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ABSTRACT

To detemine the effectiveness of the Individualized Audio-Tutorial (IAT) method of instruction, an IAT unit in biology was implemented in ninth grade classrooms in an urban school in Israel, and student achievement was measured in relation to gender, academic background in mathematics and biology, and IQ levels. The 180 subjects were randomly assigned to an experimental group (N=105) and a control group (N=65). Students were pretested for prior knowledge of biology, and an achievement test was administered at the end of each learning unit. Data from both academic achievement in biology and mathematics and scores on three intelligence scales were used to cluster students at three levels. The mean scores in the three IAT units were compared using analysis of variance, and significant differences were found: (1) low achievers in mathematics and biology obtained low scores on the IAT units; (2) middle and high level achievers received higher scores with the IAT approach; and (3) similar results were found for the control group, which had received traditional instruction. It was also found that the girls' achievement was equal to that of the boys when the IAT method was used. Differences between the results of this study and the findings of a study which included kibbutzim school students are discussed. Several statistical tables and three pages of references complete the document. (JB)

Junior High School Students' Achievements in an Audio-Tutorial Biology Setting

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The Individualized Audio-Tutorial (IAT) method of instruction developed by Postlethwait et al. (1972) pr y for college use, consists of a set of structured learning activities based on discrete units of study. In this method the students pursue the learning process individually at their own pace. The activities may require the student to read parts of texts, teacher written learning material, workbooklets and journal articles. Through the workbooklets, which take the place of student-teacher verbal interactions, students have to manipulate and examine models, view slides and films, listen to and follow directions from tape recorders and perform laboratory experiments. Thus, students use independently tools such as workbooklets, tape recorders, slide and film projectors and laboratory facilities. As a result, the teacher's role is changed: Instead of being a source of information, lecturer or discussion leader, he is available to guide students in general and to help and encourage students having difficulties. In an IAT classroom, the learning process is student-centered and students are expected to be responsible for their own learning.

Postlethwait et al. (1972) assumed that one may expect that these changes in the instructional method mentioned above will affect positively students' mastery of the subject matter.

In the present study an IAT learning unit in Biology, "The Cell," was implemented in 9th grade junior high classrooms, and student achievement was measured in relation to gender, academic background in mathematics and biology, and IQ levels. While most of the reviewed studies related to the

implementation of IAT, reported results regarding students' achievements, few were related to students' background in Mathematics and Biology nor to intelligence tests.

Novak (1970) noted that the IAT method allows students to progress at their own pace and makes it suitable for teaching heterogeneous groups. Smiley et al. (1972) described the advantages the IAT method has for students, teachers, and classroom in high school biology instruction.

However, the results regarding high school students' academic achievement reported in the literature do not show a consistent trend. Better academic achievement for students instructed with the IAT method than for students taught by conventional classroom-laboratory method (CCLM) were reported by Shavelson and Manger (1970), Fulton (1971), Smiley et al. (1972), Nordland and Kahle (1973) and Volker (1971) in Biology and De Rose (1970) in Chemistry. On the other hand, other studies show no difference in academic achievement between the two methods of instruction in biology (Lee, 1975; Nordland et al., 1975), even though Nordland et al. (1975) did report in their study that while no significant differences were found between the two methods on students' achievements, the audio-tutorial group earned higher mean scores.

Tamir and Amir (1975) implemented IAT at the elementary school level (first and second grades) and reported that pupils instructed with IAT showed significant achievement in science over their control groups. At the junior high school level, several studies about IAT implementation in ninth grade biology classes were reported. In Israeli kibbutzim schools, students instructed by IAT (using the "Cell" learning unit developed by Huppert and Lazarowitz, (1980) obtained significantly higher scores than students

taught by CCLM (Lazarowitz and Huppert, 1981). When their range of scores was calculated, it was found to be from 70 points and higher for the majority of students 70% (N=50). Assuming a score of 70 or higher as an indicator of mastery learning, the research showed that twice as many students in the experimental group achieved this level (Lazarowitz and Huppert, 1982a). In another study, Huppert (1982), using other units of learning ("Introduction to Microbiology", "Making Wine" and "Nitrogen-fixing Bacteria") reported similar results for ninth grade students from kibbutz schools, who achieved scores at the range of 75-87 points (N=170).

