Technical Report 699

Empirical Status of Feuerstein's "Instrumental Enrichment" as a Method of Teaching Thinking Skills

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Leadership and Management Technical Area

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This paper examines some 35 reports of empirical research on Feuerstein's "Instrument Enrichment" (FIE) as a method of teaching thinking skills, and asks what can be concluded from these reports with respect to the following: (a) the nature and statistical reliability of FIE effects, and, for those effects that are statistically reliable, (b) the "amount" of FIE that appears to be required in order for these effects to appear.

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FOREWORD

The Office of the Deputy Chief of Staff for ROTC (ODCSROTC) asked the Army Research Institute to investigate the possibility of developing a program to enhance the thinking and communication skills of prospective officers. Given the number of civilian programs already in existence purporting to teach such skills, the first steps were to review the published research on those programs which had been subjected to significant experimental testing and to determine which seemed suitable or adaptable for Army use. This report reviews the research on the program that has been subjected to the most testing by far--the "instrumental enrichment" program developed by Israeli psychologist Reuven Feuerstein.

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EMPIRICAL STATUS OF FEUERSTEIN'S "INSTRUMENTAL ENRICHMENT" AS A METHOD OF TEACHING THINKING SKILLS

EXECUTIVE SUMMARY

Requirement:

To provide information to help decide whether Feuerstein's "Instrumental Enrichment" technique (or some variation of it) might be useful in teaching leadership-relevant thinking skills to prospective Army leaders.

Procedure:

This review examines reports of empirical research on Feuerstein's "Instrumental Enrichment" (FIE) technique and asks what can be concluded from these reports with respect to the following: (a) the nature and reliability of FIE effects and, for those effects that appear to be statistically reliable, (b) the "amount" of FIE that appears to be required in order for these effects to appear. FIE research has been conducted in Israel, Venezuela, Canada, and in a number of locations in the United States; altogether some 35 reports of this research are examined. Some of the reports are identified but not discussed on the grounds, for example, that the study was characterized by the authors of the report as a "pilot study" or that the study used intervention procedures other than or in addition to the procedures ordinarily used in FIE programs.

Findings:

1. If one divides the studies that have been reviewed here into two groups--those that tend to show statistically reliable treatment effects and those that tend not to--one finds studies in the first group usually providing subjects with a greater dosage (in the form of instruments and classroom hours) of FIE than studies in the second group. There appears to have been no research on FIE dosage, and it is not clear just what dosage is required to produce what kinds of effects in what magnitude in what kinds of subjects. Also, FIE seems not to "work" unless there is some yet-undetermined minimum amount of training and subsequent support provided for FIE instructors (presumably the amount would vary depending on various individual-difference and situational factors) and some minimum number of hours of student exposure to FIE instruction; but, while these minimums have been speculated about, they have not--as indicated above--been studied systematically. In any event, examination of the studies reviewed here suggests that the following things characterize those studies that tend to show experimental/comparison-group differences:

a. At least a week of FIE training for instructors prior to the first year of FIE teaching--plus follow-up support during the year--and additional training prior to the second year (if there is one).

b. Generally 80 hours or more of student exposure to FIE over a 1- or 2-year period. (Feuerstein has said that 2 to 3 years are required, and several other investigators have suggested that 2 years constitute a minimum.)

c. FIE taught in conjunction with some subject matter of interest and importance to the subjects. Sometimes this was accomplished by having the instructor of a 5-hour course devote, say, 2 days a week specifically to the course subject matter and 3 days a week to FIE (usually with a different instructor teaching the FIE); and sometimes it was accomplished by selecting teachers who had their students for most or all of the school day and having the teacher devote, say, one period each day to FIE.

2. For the most part, the effects observed in these studies have been effects on certain standard nonverbal measures of intelligence (e.g., PMA, Lorge-Thorndike, Cattell, and Ravens)--tests that are largely measures of skill in processing figural and spatial information. A number of other measures have been included in one or another of these studies (e.g., measures of self-concept, classroom behavior, impulsivity, academic achievement, and course content); but effects with these measures have been either absent, inconsistent, or difficult to interpret, and there have been few demonstrations of effects in "real-life" (including academic) or simulated real-life situations.

3. Statistically significant experimental/comparison-group differences have been observed in a number of populations (in four countries, in groups from different social classes, in students classified as hearing-impaired, and in groups considered normal as well as groups considered culturally or educationally disadvantaged). It remains to be determined, however, whether FIE can be counted on to produce treatment effects in all these groups and their associated subgroups. Variables such as age and presence or type of handicap have not been investigated systematically; and, where studies have used a group from a particular age or handicap, information has not been provided in enough detail to allow one to draw conclusions about the relevant populations. With respect to subject age, one can say only that--based on the studies covered in this review--FIE effects have been observed almost entirely in individuals who were in primary or secondary school (and in the 12- to 18-year age range) at the time they were exposed to FIE. A few studies have used college or college-age subjects, but--with one exception that we know about--the intervention used in the studies has been too weak to provide a satisfactory test. This exception, however--since it found significant experimental/comparison-group differences--suggests that FIE may be able to produce effects with individuals who are beyond adolescence.

4. It would be desirable for investigators routinely to collect data on the implementation's completeness--i.e., on both the nature and extent of the implementation that was provided (How many hours of FIE were given and which pages of which instruments were used?) and on the nature and extent of the implementation that was "received" (as indicated, for example, by the magnitude of mastery and near-term effects). Also, our understanding of FIE's ability to produce effects would be increased if investigators routinely controlled and/or provided information concerning naturally

occurring sources of experimental error (e.g., pretraining differences between instructors assigned to experimental and comparison groups).

5. There is enough evidence suggesting that FIE improves thinking skills to encourage researchers to continue investigating it.

EMPIRICAL STATUS OF FEUERSTEIN'S "INSTRUMENTAL ENRICHMENT" AS A METHOD OF TEACHING THINKING SKILLS

CONTENTS

EMPIRICAL STATUS OF FEUERSTEIN'S "INSTRUMENTAL ENRICHMENT" AS A METHOD OF TEACHING THINKING SKILLS

Background and Purpose

In recent years a good deal of interest has been expressed concerning the possibility of teaching thinking skills (Glaser, 1984; Detterman & Sternberg, 1982; Furth, 1970; Lochhead & Clement, 1979; Walsh, 1984), and a number of techniques purporting to teach such skills have been developed (e.g., Bransford & Stein, 1984; Covington, Crutchful, Davies, & Olton, 1984; DeBono, 1975; Furth & Wachs, 1975; Hayes, 1981; Lipman, Sharp, & Oscanyan, 1980; Nisbett & Ross, 1984, pp. 280-286; Vye & Bransford, 1981, October; Whimbey & Lochhead, 1980. For a summary, see Nickerson, 1984, May; Nickerson, Perkins, & Smith, 1985). In most cases, however, these techniques have been subjected little, if at all, to empirical testing by researchers other than the ones who originally developed the technique; and it is often difficult to assess the claims made in their behalf. An exception to this generalization (though the data reported thus far raise a number of questions) is a technique developed by Reuven Feuerstein and his colleagues (Feuerstein, Rand, Hoffman, & Miller, 1980). This technique, which is sometimes referred to as "Instrumental Enrichment" (IE) and sometimes as "Feuerstein Instrumental Enrichment" (FIE)[1]--we have used the latter term in this review--was developed for use with culturally disadvantaged, low-performing Israeli adolescents.[2] The technique (See Appendix for a summary of the underlying theory and a discussion of its application)[3] has two ingredients: (a) a set of 14 (increasingly complex) paper-and-pencil exercises designed to help students identify basic principles of thinking and to practice self-monitoring with respect to the use of these principles and (b) a set of training procedures involving teacher-guided "bridging" back and forth between the principles identified in the exercises and various subject matters of interest.[4] Feuerstein and his col-

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[1]Depending on whether one is referring to the technique as a technique (IE) or to the technique as carried out using the particular set of materials developed by Feuerstein (FIE). At the present time, however, the distinction is largely academic since Feuerstein's materials seem to be the only ones that have been used.

[2]Feuerstein et al (1980, p. 69) make the point that although the materials were developed for use with adolescents, the principles are applicable to all age groups.

[3]Comparisons of FIE with other techniques for teaching thinking skills can be found in Bransford, Arbitman-Smith, Stern, and Vye (1985) and in Sternberg (1985).

[4]Campione, Brown, and Ferrara (1982) suggest that ". . . the actual materials themselves may have less to do with the success of the program than the training procedures" (p. 449). And Haywood et al (1982, August) say " . . . it is possible that what works is a general mediational

leagues have reported that, in a 2-year field experiment, individuals exposed to FIE performed significantly better on a variety of intellectual and behavior measures than a group of matched controls (Feuerstein, Rand, Hoffman, Hoffman, & Miller, 1979; Rand, Tannenbaum, & Feuerstein, 1979); and, on the measure examined, the superiority of the FIE subjects was observable several years after the experiment was over (Feuerstein, Miller, Hoffman, Rand, Mintzker, & Jensen, 1981; Rand, Mintzker, Miller, Hoffman, & Friedlander, 1981). In fact, according to these authors (Feuerstein et al, 1981; Rand et al, 1981), the difference between FIE and control scores was found not simply to have been retained but actually to have increased.

