearing-impaired college students being able to support one another and become somewhat independent of older mediators, whether they be hearing or deaf.

5. Instrumental Enrichment as an intervention assists in making the link between the visual and the verbal code systems for the hearing-impaired learner; this conclusion was based on the observed easy interaction back and forth between those two modalities on the instruments as noted by experimental-group instructors, by comparison with their observations of the same students at the beginning of the experiment. Once again, this conclusion is fundamentally important in regard to the hearing-impaired college student who must make transitions on a regular basis between those two modes if he or she is to be successful in the collegiate learning environment and in the world beyond college.
6. The implementation of a cognitive skills instruction program at the college level is made difficult by the flexible scheduling and optional course election that is permitted in the collegiate environment; systematic ensured instruction in cognitive skills is far more difficult in that environment than in the secondary school. Cognitive skills instruction should therefore be made a regular part of at least one course in any hearing-impaired college student's program so that all students have this systematic experience.
7. The apparent strength of the gains shown by the one-year intervention group (1985-86), shown on their tests in the spring of 1987, indicate that the cognitive modification that took place one year before had a lasting effect even though it was small; it did <u>not</u> disappear with time.

8. Any cognitive skills experiment which uses the classroom as the unit of intervention is confounded by the fact that instructor style (irrespective of systematic instructor training) can have some effect on student results. The degree to which an instructor feels a level of comfort with taking time for cognitive instruction within the regular curriculum can have a direct effect on the success of implementation of cognitive skills instruction in a college course.
9. The majority of deaf children in our society are the children of hearing parents; such was also the case with the students in this investigation. The idiosyncratic cognitive style of the hearing-impaired student who has hearing parents--the necessity from an early age for moving back and forth between a hearing and a deaf world--can lead to some inhibitions on the effects of cognitive skills instruction compared with hearing students. Thus, the intervention carried out in the current experiment reflected the same time-frame and style as normally takes place with hearing students, but the results in the current case were less marked, due in part to this variable of style.
10. All, not some, hearing-impaired college students can benefit from cognitive skills instruction; the positive changes noted in experimental subjects were general and not limited to those whose pre-test scores or individual characteristics fell in any low, middle, or high range.
11. Cognitive skills instruction must be given a legitimate and administratively supported position within the curriculum for hearing-impaired college students in order for systematic improvement to occur in the thinking patterns of these students.

RECOMMENDATIONS

Based on the findings and conclusions of this study, the following recommendations are made at this time for the implementation of cognitive skills instruction with college-age hearing-impaired students:

1. Wherever possible, cognitive skills instruction should begin at an earlier age than the college age so that college environments can reinforce rather than teach for the first time these essential skills. Colleges should take the leadership in promoting this instruction in secondary schools.
2. While it is administratively efficient to have cognitive skills instruction be the responsibility of one single academic department in which students must take courses (e.g., English), it is far better to have cognitive skills instruction embedded across all subjects and across a number of departments to which students will have exposure. If departments work in a complementary manner in regard to the responsibility for cognitive skills instruction, the burden is spread and the student benefits by seeing the connections of generic cognitive skills to a variety of subject areas.
3. The cognitive skills instruction program in an environment for hearing-impaired college students should be supplemented by a thinking skills laboratory. In such a "lab," students would have an opportunity for reinforcement of the cognitive skills being taught in their regular courses but now on a one-to-one basis with a separate skilled instructor during after-class hours.

4. Instructor training in cognitive skills instruction should take place one full year prior to their being expected to implement it systematically within their subject areas for students.

5. Special workshops for college administrators and department chairs should take place on cognitive education so as to ensure administrative support for faculty who take the "risk" of using valuable course time for incorporation of cognitive skills instruction.

The present investigation, then, has produced some important and potentially useful results, with the caveat that additional and more widespread application and experimentation is (as always) important. It is essential that the educators of hearing-impaired students at all levels, but especially at the college level, now take note that the cognitive potential of such students can indeed be raised--this conclusion is the most essential and hopeful one for the future of the hearing-impaired learner.

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