Another variable studied in implementing the IAT method was gender. Non-IAT studies of academic achievement in science indicate that girls score lower than boys (Dar, 1975) and it is of interest to see whether or not in an IAT setting girls will achieve differently. Waetjen (1965) emphasized the importance of considering gender as an important factor when planning a new curriculum or method of instruction. The other studies' findings related to gender did show that girls were successful in the IAT method in biology instruction (Volker, 1970; Armstrong, 1971; Lazarowitz & Huppert, 1981).

In studies with students of different academic backgrounds, Holliday (1976) and Brice (1974) reported that below-average students increased their achievement when the audio component was studied. Low-ability students improved their achievements when instructed in an IAT method (Novak, Ring, & Tamir, 1971) and students who were found to be below the 40th percentile norms by standardized measures of ability achieved higher than predicted in an IAT setting (Nordland, et al., 1975). In a study by Novak, Nordland and Douglas (1976) it was reported that while the IAT and the traditional mode

of learning were both effective for disadvantaged students, still the IAT mode was more efficient for those students when learning time was considered. Kahle (1978) mentioned that there is an increasing number of students with poor verbal ability in secondary schools and in their study (Kahle & Charles, 1975) they hypothesized that the IAT method may increase the achievements of non-academic students with low verbal abilities and provide ways of instruction for learners with different intellectual levels.

In this study an IAT method was implemented in an urban junior high school, and the following questions were investigated.

a) Do students instructed by an IAT method achieve higher scores than the control group instructed by CCLM?

b) Do girls achieve as well as boys in IAT settings?

c) Do students identified as low and high achievers in Mathematics and Biology and students with different IQ levels differ in their achievement as compared with the control group while instructed in an IAT method?

In this study academic achievement was the dependent variable, and the methods of instruction (IAT and CCLM), gender, academic achievement in Mathematics and Biology, and students' IQ levels served as the independent variables.

The Research Design

The Sample. One hundred and eighty students from five 9th grade classrooms participated in this study. All students belonged to a city junior high school and were randomly assigned to an experimental group (3 classes, N=105) and to a control group (2 classes, N=65). Their age ranged from 13.5 to 14.5 years. They had studied biology in the seventh and eighth

grades, having been instructed in the subjects "The Animal and its Environment" and "The Plant and its Natural Habitat". These curricula encompass the life of animals and plants, their structure and function and the ecological aspects resulting from their interaction with their environment. In junior high school, students are expected to end their biological education in 9th grade by studying the "Unity" part of the BSCS program, which includes the structure and function of the "Cell." Thus, none of them had previously studied the subject to be taught during the experiment, namely the "Cell" learning unit. Due to mortality which occurred during the study, the number of subjects will differ for the different tests taken by students over the research.

Description of the audio-visual learning units and the procedure

The learning units used were: The Cell Membrane, The Cell Nucleus and The Cell Organelles. The description of the learning units developed for audio-visual instruction, as well as the description of the procedure, experiments, the learning process, and the description of a typical period, were presented in a previous paper (Lazarowitz & Huppert, 1981). In the present study, the learning material and research procedure, described in the 1981 investigation, were strictly followed in order to assure conformity and similarity between the present study (with urban school students) and the previous study (Lazarowitz and Huppert, 1981), which included kibbutzim school tudents. The study lasted 6 weeks, and each learning unit was studied during two weeks. The control group studied the "Cell" topic using the BSCS learning material in a conventional classroom-laboratory method of instruction during the six weeks.