Reports such as these are striking, to say the least; and--based presumably on these reports, the considerable intuitive appeal of the technique's underlying theory, and the fact that a number of individuals not directly involved in this research have spoken favorably either of the technique itself or of the technique's seeming potential (Bruner [in Hall, 1982, January]; Campione, Brown, & Ferrara, 1982; Chance, 1982, October; Glaser, 1982; Hobbs, 1980, April; Sternberg, 1983, February; Ziegler & Berman, 1981)--a number of school administrators and other educators have recommended adopting the technique for use in their school districts or colleges.[5] In view of this fact, and particularly in view of the fact that the Army has recently expressed interest in the technique (e.g., as a way of enhancing leadership-relevant thinking skills in prospective officers - see Russ-Eft et al., 1984; Twohig et al., 1985), it seems an appropriate time to examine the relevant empirical research and to ask what this research has shown with respect to the technique's success in doing what its developers said it was capable of doing.

This review examines reports of empirical research on FIE--journal articles, doctoral dissertations, conference papers, and institutional reports--and asks what can be concluded from these reports with respect to the following: (a) the nature and statistical significance of FIE effects and, for those effects that are statistically significant, (b) the "amount" of FIE that appears to be required in order for these effects to appear. Before proceeding further, however, it may be useful to indicate just how the documents reviewed here were selected, what kinds of reports are not included in the review, and (to assist the reader in assessing the rele-

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teaching style rather than mainly the curriculum and its paper-and-pencil exercises themselves." (p.14).

[5]According to Frances Link (personal communication, 8 September 1984), whose organization (Curriculum Development Associates) provides training and materials for FIE instructors, FIE is currently being used in some 500-800 school districts in 40 states in the United States, as well as in five colleges, and in 15 local education authorities in the United Kingdom. Reuven Feuerstein (cited in Cordes, 1984), whose organization (Hadassah-Wizo Canada Research Institute) also provides FIE training and materials, says that about 30,000 of Israel's 500,000 students are enrolled in programs involving FIE.

vance of negative findings) what conditions the developers of FIE believe are required for adequate implementation. In addition, it may be useful (again, to assist the reader in interpreting the reported findings) to say a word about an issue that is raised (though only implicitly) by most of the studies reviewed here--viz., the issue of what exactly one wants an FIE intervention to show.

Source of documents reviewed. We began by searching Science Citation Index and Dissertation Abstracts International, through December 1984, for publications that cited Feuerstein's major publication on FIE (Feuerstein et al, 1980). We also examined recent copies of American Psychological Association (APA) and American Educational Research Association (AERA) convention programs in search of conference papers reporting FIE research. Finally, we obtained copies of reports cited in these sources as well as reports we learned of from individuals to whom we had sent the first draft of this paper for comment.

Some exclusions. As indicated above, not all the reports we obtained or heard about are discussed in this review. We have not discussed reports (a) where the study was characterized by the investigators as a pilot (Kieta, Pfohl, and Redfield, 1982, March; Martin, 1984a, 1984b, 1985; Messerer, Hunt, Myers, and Lerner, 1984; Russ-Eft, McLaughlin, Oxford-Carpenter, Harman, Zimutis, & Baker, 1984; the first study reported in Haywood and Arbitman-Smith, 1981), (b) where the intervention was not yet complete (Royer and Swift, 1984, August; Rosine Debray, personal communication, 1 February 1985; Mogens Jensen, personal communication, 15 January 1985), (c) where the study (in most cases a pilot) did not include a comparison group (e.g., Jackson, 1984;[6] Redfield, Kieta, Pfohl, & O'Connor, 1983, March), (d) where the study used intervention procedures other than or in addition to the procedures ordinarily used in FIE programs (Beasley, 1984; Jackson, 1984; Waksman, Silverman, & Messner, 1982 [summarized in Waksman, Silverman, & Messner, 1984]), and (e) where the purpose of the study was to investigate effects of FIE on the instructors who were using it rather than on the students who were being taught (Kersh & Cerke, 1984, April; Martin, 1984, November). This last topic is an important one, as Feuerstein et al (1980) have pointed out, but to date there has been very little research on it.

Conditions required for implementation. The developers of FIE (Feuerstein et al, 1980), as well as others who have been associated with them in this research (e.g., Arbitman- Smith, Haywood, & Bransford, 1984; Michael Begab, personal communication, 18 December 1984; Hobbs, 1980, April; Link, personal communication, 7 January 1985; Abraham Tannenbaum, personal communication, 4 January 1985), have pointed out that certain minimum conditions must be provided as part of the FIE implementation before effects of any real significance can be expected. There apparently

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[6]The intervention used in the study by Jackson (1981), which reports a reanalysis of data obtained from the Atlanta public school system, is the only one we have found that used all 14 of the available instruments.

has not been much research focusing systematically on these conditions (e.g., on the "amount" of FIE required to produce an effect of specified magnitude in a specified population); but there appears to be a good deal of agreement that researchers should pay particular attention to certain things and that among them are the following: (a) preliminary and subsequent training of FIE instructors in the theory and method of FIE, as well as follow-up supervision and consultation while the intervention is being carried out; (b) the "dosage" of FIE given to the students, meaning mainly the number of (increasingly complex) FIE instruments gone through but with implications for the number of hours devoted to the implementation as a whole; and (c) the integration of FIE and regular subject matter instruction, which in most cases means having FIE taught by individuals who are involved in regular classroom instruction rather than by someone who comes in just for the FIE. In Feuerstein's original study (See Feuerstein et al, 1980, pp. 325-410), FIE instructors participated in a 10-day workshop before the start of the program and in a second (12-day) workshop before the start of the second year. In addition, throughout the two-year period FIE instructors were supervised in their work and given opportunities for consultation. With respect to "dosage," students in the experimental classes received 3-5 hours of FIE a week for the two years; and during this period they were exposed to 13 of the 14 available FIE instruments. With respect to instructional integration, FIE was taught by individuals who had the students for other subjects as well. Arbitman-Smith, Haywood, and Bransford (1984) have said that FIE is "designed to be taught 300 to 350 hours for a period of 2-3 years" (p. 467) and that, in order to realize significant gains, "necessary. . . investment may be in the range of 75-100 hours in an academic year" (Haywood et al, 1982, August, p. 13). Frances Link (personal communication, 3 May 1985) has said that what is desired is to go through all 14 of the available instruments and that, depending on the abilities of the students,[7] doing this can take from 1-3 years.

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[7]Bransford (personal communication, January 1985) has made the point that ". . . the question of <u>who</u> is being taught and tested is extremely important. It undoubtedly interacts with the number of hours of instruction needed and perhaps even with what it means to 'deliver effective instruction.'" More generally, FIE researchers seem to be saying (a) that FIE is designed to provide a particular thing for those individuals whose prior experience has been deficient in it--what Feuerstein and his colleagues call "mediated learning experience" (For a discussion, see Bransford et al, 1985, pp. 181-185; Feuerstein et al, 1980, pp. 13-70; Passow, 1980, May)--and (b) that to the extent that particular individuals do not have the deficiences addressed in FIE, they would not be expected to show improvement after exposure to the program. In addition, Haywood et al (1982, August, p. 14) suggest that it may be useful to spread out the program for very slow-learning students, giving many hours of instruction on a few pages and exercises and taking longer to cover the whole program.

The issue of what an FIE intervention should show. FIE is primarily designed to improve cognitive performance; and, in view of the fact that there already exist a number of standardized measures of such performance--many with satisfactory reliabilities--it would seem entirely appropriate to employ such measures as part of an effort to evaluate the effectiveness of FIE.[8] And, in fact, most evaluations of FIE have used one or more such measures (e.g., Thurstone's test of Primary Mental Abilities). Most users (or potential users) of the FIE program, however, will probably want to see more general transfer-of-training effects. They will want, for example, to see improved performance in academic areas and in other "real life" situations. Given the difficulties in designing and interpreting measures of such effects,[9] however, researchers have usually opted for standardized paper-and-pencil tests (sometimes supplemented with other measures that sought to provide at least tentative evidence of wider transfer-of-training effects) and have used the results of these tests to judge whether or not FIE had had an effect. With respect to the issue of what one wants or expects an FIE intervention to show, clearly one would like to see something more than "simply" a set of comparisons on paper-and-pencil measures of general intelligence. As to whether the results of such comparisons are viewed as providing evidence about the effectiveness of FIE, however, we leave it to the reader to judge.

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[8]Sternberg (1984) has argued that standard paper-and-pencil intelligence tests can be good predictors of general cognitive performance, although these are not the only types of tests he would recommend.

[9]In the case of academic performance, for example, measures are usually available or can be constructed, but performance on the measures is usually dependent on acquired knowledge as well as cognitive skills. In the case of success in "real life" pursuits, the necessary data often require a long-term longitudinal research effort; and while follow-up measures of behavior in "real-life" tasks have been developed, their reliabilities are seldom known. (An exception in the present set of studies is the classroom participation scale developed by Abraham Tannenbaum--see below.) Such problems, however, are not peculiar to evaluations of FIE and indeed plague all research in the area of cognitive skill training.

REVIEW OF FIE RESEARCH

The Israel Studies

The first study, which was conducted in Israel in the early 1970s (Feuerstein et al, 1979; Rand et al, 1979)[10] was a two-year field experiment using what Cook and Campbell (1979) call an "untreated control group design with pretest and posttest." In this design, subjects--in the present instance, groups of subjects--are assigned on a basis other than random to experimental and control conditions, are given a pretest, and then (after an experimental intervention) are given a posttest. Analysis of treatment effects uses either (as here) a covariance design or (as in some of the other studies discussed) a repeated-measure design, with "time of testing" being included in the design as an independent variable.

The experiment was carried out at two remedial/vocational education centers--one a residential center, the other a day school--that the Israeli government had established to provide special education for adolescents who, because of their special histories as well as their scores on various socioeconomic and ability measures (cf. Feuerstein et al, 1980; Peleg & Adler, 1977), had been characterized as "culturally disadvantaged."[11] At each center two groups of classes were identified. One group (consisting of the experimental classes) was to receive approximately 45 minutes of FIE 3-5 days a week for two years (estimated total of 200-300 hours) as an adjunct to "the usual Aliyah curriculum," which the investigators refer to as "general enrichment" (GE). The other group (consisting of the control classes) was to receive only the GE.[12] During the first year of the experiment, the total number of FIE classes was 18 (7 at the residential center and 11 at the day school); and during the second year, the number was 10 (4 at the residential center and 6 at the day school).[13] At one time or another during the two years of the experiment, some 515 students ages 12-15 were enrolled in these four (two FIE and two GE) groups; but--because there were some students who entered these groups after the experiment had started and because there were some who left before it was over--only 218

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[10]These two articles report the same study. The main difference between them is that one of the articles (Feuerstein et al, 1979) includes data from after-only as well as from the pretest-posttest measures, while the other article (Rand et al, 1979) includes only the latter. This study--including the after-only data--is also reported in Feuerstein et al, 1980, Chapter 10.

[11]Feuerstein et al (1980) distinguish this condition and its associated problems from the condition and associated problems of being "culturally different" (p. 13f).

[12]It is not clear from the reports of this study just what procedure was used in designating these groups as "experimental" and "control".

[13]The corresponding ns for the control group are not reported.

of the students (114 FIE and 104 GE) were present for the full 2-year period.[14] From this set of 218 students, which Feuerstein et al (1980) refer to as the "population," the investigators selected 114 (57 matched pairs) to serve as the sample for the study; and it is the data from these 114 that were analyzed and reported in this first study.[15]

The amount of training and supervision given to the FIE instructors appears to have been considerable. According to the investigators (cf. Feuerstein et al, 1980), these instructors took part in one (10-day) workshop during the first year and another (12-day) workshop during the second year; and, in addition, they were visited regularly for consultation and supervision throughout the two years of the experiment. The instructors taught their students both in the FIE classes and in other (academic subject matter) classes as well; and in most classes the instructor got through 13 of the 14 available instruments.

Data were analyzed by means of a treatment (FIE vs GE) x location (residential vs day school) analysis of covariance; but since the residential-nonresidential variable produced almost no effects, it will not be considered further in the present review.[16] For those measures that were administered both pretest and posttest (Thurstone Primary Mental Abilities Test, Project Achievement Battery, two classroom participation scales, and the 3-factor Levidal Self-Concept Scale), the pretest score was used as the covariate; and for those measures that were administered only as a posttest (Witkin Embedded Figures Test, Human Figure Drawing Test, Kuhlmann-Finch Postures Test, Lahy Test, and the D-48 Test), the subject's pretest score on Thurstone's PMA (sometimes combined with another measure) was used as the covariate. Reliability coefficients are not reported, but the authors say (Feuerstein et al, 1979, p. 544) that the measures "yielded satisfactory reliability coefficients that are reported elsewhere (see Feuerstein & Rand, Note 2)."

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[14]The reports do not provide data on drop-out rates from the original experimental and control groups.

[15]At each of the two facilities, pairs of students were identified--one student from the experimental group and one form the control group--who were alike in sex, ethnicity, and pretest score on Thurstone's Primary Mental Abilities (PMA) Test.

[16]On the Terman Test there was, in addition to a treatment main effect, an interaction indicating that the treatment variable made more of a difference at the residential center than at the day school. On the Reading Comprehension subtest of the PMA there was also an interaction (though no main effect), but the pattern for that interaction is not described. Finally, a subscale from one of the two classroom interaction scales (the one that showed no main effects of FIE-see text) showed an interaction; but this interaction is not described either.

With respect to the pretest-posttest data, analysis of covariance showed that the FIE group had higher scores than the GE group on the PMA, both on the total score (approximately 173 vs approximately 164)[17] and on each of the eight subtest scores; and the difference is statistically significant in the case of the total score and three of the subtest scores ("Numbers," "Addition," and "Spatial Relations"). On the Project Achievement Battery, a set of specially-prepared measures of scholastic achievement in eight areas, FIE subjects scored higher than GE subjects in six of the eight areas; but only one of the measures (Bible) was statistically significant.[18] On the two sets of classroom interaction scales (Tannenbaum & Levine, 1968), the data were mixed: In one set, FIE students scored higher than GE students on all three subscales (significantly higher on two of them); but in the other set, the two groups did not differ on any of the subscales.[19] Finally, on the Levidal Self-Concept scale, there were no significant differences between the two groups on any of the three factors (failure at school, motivation for learning, and confidence in personal success).

With respect to the posttest-only data, the analysis of covariance (PMA pretest as covariate) showed that on two measures of general intellectual ability (Terman nonverbal IQ and the D-48, which is a nonverbal analogies test) FIE subjects scored significantly higher than GE subjects, while on the third measure (Porteus Maze Test) there was no significant difference between the two groups. On the measures of specific abilities (Embedded Figures Test, which is viewed as a measure of perceptual discrimination; Human Figure Drawing Test, which is viewed as a measure of psychological differentiation; Postures Test, which is viewed as a measure of spatial orientation; and the Lahy Test, which is viewed as a measure of rapidity-precision), FIE subjects performed significantly better than GE subjects in almost every instance.

Approximately two years after the conclusion of the study, Feuerstein and his colleagues (Feuerstein et al, 1981; Rand et al, 1981)[20] analyzed some test scores that the Army provided them for 184 individuals from

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[17]The reports by Feuerstein et al (1979) and Rand et al (1979) give slightly different figures for two of the PMA subtests and the total.

[18]The authors make the point that, although the FIE subjects did not perform any better than the GE subjects on the Project Achievement Battery, they performed just as well and did so in spite of the fact that they had received some 300 fewer hours of academic instruction (the hours devoted to FIE) than the GE subjects had received (cf Feuerstein et al, 1980, p. 369).

[19]According to Abraham Tannenbaum (personal communication, 4 January 1985), one of the scales (the one that showed reliable treatment effects) has an estimated reliability of .90 while the other (the one that did not show reliable effects) has an estimated reliability of .79.

[20]This study, like the previous one, was reported twice.

the original population who now were in the Army.[21] One of the tests for which scores were provided was the Dapar, which the authors describe as a 2-part instrument consisting of "(1) a verbal intelligence test similar to the. . . Army Alpha Test and (2) a figural intelligence test similar to the Raven's Matrices Test" (Rand et al, 1981, p. 143).[22] Using subjects' scores on the Dapar as a dependent measure, the authors performed a series of three analyses.

In the first analysis the subject's PMA pretest score was used as a covariate, and the investigators performed a covariance analysis on the Dapar test scores and found that those who had been in the FIE group scored significantly higher (about two-thirds of a standard deviation higher, on the average) than the ones who had been in the GE group.[23]

In the second analysis the investigators cast the total group into a 2x2x2 matrix according to (a) whether subjects had been through FIE or GE, (b) whether their pretest PMA scores were above or below the median for the group as a whole, and (c) whether their Army Dapar scores were above or below the Armywide mean (which was also the cutoff point for selecting individuals to become officers).[24] A chi square analysis of the cell frequencies indicated that significantly more experimentals than controls were in the top half of the Dapar distribution, and this was the case both for those who were in the top half of the (PMA) pretest distribution and for those who were in the bottom half.[25]

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[21]The authors do not say how many of the 144 (57 matched pairs) who provided the data for the original study are included in the 184.