Instruments Used and Procedures

1. Achievement Tests

Students were pretested for prior knowledge of biology and the cell subject. The test included 44 multiplie choice questions taken from tests developed by the Israeli Science Teaching Center for the BSCS Israeli Yellow Version adaptation. Content validity of the test was established by a group of six biology teachers and science educators. The test was administered on the first day of the semester in which students started to study the "Cell" unit. Data obtained were used for comparing the entry behavior of the experimental and control groups.

2. Learning units and achievement tests

At the end of each learning unit (Cell membrane, cell nucleus, and cell organelles) an achievement test consisting of 20 multiple choice questions was administered. The questions were taken from the BSCS Yellow Version test items. The scoring of the three tests was accomplished by assigning 20 points to each test and then calculating the percentage for every student according to his number of correct answers on each test. Therefore, every student received three scores for the three tests. Content validity of the tests was established by the same group of six biology teachers and science educators.

3. Academic achievements in biology and mathematics

Scores on these two subjects served as data for categorizing students as to three academic levels, low (1), medium (2), and high (3), (see categorization range scores in Tables III and IV) and served as an independent variable. The scores were collected from the previous

semester in which students were taught mathematics and biology in a traditional frontal classroom instruction.

4. IQ tests

Turim, OTIS, and Raven's Matrices Tests: These tests are used at the end of the eighth grade as criteria for streaming students into different academic levels for the following academic year (9th grade). The Turim test (1976), the Otis (1972) and Raven's Matrices (1956) tests were described and their validities and reliabilities presented in a previous paper (Lazarowitz, 1981).

Results and statistical treatment

Mean scores on students' previous knowledge in biology and on the three learning units for experimental and control groups, are presented in Table I.

Insert Table I here

The mean scores were treated by one-way analysis of variance. In Table I, it can be seen that the entry knowledge of the experimental group, indicates that their previous knowledge in biology was significantly higher than the control group (F=16.08 -- significant at 0.01 level). Regarding the results on the three achievement posttests on the learning units, it can be seen that only in the Cell membrane test did the experimental group show a slightly higher difference (F=2.09, significant at 0.10 level only), over the control group. In the two other tests, Cell Nucleus and Cell Organelles, no significant differences were found.

Results regarding differences in achievement between boys and girls in the experimental group only are presented in Table II. The mean scores of boys and girls were treated by one way analysis of variance.

Insert Table II here

The results displayed in Table II indicate that while the entry knowledge of boys was significantly higher than that of girls (F=3.34 - significant at 0.10 level only), the post-achievement tests in all three learning units show no differences related to gender. Thus, girls did equally well as boys in academic achievements, despite their low previous knowledge in biology.

Can academic levels in biology and mathematics be good predictors of achievement while students are instructed in an IAT approach? Our results displayed in Tables III and IV clearly indicate a relationship between the students' academic levels in biology and mathematics and achievements obtained in the three achievement tests in the three IAT learning units.

Insert Tables III and IV here

As can be seen, students were divided into three academic groups, according to their grades obtained in a previous semester in the same academic year. Those grades served in categorizing students in a low group (Level 1; scores ranged from 10 to 59 points); a middle group (Level 2, 60 to 79 points); and a higher group (Level 3; 80 to 100 points). Then the mean scores in the three IAT learning units were compared, using

analysis of variance. Results show that significant differences were obtained among the three levels. Students with low grades in biology and mathematics obtained low scores when the Cell subject was taught in an IAT method. Middle and high level students in biology and mathematics did better in the IAT approach. Similar results were found for the control group which was instructed in the same subject, "The Cell", but in a frontal approach.

The three tests used for measuring intelligence were as presented previously: (a) the Turim test, which measures intelligence by means of a set of numbers; (b) the Otis, which measures verbal ability, vocabulary concepts, and relations among concepts; and (c) Raven's Matrices, which is a nonverbal test considered to correlate highly with "g" factor of general intelligence and is known as a measure of analytical thinking. This test was found to be appropriate for this study due to the fact of being culture-free, and based on visual perception and not on verbal thought.