[22]The authors do not report separate scores for the verbal and nonverbal parts of the Dapar.

[23]One of the reports of this study (Rand et al, 1981) presents data from three other measures that were administered by the Army, while the other report (Feuerstein et al, 1981) does not. We have chosen not to discuss these other data on the grounds (a) that their relevance is not entirely clear and (b) that the measures used in collecting these data do not seem to have been entirely objective.

[24]Splitting scores into those that were above and below the Armywide mean put 93 in the top group and 91 in the bottom group.

[25]Of the GE students who were in the top group on the PMA pretest (n=58), approximately 57% were in the top group on the Dapar also; but of the FIE students who were in the top group on the pretest (n=34), some 88% were also in the top group on the Dapar. Of the GE students who were in the bottom group on the PMA pretest (n=31), approximately 87% were in the bottom group on the Dapar also; but of the FIE students who were in the bottom group on the pretest (n=61), only 54% were in the bottom group on the Dapar also.

In the third analysis the authors sought evidence on what they termed the "divergent effects hypothesis," the hypothesis that FIE effects do not only not disappear but actually increase over time. The authors sought to test this hypothesis using a procedure that unfortunately is described in only one or two sentences. Apparently, however, the procedure involved identifying individuals (n=163) for whom scores were available for all four test periods (pretest [PMA], first-year posttest [PMA], second-year posttest [PMA], and follow-up [Dapar]), standardizing subjects' scores on PMA and on Dapar, computing difference scores at each of the four time periods, and performing a trend analysis on these differences.[26] The result of this analysis, which the authors report in a single sentence, was that "The obtained linear function was confirmed by trend analysis, which yielded a highly significant ($p<.000$) linear trend and no significant quadratic trend." (Feuerstein et al, 1981).[27]

This study is interesting--particularly in its use of nonverbal measures of intellectual abilities, its effort to measure overt behavior in a nontest situation, and its effort to follow-up subjects some two years after the intervention had ended. The results of the study, however, lend themselves to more than one interpretation. Examination of experimental/control-group differences show that these differences tend to be larger and more clear-cut on those measures (e.g., the PMA subtest on spatial relations, the D-48, and the Embedded Figures Test) that are most similar in content to the FIE materials used in the intervention; and one must ask (particularly with regard to the measures of intellectual ability) whether the study produced anything more than near-transfer or "practice effects" (cf. Anastasi, 1981; Messick & Jungeblut, 1981)--i.e., whether the real effect of the intervention was simply to improve subjects' ability to solve problems of the type found on tests such as those used in the study.[28] The study did include measures of behavior in a nontest situation (classroom participation scales); but these measures were apparently not independent, and if this is the case they cannot be viewed as providing evidence concerning behavioral effects of FIE. The follow-up data are consistent with the idea that FIE effects (however they are interpreted) are lasting, but the fact that pretest and posttest data were obtained with different instruments introduces at least a degree of uncertainty. There are also the more general questions of what one does about the increased probability of Type-1 error when multiple F tests are performed (we counted over 100 in the present study) and whether observed experimental/control-group differences--even where statistically reliable--are large enough to warrant sci-

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[26]Some things about the analysis are not clear. For example the authors imply that these difference scores were obtained from matched pairs of subjects but do not explain why the N used in the analysis is an odd number.

[27]The corresponding statement in the other report of this study (Rand et al, 1981) is similar.

[28]A similar concern is expressed by Bransford et al (1985) and by Campione, Brown, and Ferrara (1982).

entific or educational attention (cf Bradley, 1983). Finally, there is the question of how one should interpret the study's failure to find statistically significant effects on measures (e.g., the majority of the PMA subtests and the three self-concept measures) that one would have expected to show such effects. In the case of the self-concept measures, for example, the authors have elsewhere said (Feuerstein & Jensen, 1980, May) that one of the program's subgoals "consists in changing drastically the student's perception of himself or herself from a passive recipient of information to an active producer, creator, and generator of new information. This as probably the central goal of our program..." (p. 429)[29]

What then can be said about the results of these two (initial and follow-up) studies? Taken together, the reports of these studies are striking and suggest the possibility (at least with culturally disadvantaged students) that FIE is capable of producing some lasting improvement in the ability of some students to do well on at least some measures of intellectual ability. As indicated above, however, such things as the seeming relationship between FIE-material/dependent-measure-material similarity and the magnitude or statistical significance of treatment effects--plus the absence of some effects one would have expected to find--indicate that these results can be interpreted in more than one way.

The Venezuela Studies[30]

In a replication of the original Feuerstein study (Feuerstein et al, 1979; Rand et al, 1979), Ruiz and Castaneda (1983) administered FIE to a sample of Venezuelan children, ages 10-14, over the two-year period 1980-82. From the population of public and private schools in the city of Guayana the investigators randomly selected 12 schools--six considered high SES and six considered low--and in each group randomly assigned the schools to experimental and control conditions. Some of the schools had more than one class at the desired (fifth grade) level, and in each of the four (FIE/control x low/ high-SES) cells there were three schools/four classes. Instructors for the eight FIE classes (one instructor for each class) were given special training; and over the following two years these instructors devoted one hour each day five days a week to FIE, making a total of about 275 hours (11 FIE instruments) altogether. Except for this daily one hour of FIE, experimental and control classes were exposed to the same (standard) fifth-grade (and, later, sixth-grade) curriculum.

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[29]There are also the more general questions of how one interprets data statistically when there has been no random assignment (in the case of many of the measures used, no pretest either) and how one deals with the absence of data on experimental attrition and on the psychometric properties, in the subject population, of the measures used. These latter questions, however, could be asked of most of the studies discussed in this review.

[30]Some of the information presented here was provided by Ruiz in personal communications, 19 April 1985 and 28 May 1985.

Subjects were tested and (two years later) posttested on (a) the Cattell-2 intelligence test (in the subject population, reliability estimates for the total test range from .82 to .87), (b) the BARA test (a combined language and math achievement test which in the subject population has reliability estimates of .70 and .80 for the language and math subtests and .85 for the total), (c) a three-factor (personal, social, intellectual) self-concept inventory (overall reliability estimated for the subject population is .91), and (d) a three-factor (adaptiveness to work demands, self-sufficiency, and interpersonal conduct) classroom-participation scale[31] filled out on the students by their teachers and by visiting supervisors (total test reliability estimate in the subject population is .91). In addition, the authors constructed an index of socioeconomic status (SES); and, based on responses to the items making up the index, subjects were classified as high-vs-low in SES. At the end of the two-year period the investigators, separately within each SES category, selected pairs of students--one from an experimental class and one from a control class--who were similar in age, sex, SES, and pretest score on the Cattell-2 test. The result of this pairing was that there were 170 pairs in the high-SES group and 148 pairs in the low-SES group, making a total of 636 subjects altogether. Data were analyzed by analysis of covariance, with Cattell-2 pretest scores (and age) being used to adjust dependent-measure scores on the Cattell-2 and BARA tests, with self-concept pretest scores being used to adjust dependent-measure scores on the self-concept inventory, and with classroom-participation pretest scores being used to adjust dependent-measure scores on the classroom-participation scales. The covariance analyses indicated that FIE subjects scored significantly higher than controls on the Cattell-2, the BARA, and the classroom-participation measures. FIE subjects also scored higher than controls on the combined three-factor self-concept measure; but no one of these factors, by itself, showed a significant treatment or interaction effect. In the case of the BARA test there was an interaction indicating that the treatment effect was clearer in the high-SES than in the low-SES group, and the simple effect for the low-SES group was not significant. And on each of the three classroom-participation factors there was an interaction indicating that the treatment effect was clearer in the low-SES than in the high-SES condition, but here the simple effect was significant in both SES groups.

In 1983 and again in 1984--one and two years after the end of the intervention--the investigators collected follow-up data on those of their original 636 subjects who were still available (Ruiz, 1985a). These subjects (234 in 1983 and 180 in 1984) were given the Cattell-2 test, the Lorge-Thorndike test of general intelligence (non-verbal, level 4), and the D-48 (described as a non-verbal test of ability to conceptualize and apply systematic reasoning to new problems). As indicated above, the Cattell-2 is a non-verbal test of general intelligence and is generally viewed as

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[31]This was a combined adaptation of the two classroom participation scales that were used in the Israel study. According to Ruiz (personal communication, 28 May 1985), the median inter-rater agreement across several measuring situations was .79.

having satisfactory reliability estimates. The Lorge-Thorndike, level 4, consists of three subtests: figure classification, number series, and figure analogies. Reliability estimates in the subject population range from .77 to .92, and its correlation with other intelligence tests ranges from .79 to .81. The D-48 has reliability estimates ranging from .85 to .91.

In 1984, the investigators selected from those former subjects who were still available (separately within each SES group) pairs of subjects--one who had been in one of the experimental classes and one who had been in one of the control classes--who were similar in age, sex, and score on Cattell-2 (total N=114). These 114 (57 pairs) were the subjects who provided data for the three analyses that made up the second-year follow-up study.

First analysis. A covariance analysis was performed on the second-year follow-up scores on the Lorge-Thorndike and the D-48, with Cattell-2 pretest score (and age) used as a covariate. The results indicated significant treatment effects on the Cattell-2 and the Lorge-Thorndike but not on the D-48; and while there was a main effect of SES on all three variables, there were no treatment x SES interactions.

Second analysis. Following the general procedure used by Feuerstein (Feuerstein et al, 1981; Rand et al, 1981), the investigators classified their 57 (matched) pairs as high-vs-low on the Cattell-2 pretest (using the mean as the cutting point) and, within each group, classified individual subjects as high-vs-low on the Lorge-Thorndike follow-up measure (again using the mean as the cutting point). As in the Israel follow-up study (Feuerstein et al, 1981; Rand et al, 1981), a chi square analysis of the cell frequencies indicated that significantly more of the experimentals than controls were in the top half of the follow-up distribution, and this was the case both for those who were high on pretest scores and for those who were low.[32]

Third analysis. To provide evidence on the divergent effects hypothesis the authors did the following: (a) identified subjects' scores from four testing periods (Cattell-2A pretest, Cattell-2B posttest, Lorge-Thorndike first-year follow-up, and Lorge-Thorndike second-year follow-up), (b) converted to z-scores the raw scores obtained on each of these tests, (c) computed an FIE-minus-control difference score for each of the matched pairs at each of the four test periods, and (d) performed a trend analysis.

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[32]Of the control subjects who were in the top group on the pretest (n=25), 44% were in the top group on the follow-up measures also; but of the FIE subjects who were in the top group on the pretest (n=25), 80% were in the top group on the follow-up. Of the control subjects who were in the bottom group on the pretest (n=32), 69% were in the bottom group on the follow-up measure also; but of the FIE subjects who were in the bottom group on the pretest (n=32), 34% were in the bottom group on the follow-up.

The authors report the results of this analysis (the relevant descriptive statistics are not presented) by saying that the linear component is statistically significant ("$p<.000$") but the quadratic component is not.

In 1982 FIE was administered to a sample of post-secondary-school students who were enrolled in remedial math and language courses at the Guayana Technical Institute and who had an average IQ of about 85 (Ruiz, 1985b). These students ($n=86$) were randomly assigned to experimental (FIE) and control (non-FIE) classes (one class in each case), with the experimental group receiving an hour of FIE each day during the 17-week semester (about 85 hours total). FIE was taught by three specially-trained instructors (not the regular classroom teachers) who had taken part in an earlier study (Ruiz & Castaneda, 1983). These instructors rotated in the teaching of the FIE classes, with each instructor being used every third day. Nine of the 14 FIE instruments were used, the nine being grouped into blocks of three, and each day the instructor used a page from each of the instruments in a given block. The blocks were rotated throughout the semester, the sequence being blocks 1, 2, 3, 1, etc. The rest of the time (i.e., the time not devoted to FIE teaching) was spent in regular remedial classes. Subjects were pretested and posttested on the Cattell-2 test of general intelligence; and posttest scores were subjected to an analysis of covariance, with pretest scores serving as the covariate. Experimental subjects scored significantly higher than controls.

The Venezuela studies are similar in many respects to those conducted in Israel (Feuerstein et al, 1979; Feuerstein et al 1981; Rand et al, 1979; Rand et al, 1981). There are, however, some important differences. First, the study was conducted in a different country with a different culture and traditions. Second, although the basic replication was conducted with students approximately the same age as the students who got the FIE intervention in the Israel studies (i.e., approximately 12-15), one of the Venezuela studies was conducted with post-secondary-school students and thus provides some evidence about possible effects in a somewhat older group. Third, with respect to the basic replication, the subjects used in the Israel studies came from a culturally disadvantaged population while the subjects used in the Venezuela studies (or, rather, the schools attended by these subjects) were selected randomly from the total set of schools in the city. As for the results of the Venezuela studies, they are generally consistent with those found earlier in the Israel studies. FIE control differences were again found on a non-verbal (though different) measure of general intelligence; and, on two of the three follow-up measures of intelligence, group differences were observable some two years after the end of the intervention. And, as before, the authors report that a trend analysis shows differences that do not simply not disappear over the four-year period but actually get larger. The Venezuela study found a fairly clear effect on the achievement test while the Israel study did not, but there are some possibly important differences between the tests used in the two studies. The Israel study used what might be referred to as an "omnibus" achievement test (general knowledge, Bible, geometry, reading, arithmetic, etc.) whereas the Venezuela study used a test consisting of only two (math and language) subtests. Finally, the Venezuelan adaptation

of the classroom participation scale used in the Israel study found clear and consistent effects favoring the FIE group. Again, however, this measure appears not to have been independent and cannot for that reason be viewed as providing evidence regarding FIE. Taken as a whole, the results of the Venezuela studies (like the results of the Israel studies) are striking and suggest the possibility that FIE can produce lasting improvement in some students' ability to do well on at least some nonverbal measures of intelligence. As indicated above, however, these results can be interpreted in more than one way.

Studies from the Nashville Center

A programmatic effort consisting mainly of several one-year studies[33] (plus a pilot study and several studies investigating the locus of cognitive change, which we have not discussed here) was carried out by a group of individuals associated with the John F. Kennedy Center of Vanderbilt University. Data were collected in classes of various sorts in Nashville, Louisville, and Phoenix, although in most cases data from two or more studies are presented in a single report. The reports of these studies (Arbitman-Smith, 1980; Arbitman-Smith, Haywood, & Bransford, 1984; Haywood & Arbitman-Smith, 1981; Haywood, Arbitman-Smith, Bransford, Delclos, Towery, Hannel, & Hannel, 1982, August) vary in their completeness; and none of these reports provide all the information needed for full understanding.[34] Essentially, however, the studies were carried out on students,

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[33]According to the investigators, several of these (one-year) studies were intended to be simply the first year of a two-year study. The investigators write: "Unfortunately for us, the Nashville public school system has been undergoing some upheaval, and it has been extremely difficult to continue classes intact for the second year of IE; therefore, we have repeated the first year with a succession of different groups and have very few data on the two-year program" (Haywood et al, 1982). It should be noted also that these investigators conducted a number of smaller studies (cf. Arbitman-Smith et al, 1984; Haywood et al, 1982, August) seeking to assess FIE recipients' mastery of the materials and procedures they had been taught as well as their ability to apply these principles to everyday problems and tasks. In one study (Haywood et al, 1982, August, pp. 17-18), for example, EMR students were given either no FIE ($\underline{n}$=10), ten hours of FIE ($\underline{n}$=10), or 67 hours of FIE ($\underline{n}$=10), and then given a behavioral measure of task persistence. Examination of the resulting data indicated that the 67-hour group persisted longer and worked more efficiently than the 10-hour group, which in turn persisted longer and worked more efficiently than the no-FIE group, and that the set of differences was statistically significant. Studies like these are valuable, although interpretation is difficult because of the absence of information about how the three groups were formed and whether the overall trend and/or the individual contrasts are significant.

[34]It is not always clear in particular studies, for example, how many of the FIE instruments were used, how many subjects were involved, which dependent variables were measured, how large an effect a given difference

ages 11-15, whose mean educational achievement was 2-7 years below what would be expected for students of their age. The design, which included type of disability as a classification variable, appears in the main to have been what Cook and Campbell (1979) call an "untreated control group design with pretest and posttest."[35]

FIE instructors at the three sites were all given about the same amount of training (80-plus hours before the start of the school year as well as follow-up supervision and consultation). In certain respects, however, the studies conducted in Phoenix were different from those conducted in Nashville and in Louisville. In the first place, in Phoenix the FIE classes were taught by regular classroom teachers who during the rest of the day taught the students in other classes also, while in Nashville the practice was to use "itinerant" FIE teachers, who in most cases had the students only for FIE (It is not entirely clear which of these practices was followed in the Louisville studies.) In the second place, at the schools in the Nashville Study, the investigators said they were unable to get much more than 50 hours of FIE, "while in the other sites, especially in Phoenix, a minimum of 80 hours--and often many more--has been the rule" (Haywood et al, 1982, p. 21). In the third place, the subjects in Phoenix--most of whom were children of Mexican-American migrant farm workers--"most closely resembled the Israeli immigrant population on which Instrumental Enrichment was developed and originally tested" (Haywood & Arbitman-Smith, p.132).[36] Since these differences were thought by the in-

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represents, or what the effects were (if any) of experimental attrition. Also--although "type of disability" was usually included in the design as a independent variable--data are not provided on the statistical reliability-unreliability of treatment x type-of-disability interactions.