Data collected on these three intelligence scales helped to cluster students in three categories: (1) low, (2) middle, and (3) high level, according to national norms used by the Municipal Psychological Service of the schools. These categories are presented on the bottom of Table V. The mean scores obtained by students on IAT achievement tests were analyzed by analysis of variance among the three categories mentioned above, and are presented in Table V.

Insert Table V here

Results presented in this table indicate that low level students in these three intelligence scales received lower scores in their entry knowledge (see previous knowledge in biology) and achieved scores significantly lower in IAT achievement tests in general. On the other hand, higher level students received higher scores in their entry behavior tests, and received higher scores in IAT achievement tests in general, too. There is one exception on the Cell Organelles test, where on Raven's Matrices, no significant differences were found among the groups.

Discussion

Regarding students' achievement, the results had shown that while the entry knowledge of the experimental group was higher than the control group, no significant differences were found in two post-achievement tests, and a slight difference in the third test. These results are different from those obtained with kibbutzim school students (Lazarowitz & Huppert, 1981). It should be remembered that in both studies, we used the same learning material, same procedures, students' age and tests. These different results can be explained by the fact that while grades do not play an important role in students' status in kibbutzim schools, they do in city schools. In city schools, grades are emphasized as a condition for status and passage to a higher class. Therefore, one can hypothesize that teachers who taught in the city-controlled classrooms probably felt threatened by the expected achievements in the experimental groups. According to neutral observers whom we had placed in both experimental and control classrooms, teachers in the latter exercised more authority and stressed higher achievement. On the other hand, in experimental classrooms, the atmosphere was more permissive and less oriented towards higher achievement. Our different results

from both studies (kibbutzim and city school populations) are inconclusive in respect to superiority of achievement gained by the IAT method. Further research should be carried out with control classrooms in a different school from the experimental classroom, thereby freeing the control groups' teachers from fear of new methods and their success.

Both in the literature as well as in our studies, inconsistent results regarding academic achievements have been found. In order to find an explanation for this inconsistency, one should look closely at the conformity expected in all studies reported in the literature. This task is very difficult, since different studies used different subject matters, different procedures, different length of instructional time, different students' age, tests and statistical treatment. In other words, the different independent variables used, as well as the different tools used to measure the dependent variable, namely, achievement, make the task of finding an explanation very difficult.

Therefore, we tried in our present study to look for characteristics of students which could give a partial answer. These characteristics include previous grades in biology and mathematics and various measurements of intelligence. In the Israeli junior high schools, students' status is defined according to these grades and tests. Our results clearly show that low achievers in all tests mentioned above also did poorly under the IAT method. Is the IAT method only for high achievers? Or, can we ask, are the IAT method's required skills, such as self-paced learning, personal responsibility, and the individualized aspects of this process, too difficult for the poorer student? The different academic levels in biology and mathematics and the different levels obtained by the intelligence test,

other words the results of this study emphasize the need of preparing the same topic to be taught in an IAT method at different academic levels, so each student can cope with it. The individualized self pace approach can be therefore an avenue to deal simultaneously with different students thus meeting their needs and various abilities. As to the issue of the needed new skills when a new method of instruction is implemented, there is no clear answer but we think that a prior condition should be considered. The condition is connected with this question: Can one cope with a new method of learning without previous preparation and without prerequisite skills? As we know, any implementation of a new curriculum or new method of instruction requires inservice teachers' preparations. Are students an exception? Can one assume that students can use a new method of learning without any previous preparation? No study related to the implementation process of the IAT method in junior high school reported any kind of such preparation, nor did our studies. Eliot Arenson, in his book, Jigsaw in the Classroom (1978) asked about the necessity of preparing students for cooperation and study in small cooperative groups before the mode of instruction is implemented.