[35]In designs of this type a main effect of treatment appears as a 2-way (treatment x time-of-testing) interaction, whereas in designs of the type used in the Israel studies it appears simply as a main effect. As noted above, however, many of the Nashville studies included a subject variable--type of disability--in addition to the treatment and time of testing. At the Nashville site the experiment was conducted with four experimental and control subgroups (educable mentally retarded, learning disabled, varying exceptionalities, and behavior disordered), and at the Phoenix site it was conducted with one experimental and two control groups (control-tutored and control-nontutored). At one of the schools used in one of the Nashville studies, students were assigned to FIE and control groups by means of a systematic procedure (See Arbitman-Smith & Haywood, 1980, p. 58), although in most cases this was apparently not the case.

[36]There was apparently a fourth difference--in the way students at the two (sets of) locations were assigned to FIE and non-FIE groups. At the Phoenix site, "administrative policy was to assume that FIE would be an effective remedial treatment and therefore to assign lowest-achieving students to IE, with the result that the initial scores on criterion instruments always favored the comparison groups" (Haywood et al, 1982, August, p.11). Because of this fact, at least some of the post-treatment differences at

vestigators to have been responsible for the differences between the results obtained in Phoenix and the results obtained in Nashville and Louisville (Haywood, Arbitman-Smith, & Bransford, 1982), the data collected at the two (sets of) locations will be discussed separately.

Data collected in Phoenix. The students who took part in this study (N=70 during the first year) were, as indicated above, mostly the children of migrant farm workers; and during the first year those in the experimental group received more than 80 hours of FIE from teachers who taught them in other classes also. On the two measures administered, the Lorge-Thorndike Nonverbal IQ and the Ravens Matrices, FIE students consistently showed greater gains than the control groups with which they were compared; and with one exception (gains on the Lorge-Thorndike in the tutored controls) the difference is statistically significant. During the following year (the N was now down to 36) examination of the data showed that the previously-observed differences between FIE and controls were still in evidence.

Data collected in Nashville and Louisville. As part of the same study that collected data in Phoenix, data were also collected in Nashville (N=47) and Louisville (N=98). This study found no consistent effects on either the Lorge-Thorndike or the Reasoning subtest of the PMA, the two tests of general intelligence that were used, or on any of several other measures that were administered. In a second Nashville study (N not specified) reliable effects were not found on PMA but were found on (a) Ravens Matrices and (b) four of the five subtests of the Woodcock-Johnson Psycho-Educational Battery, the fifth being Perceptual Speed. The authors comment that the failure to find significant effects on this subtest is not surprising since FIE students are explicitly taught to "stop and think." Two years later--the N was now down to an unspecified number--follow-up measures found no experimental-control group differences.

Conclusions. Although these studies appear to have been both well-conceived and well-designed, one cannot--because of the great variability in outcomes and the fact that not all the information needed for full interpretation is provided--be very confident in drawing conclusions about them. One is inclined, however, to agree with the investigators that the differing procedures used at Nashville and Louisville, on the one hand, and at Phoenix, on the other, were instrumental in producing the differing patterns of results at the two (sets of) locations. What these patterns suggest is that FIE can improve performance on standard nonverbal-IQ-type measures (a) when it is used by teachers who are also teaching the students in some other subject and are thus able to apply the relevant principles ("bridge") to some subject matter that has its own identity and (b) when students get a significant degree of exposure (perhaps 80 hours or more in a given year). Neither of these conditions was found in the Nashville studies, and at least one of them was absent in the Louisville studies, and it is therefore not surprising that at these sites FIE effects were gener-

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this site could be attributed to differential experimental regression.

ally inconsistent or nonexistent. Both of the conditions, however, were found at the Phoenix site, where results consistently favored the FIE group.

Other Nashville Studies

Hall (1982) set up three groups consisting of students, age 12 and older, who were enrolled in a special education program in the Nashville/Davidson-County Public Schools. One group (3 classes, total $\underline{n}$=33) was given FIE; a second group (6 classes, total $\underline{n}$=55) was given an intervention called "social learning curriculum" (SLC), and a third group (6 classes, total $\underline{n}$=55) was given its usual program and considered a comparison group for the other two. Regular class instructors were given FIE training (amount of time not specified) in a workshop that met before and also during the intervention, which continued for the full school year; and FIE students, going through a total of four FIE instruments, received FIE instruction one period a day each day, making about four hours a week altogether. Data were analyzed by analysis of covariance, with pretest scores on the various dependent variables being used as covariates. FIE students showed significantly greater gains (i.e., greater reduction in the number of errors) than the comparison students on the Matched Familiar Figures Test and on the general information subtest of the Peabody Individual Achievement Test; but there were no effects on the Ravens Progressive Matrices, the Test of Social Inference, a nonstandardized "test of social knowledge," and the Piers-Harris Children's Self-Concept Scale. The author comments that the absence (as well as the presence) of effects is difficult to interpret because of the fact that none of these measures were standardized on subjects like the ones included in this study.

McRainey (1983), who studied not thinking skills but social outcomes, arranged to have the University School of Nashville devote one of its enrichment classes ($\underline{n}$=17) to FIE and to use an enrichment class in dramatic arts ($\underline{n}$=19) as a comparison group. Pretest scores on the Ravens indicated that the two groups were not significantly different on that measure. There were approximately 30 40-minute class sessions; and, altogether, the FIE group received about 20 hours on four of the FIE instruments. At both the beginning and the end of the course, students' social behavior was rated (pretest $\underline{r}$=.89) by the FIE and dramatic arts teachers as well as by other teachers who taught the students in other courses. When judged by the FIE and dramatic arts teachers, experimental subjects showed significantly more improvement than the comparison students; but when judged by the students' other teachers, the two groups did not differ significantly. In other words, where teachers' ratings of their students were neither disinterested nor independent, experimental/control-group differences were found; but where these ratings were at least disinterested--we are not told whether they were independent--such differences were not found. A second measure was a classroom environment scale consisting of 90 true/false statements (information about the scale's psychometric properties was not provided) to be responded to by the students. Pretest-posttest comparisons on this scale showed no experimental effects.

What can be said about the results of these other Nashville studies? In one case (Hall, 1982) the results are mixed; but this fact is difficult to interpret because--as the author acknowledges--the tests were not standardized on individuals like the ones in the present experiment. Also, the number of FIE instruments used was only four; and the adequacy of the instructor training period is difficult to assess. In the other case (McRainey, 1983) the author was studying not thinking skills but "social outcomes," and in that study--possibly because of the relatively small amount of exposure to FIE (20 hours and 4 FIE instruments)--there were no easily interpretable effects.

Studies from Toronto

In a study conducted with 150 ninth-grade students at a "city-core, multi-ethnic" school in Toronto, Graham (1981) assigned classes in remedial-English ($\underline{n}$=2) and common-English ($\underline{n}$=4) to FIE and control conditions,[37] with FIE classes ($\underline{n}$=3) getting three hours a week of FIE and two hours of remedial or common English for the duration of the school year. Control classes ($\underline{n}$=3) received remedial or common English five days a week. During the course of the year the experimental subjects were exposed to a total of six FIE instruments. Each teacher taught only one (FIE or control) class; and the author began, appropriately, by testing the data for between-teacher and between-class effects. Based on the results of this testing, the author decided that some of the dependent measures (those that had shown such effects) could not be used. The remaining data, which the author analyzed with some misgivings, were examined by means of a covariance design, with pretest scores used as covariates. The results of this analysis showed FIE students scoring reliably higher than controls on the remaining measure (Lorge-Thorndike, test 3) and five times as many FIE students as controls reaching the ceiling for this test.

In a second study, Yitzhak (1981) administered FIE to learning-disabled students, ages 14-16, at each of two vocational high schools, with other learning-disabled students at these schools serving as controls. The FIE students, who were given FIE by their regular classroom teachers, were exposed during the year to a total of four instruments (number of FIE hours not indicated). The total $\underline{N}$ for the two schools was initially 66, but by the end of the year the number had dropped to 51. FIE effects, which were measured on Piaget-type conservation tasks using multivariate and univariate analyses of covariance, were not significant.

Narrol, Silverman, and Waksman (1982) administered FIE to five classes of low-performing vocational high school students, with four other classes at these schools serving as controls. The total $\underline{N}$ was 102, with one of the control classes serving as a comparison for two of the experimental classes. Experimental classes received one hour of FIE each day five days

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[37] Graham (1981) says that the school administration assigned students to the various English classes (presumably within class type) but does not say how these classes were then designated as experimental and control.

a week for the school year, and during the year they were exposed to a total of four FIE instruments. Data were obtained, using a covariance design, on Lorge-Thorndike (level 3), PMA (letter series), the Piers & Harris self-concept Scale, a locus-of-control measure, and a measure of school morale. The design is essentially a set of five nonequivalent pretest-posttest control-group designs (Campbell & Stanley, 1963), with approximately 40 subjects in each design.

On the Lorge-Thorndike all differences favored the FIE group, and in three of the comparisons the difference is statistically significant. On the PMA (letter series) all differences again favored the FIE group, and four of these comparisons are statistically significant. On the self-concept measure, and also on the locus-of-control measure, none of the differences are statistically significant. On the school morale measure two of the five differences are statistically significant, and both of these differences favored the FIE group.

What can be said regarding the Toronto studies? Generalizations are difficult, in part because not all the information about dosage is provided in each study. One notes, however, that both of the studies that reported fairly clear experimental effects (Graham, 1981; Narrol et al, 1982) seem to have provided more than 80 hours of FIE (in one case, perhaps up to 150), and one of them used six of the 14 available instruments.

Other Studies

Several studies, including a pilot (Martin, 1984), have been carried out using hearing-impaired students at the Model Secondary School for the Deaf (MSSD). One of these was a 2-year (1982-84) study, the first-year of which is reported in Jonas & Martin (1985). In that study, FIE was given each day, 2-3 days a week during the school year, to 50 MSSD students in Math and English classes; and a similar number of students in these kinds of classes served as controls. Four of the FIE instruments were used. By the end of the year, 41 remained in the experimental group and 47 remained in the comparison group; and for each of the experimental subjects the investigators identified a comparison group member who could be matched on sex, age, and level of class placement (remedial, regular, or advanced). These 82 students (41 matched pairs) were the ones who provided first-year data for that experiment. Dependent measures included Ravens Progressive Matrices; diagramming and letter-set tests from the Kit of Factor Referenced Cognitive Tests (KFRCT); three problem statements requiring written solutions; and the reading-comprehension, math-concepts, and math-computations subtests from the Stanford Achievement Test for Hearing Impaired (SAT-HI). At the end of the year, FIE gains on the Ravens were significantly greater than the corresponding gains in the comparison group. Data for the SAT-HI, however, were not available at the time of the initial report. The investigators have recently reported additional data from the study. In this more recent report (Jonas & Martin, 1984) the investigators report that FIE effects on Ravens scores continue to be observed at the end of the second year--by which time a total of eight FIE instruments have been used--and that the (two-year) data on SAT-HI indicate significant

effects on these measures also. With respect to the KFRCT, no FIE effects were found; and with respect to the three problem statements (average inter-rater r=.82), effects were found for one but not the other two.[38]

McDaniel (1983) examined FIE effects in a sample of 70[39] students in self-contained educable mentally retarded (EMR) classes in an urban school system who were mainly male, low SES, and black, and who ranged in age from 10 to 15. Thirty-three of these students were in classes exposed to 25 hours of FIE, and in these classes students were trained to the FIE Numerical Progression instrument (20 hours) and on variations of the Ravens Matrices (5 hours). The remaining 37 students were in other classes that were used for comparison. FIE teachers were given FIE training in two 2-hour workshops. Pretest-posttest comparisons indicated that FIE students showed (a) significantly more improvement on the Ravens Matrices and on the mathematics subsection of the Stanford Achievement Test than did the comparison group but no greater improvement than the comparison group on the Columbia Test of Mental Maturity. The data suggest that these EMR students were capable of learning the kinds of things they were taught (at least, when they are taught with FIE procedures); but--because of the similarity of instructional and testing materials--the data provide little evidence about the efficacy of FIE as a method of teaching thinking skills.

Brainin (1982) studied FIE effects with 49 underachieving sixth-grade youngsters in Westchester County of New York State. Students had been randomly assigned to four small-core classes that had been set up for students who were reading at more than two years below grade level. The FIE group consisted of two classes (total n=27) as did the comparison group (n=22). In the experimental classes FIE was given for 30 minutes to an hour, 2-3 days a week, for about 59 hours (four instruments) total for the year. These teachers--who were the FIE student's regular teachers in these classes--received about 50 hours of training and consultation. Experimental effects were found on a criterion referenced test developed by the investigator (internal consistency = .76), indicating that the experimental subjects had learned the special material they had been taught. With respect to the primary dependent variables, pretest-posttest comparisons found no evidence of an experimental effect on the Thorndike-Hagen Cogni-

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[38]According to Jonas (personal communication, 11 January 1985), the problem statement on which significant effects were found may have been more interesting to the students than the two on which significant effects were not found. Jonas said that while he had not yet analyzed the relevant data it was his recollection (a) that, on the average, students has used more words in responding to this problem than to the other two problems and (b) that, in comparison to the other two problems, this particular problem--which was number 3 in the list of statements presented--was less often omitted by those who failed to respond to all the problems.

[39]This is the number of students for whom data were available for the full three years. The authors do not mention attrition, but one assumes the original n was greater than this.

tive Abilities Test or the Devereaux Elementary School Behavior Rating Scale but did find evidence of an effect on the Total Reading Score of the Comprehensive Test of Basic Skills.

Genasci (1984) examined FIE effects in two samples: (a) 88 high-achieving seventh and eight graders (46 experimental and 42 comparison) at four regular high schools and (b) 38 students ages 15-18 (29 experimental and 9 comparison) from learning-center classrooms in 10 "alternative" high schools. (Students at the regular high schools had suffered 18% attrition, while students at the alternative high schools had suffered 63% attrition.) The (high-achieving) students at the regular high schools were given FIE 2-3 days a week by their regular math and computer science teacher (about 22 hours total) with the other 2-3 days each week being devoted to the regular (math, algebra, and computer science) course subject matter. Students at the alternative high schools were also given FIE 2-3 days a week (about 19 hours total), but for these students FIE was given by some one other than their regular teacher--i.e., an "itinerant" teacher who came to the school just for the FIE instruction. In each group, five FIE instruments were used. For the (high-achieving) students from the regular high school there were no effects on a measure of academic self-confidence, and there was no effect on the total score of the Primary Mental Abilities (PMA) test. On the PMA verbal subtest, however, significantly more improvement was shown by the FIE than by the comparison students. For the alternative high school students there were no effects at all.

Muttart (1984) administered FIE (three instruments) to seventh and eighth-grade students in remedial programs over a period of nine months, with FIE being given 2-3 hours per week. The author does not say how experimental and control groups were constituted except to say that the original N was 22 and that the final ns were 9 (experimental) and 8 (control). The two groups were compared by t-test on measures of intelligence (PMA total), academic achievement (composite score on Canadian Test of Basic Skills), and self-concept (Brookover Self-Concept of Ability Scale, St. John Academic Self-Concept Scale, Achievement Self-Esteem, and Lipsett Self-Concept Scale). Significant differences were found on the achievement measure and on one of the four self-concept measures.

What can be said about these five "other" studies? It should be noted first that one of the studies was conducted with a population (hearing-impaired) not used in previous studies; and in that study, which used the regular teachers and which administered FIE for two years and used eight instruments, the original finding with respect to nonverbal measures was replicated. Second, two of the studies (one involving high-achieving and the other involving underachieving students) produced mixed effects. In both these studies the number of hours and the number of instruments were relatively small, but in each of the studies the students were given FIE by individuals who taught them in other classes also and who were able to use FIE principles during these other class sessions. The remaining studies, which provided relatively small dosages of FIE and used special rather than regular teachers, found no effects.

CONCLUDING COMMENTS

Before attempting to draw conclusions about the studies we have reviewed, we want to recall several things about these studies. First--and this of course is not surprising--the studies differ among themselves with respect to the designs and procedures they employed (type and number of dependent variables, type and number of measuring instruments, etc.). Second, the reports setting forth the results of these studies differ in the completeness of the information they provide about these designs and procedures. To take just a few examples, it is not always clear how many hours of FIE the experimental subjects were exposed to, how many FIE instruments were used, how many subjects there were at the beginning (or, conversely, at the end) of a study, or whether FIE instructors taught their students in other subjects besides FIE[40]. Third, in most cases the report of a study provides no indication as to whether one of the dependent variables is any more or less important than the others for testing the efficacy of FIE; and it is therefore difficult in many cases to say with respect to a particular study that its results do or do not support FIE[41]. Nevertheless, the following observations seem warranted:

1. If we divide the studies that have been reviewed here into two groups--those that tend to show statistically reliable treatment effects and those that tend not to--one finds studies in the first group usually providing subjects with a greater dosage of FIE than studies in the second group. There appears to have been no research on FIE dosage, and it is not clear just what dosage (which instruments and what number of classroom hours) is required to produce what kinds of effects in what magnitude in what kinds of subjects. Also, FIE seems not to "work" unless there is some yet-undetermined minimum amount of training and subsequent support provided for FIE instructors (presumably the amount would vary depending on various individual-difference and situational factors) and some minimum number of hours of student exposure to FIE instruction; but, while these minimums have been speculated about, they have not--as indicated above--been studied system-

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[40]Some of the other things that were not always clear were the amount of pre-intervention training given the FIE instructors, basis for assigning teachers or students (or classes) to experimental and control conditions, whether any of the experimental variables interacted, and what the relevant means and standard deviations were.