Perhaps one should not expect that such skills as students are required to use in connection with the IAT method could be obtained by the use of the IAT material only. It could be hypothesized that skills like self-learning ability, meaningful reading, independence from teacher, and self-responsibility, just to name a few important for students' achievement, are skills for which we have to prepare students before implementing a method like IAT. This comment is supported by the fact that students in the experimental group have to deal with two matters simultaneously: first, mastering the new learning material, and second, performing new skills in this learning process, skills which are required by the new method. At the same time,

new learning material, and second, performing new skills in this learning process, skills which are required by the new method. At the same time, students in the control group have the advantage of only being asked to master the new learning material, since they are not required to perform new learning skills. Therefore, the question as to how to help students master needed new skills and when, is crucial when implementing a new method of instruction.

Results related to gender are encouraging. In both our studies, while the entry knowledge of the girls was lower than that of the boys, in the end girls achieved as well as the boys. Thus, while we know at least in Israel that science teachers' expectations from girls and self-expectations of the girls themselves are lower regarding achievements in science, in both cases --in city and kibbutzim schools--girls' achievement was equal to that of the boys when the IAT method was used. A partial support of the assumption that the individualized and audio-visual approach may contribute to overcome social expectations regarding girls' achievements can be found perhaps in the more favorable attitudes of girls than that of boys towards the different aspects of the IAT method which were found in another study (Lazarowitz & Huppert, 1982b).

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Table I

Analysis of Variance of Mean Scores on Achievements of Experimental and Control Groups

Test Achievements on:	Experimental Group (N = 115) Mean (SD)	Control Group (N = 65) Mean (SD)	F
Previous Knowledge in Biology	76.95 (34)	57.89 (24)	16.08*
Cell membrane unit	15.36 (6.50)	14.10 (3.45)	2.09**
Cell nucleus unit	11.85 (6.96)	12.22 (3.11)	0.16***
Cell organelles unit	15.94 (3.13)	15.40 (3.39)	1.05***

* = significant at 0.01 level
** = significant at 0.10 level
*** = non-significant

Table II

Analysis of Variance of Mean Scores on Achievements of the Experimental Group by Gender

Test Achievements on:	Boys		Girls		F
	N	Mean (SD)	N	Mean (SD)	
Previous Knowledge in Biology	53	20.83 (6.62)	55	18.54 (6.36)	3.34*
Cell membrane unit	35	15.02 (4 19)	47	14.82 (3.71)	0.05**
Cell nucleus unit	39	11.76 (4.27)	48	10.89 (3.87)	0.99**
Cell organelles unit	34	16.02 (2.82)	47	16.04 (3.26)	0.10**

* = significant at 0.10 level
** = non-significant

Table III

Analysis of Variance of the Mean Scores in IAT by Levels of Achievement in Biology

Test Achievements on:		Level 1 (10-59 p)		Level 2 (60-79 p)		Level 3 (80-100 p)		
	Groups	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	F
Previous Knowledge in Biology	Exp. gr.	41	17.07 (5.05)	18	20.38 (5.77)	31	25.29 (5.12)	21.84*
	Cont. gr.	24	21.29 (4.18)	17	22.58 (3.16)	21	25.90 (3.46)	6.28*
Cell membrane unit	Exp. gr.	24	11.33 (4.13)	16	17.37 (2.39)	29	16.72 (2.51)	25.07*
	Cont. gr.	27	13.29 (3.47)	18	12.61 (3.20)	18	16.38 (2.54)	7.56*
Cell nucleus unit	Exp. gr.	28	7.78 (3.68)	19	13.94 (2.01)	25	13.92 (2.87)	34.98*
	Cont. gr.	26	10.92 (2.44)	19	12.15 (3.09)	17	14.52 (2.80)	8.82*
Cell organelles unit	Exp. gr.	20	14.20 (3.65)	21	16.09 (2.58)	30	17.66 (2.05)	9.65*
	Cont. gr.	28	14.28 (3.92)	19	15.42 (2.43)	20	17.40 (2.23)	5.88*