[41]Another point that may be worth recalling is that all the studies reviewed here were field studies, with interventions typically lasting at least a year and sometimes two years. In situations like this it is not surprising to find--as we found here--that implementation efforts often fall a good deal short of what the researchers had hoped for and intended. In fact, the present review was initiated as part of an effort that was eventually discontinued as a result of just such problems. (See Twohig, Rachford, Savell, & Rigby, 1985).

atically. In any event, examination of the studies reviewed here suggests that the following things characterize those studies that tend to show experimental/comparison-group differences:

a. At least a week of FIE training for instructors prior to the first year of FIE teaching--plus follow-up support during the year--and additional training prior to the second year (if there is one).

b. Generally eighty hours or more of student exposure to FIE over a one-or two-year period. (Feuerstein has said that two-to-three years are required, and several other investigators have suggested that two years are a minimum.)

c. FIE taught in conjunction with some subject matter of interest and importance to the subjects. Sometimes this was accomplished by having the instructor of a five-hour course devote, say, two days a week specifically to the course subject matter and three days a week to FIE (usually with a different instructor teaching the FIE); and sometimes it was accomplishd by selecting teachers who had their students for most or all of the school day and having the teacher devote, say, one period each day to FIE.

2. For the most part the effects observed in these studies have been effects on certain standard nonverbal measures of intelligence (e.g., PMA, Lorge-Thorndike, Cattell, and Ravens)--tests that are largely measures of skill in processing figural and spatial information. A number of other measures have been included in one or another of these studies (e.g., measures of self-concept, classroom behavior, impulsivity, academic achievement, and course content); but effects with these measures have been either absent, inconsistent, or difficult to interpret, and there have been few demonstrations of effects in "real-life" (including academic) or simulated real-life situations.

3. Statistically significant experimental/comparison-group differences have been observed in a number of populations (in four countries, in both high and low social class groups, in students classified as hearing-impaired, and in groups considered normal as well as groups considered culturally or educationally disadvantaged). It remains to be determined, however, whether FIE can be counted on to produce treatment effects in all these groups and their associated subgroups. Variables such as age and presence or type of handicap have not been investigated systematically; and, where studies have used a particular age or handicap group, information has not been provided in enough detail to allow one to draw conclusions about the relevant populations. With respect to subject age, one can say only that--based on the studies covered in this review--FIE effects have been observed almost entirely in individuals who were in primary or secondary school (and in the 12-18-year age range) at the time they were exposed to FIE. A few studies have used college or college-age subjects, but--with one exception that we know about--the intervention used in the studies has been too weak to provide a satisfactory test. This exception,

however--since it found significant experimental/comparison-group differences--suggests that FIE may be able to produce effects with individuals who are beyond adolescence.

4. It would be desirable for investigators routinely to collect data on the implementation's completeness--i.e., on both the nature and extent of the implementation that was provided (How many hours of FIE were given and which pages of which instruments were used?) and on the nature and extent of the implementation that was "received" (as indicated, for example, by the magnitude of mastery and near-term effects). Also, our understanding of FIE's ability to produce effects would be increased if investigators routinely controlled and/or provided information concerning naturally-occurring sources of experimental error (e.g., pre-training differences between instructors assigned to experimental and comparison groups).[42]

5. There is enough evidence suggesting that FIE improves thinking skills to encourage researchers to continue investigating it.

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[42]For a discussion, see Lindquist (1953, pp. 8-11).

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APPENDIX

Feuerstein's Theory and the FIE Method[1]

Feuerstein's theory is basically a theory of cognitive development, and the key construct of this theory is what Feuerstein calls a "Mediated Learning Experience" (MLE). MLE is said to occur when an individual (typically a child) is shown or taught cognitive methods for interpreting information, for solving problems, or for learning something. For example, in interacting with a child an adult might illustrate the usefulness of categorizing a particular piece of information and then go on to demonstrate a technique for doing this categorizing. Feuerstein, like Piaget (1954), believes that children can learn from interacting with the environment; but, like Vygotsky (1962), he emphasizes the importance of the mediation of the child's learning by adults.

Feuerstein argues that enhancing a child's cognitive abilities can have a snowballing effect in that, with these abilities enhanced, the child is capable of learning additional and even more complex cognitive operations and strategies. Feuerstein has tried to measure children's potential for such enhancement--he refers to this potential as "cognitive modifiability" --by means of a set of procedures and materials referred to collectively as the "Learning Potential Assessment Device" (LPAD) (See Feuerstein, Rand, & Hoffman, 1979). It is Feuerstein's view that this potential for cognitive enhancement--this cognitive modifiability--can be changed and that the FIE program has the capability of accomplishing this change.

As suggested above, one of the results anticipated from providing children with MLEs is that they would become more aware of their cognitive processes and abilities--i.e., they would exhibit an increase in their metacognitive activity. An increase in metacognitive awareness, in turn, would be expected to give the children greater control over their cognitive styles and thus greater consistency with respect to the patterning of their cognitive processes. Feuerstein is particularly concerned with children who exhibit an impulsive problem-solving style, since this style is so often found to be ineffective (Kagan, 1965); and he is also concerned that children should be able consistently to generalize from their experience and to adopt an abstract rather than a concrete cognitive style (Goldstein and Blackman, 1978).

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[1]This summary draws from a number of sources--e.g., Arbitman-Smith, Haywood, and Bransford (1984); Bransford, Arbitman-Smith, Stein, and Vye (1985); Feuerstein and Jensen (1980, May); Feuerstein and Hoffman (1985); Feuerstein, Rand, Hoffman, and Miller (1980); Hobbs (1980, April); Link (1980, May); and Passow (1980, May).

Feuerstein combined this theoretical framework with generally accepted principles of learning (e.g., the value of extensive practice and of getting feedback on results); and, drawing on his own experience with the LPAD (which had led him to identify what he considered a key set of cognitive skills), Feuerstein developed a set of classroom instructional procedures and a collateral set of (n=14) paper-and-pencil instruments (See Feuerstein et al, 1980, pp. 125-256). Feuerstein believes that these procedures and instruments, when used together in the way he proposes, have the capability of significantly enhancing students' cognitive skills. The use of these procedures with one of the FIE instruments--the instrument called "Organization of Dots" (OD)--is described below.

OD--like the other instruments--is included in a single booklet, with each page typically presenting a series of problems for the student to solve. On the cover of the booklet is printed the slogan for the program, "Just a minute--let me think," along with a drawing of a young man in thought. The booklet is divided into sections (not separately identified in the student's booklet), with each section emphasizing a particular cognitive skill (e.g., precision in problem analysis, ability to recognize recurring patterns) or strategy--e.g., a strategy for identifying errors. In the case of OD, the booklet presents the student with a set of dots; and the student is asked to draw lines connecting the dots but to do this in a way that makes the resulting drawings match a model pattern that is presented (e.g., two squares and a triangle). The booklet contains a number of such sets, and the student is asked to complete as many of these sets as possible. Generally speaking, the problems get more difficult as the student works through the booklet; and some of the problems prove difficult even for college-educated adults. The following would be a typical classroom sequence:

* The students are asked to comment on the slogan ("Just a minute--let me think") that is printed on the cover of their booklet. The expectation here is that doing this will stimulate discussion with respect to impulsive problem-solving styles and the desirability of not using such styles.

* The students' attention is directed at one of the pages in the booklet, and the students are asked to say what they think their task on that page will be. (FIE problems use a minimum of explicit instructions, and some aspects of the tasks must be inferred.) In the case of OD, some of the dots in the first few problems have already been connected; and, as the discussion progresses and if students seem to be having difficulty, the instructor offers suggestions (more or less explicit, depending on the judged needs of the student at that moment) as to what the student might try next. For example, the instructor may call students' attention to certain critical features of the information already provided.

* Ordinarily, students work on the problems independently; but there is a provision for working in pairs or in groups, and the instructor circulates, providing probing questions or hints (e.g., "Is your triangle the same size as the model?")

* Students discuss their solutions to the problems they have been working on, and one or more students may be asked to present their solutions to the group. Mistakes, as well as what the instructor considers faulty approaches, are discussed with an eye to improving students' future problem-solving behavior and their awareness of the cognitive patterns they typically use.

* The instructor encourages induction by the students of general principles and provides them with examples of possible applications. For example, the instructor (or the students) might relate the organizing of the dots into patterns to the organizing of stars into constellations and--at a more abstract level--to the organizing of text material into paragraphs. This two-step process of inducing principles from the work they have carried out in performing the tasks and then applying these principles to some other content area is referred to as "bridging," and students are encouraged to generate their own bridges and to apply them to subject matter (including school subjects) that is of interest to them.