* = significant at 0.01 level

Exp. = experimental
Cont. = control

Table IV

Analysis of Variance of the Mean Scores on IAT by Levels of Achievements in Mathematics

Test Achievements on:		Level 1 (10-59 p)		Level 2 (60-79 p)		Level 3 (80-100 p)		
	Groups	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	F
Previous knowledge in biology	Exp. gr.	25	16.60 (5.00)	21	20.04 (5.18)	37	22.83 (6.37)	8.94*
	Cont. gr.	9	21.11 (2.61)	24	21.50 (4.49)	27	25.40 (4.83)	6.07*
Cell membrane unit	Exp. gr.	15	10.40 (3.29)	17	15.47 (4.30)	28	17.03 (2.54)	19.57*
	Cont. gr.	10	14.40 (3.37)	26	12.80 (3.61)	26	15.11 (3.10)	3.12**
Cell nucleus unit	Exp. gr.	14	5.71 (2.39)	19	11.94 (3.65)	31	13.67 (2.66)	35.71*
	Cont. gr.	9	10.55 (2.69)	25	11.48 (2.61)	27	13.85 (2.85)	7.26*
Cell organelles unit	Exp. gr.	7	13.71 (4.30)	22	15.36 (2.85)	34	16.82 (2.69)	3.93**
	Cont. gr.	10	13.80 (3.08)	22	14.40 (3.88)	33	16.96 (2.43)	6.57*

* = significant at 0.01 level
** = significant at 0.05 level

Exp. = experimental
Cont. = control

Table V

Analysis of Variance of the Mean Scores on IAT by TURIM, OTIS, and Raven Matrices for Experimental Group

Test Achievements on:	Tests	Level 1 N	Level 1 Mean (SD)	Level 2 N	Level 2 Mean (SD)	Level 3 N	Level 3 Mean (SD)	F
Previous knowledge in biology	TURIM[1*]	43	18.16 (5.72)	25	21.96 (4.77)	8	20.62 (6.34)	3.90**
	OTIS[2*]	46	17.71 (5.24)	26	21.84 (4.94)	4	27.25 (5.85)	9.87*
	Raven[3*] Matrices	15	16.73 (6.19)	48	19.89 (5.54)	10	23.80 (3.79)	5.00*
Cell membrane	TURIM	29	14.31 (4.79)	18	16.38 (3.05)	4.	14.50 (4.43)	1.37***
	OTIS	26	13.03 (4.62)	22	17.09 (2.58)	3	18.00 (1.00)	7.90*
	Raven Matrices	9	12.33 (5.59)	33	15.03 (3.77)	8	18.00 (2.00)	4.34*
Cell nucleus	TURIM	31	9.74 (4.01)	19	13.31 (3.46)	7	12.71 (3.98)	5.65*
	OTIS	32	9.00 (3.68)	23	14.41 (1.99)	2	16.00 (20.09)	21.66*
	Raven Matrices	11	7.81 (4.02)	37	11.59 (3.49)	8	15.00 (2.72)	9.95*
Cell organelles	TURIM	31	14.64 (3.42)	20	16.95 (1.98)	7	14.14 (3.89)	4.08**
	OTIS	29	14.20 (3.14)	24	16.62 (2.51)	4	18.25 (1.50)	6.86*
	Raven Matrices	6	14.00 (4.28)	39	15.38 (3.01)	10	16.70 (2.79)	1.45***

* = significant at 0.01 level
** = significant at 0.05 level
*** = non-significant

1* TURIM Level 1 = 3-11 points; Level 2 = 12-18 p; Level 3 = 19-26 p
2* OTIS Level 1 = 6-20 points; Level 2 = 21-31 p; Level 3 = 32-43 p
3* Raven Matrices Level 1 = 24-34 points; Level 2 = 35-46 p; Level 3 = 47-60 p