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CONCEPT MAPPING AND GOWIN'S CATEGORIES AS HEURISTICS DEVICES, IN SCIENTIFIC READING OF HIGH SCHOOL STUDENTS

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ABSTRACT Analysis of a scientific article is part of the Biology Matriculation examination (Bagrut) in Israel. This task which is followed by planning a continuation of the research study appears to be difficult for many students and the mean score is lower than in other parts of the examination. In order to enhance meaningful reading of scientific texts and the ability to plan a continuation to the research, a unit was prepared that explains the nature of scientific research and guides the analysis of scientific texts with the aid of categories based on Gowin's Vee and concept mapping. Seventy eight 11th and 12th grade students analyzed 3-4 articles using our unit. Compared to the pretest as well as the control group, the experimental group did significantly better in the posttest. One of the 12th grade classes in the experimental group received the highest score in the country in this section of the Bagrut examination. Based on the research the use of concept mapping and Gowin's Vee are recommended as means of promoting meaningful learning in the analysis of scientific articles as well as enhancing the integration of theory and practice.

LITERATURE REVIEW

Reading is one of the most important learning strategies for learning new materials. Students advance from the level of learning the technique of reading, to the level of learning with the aid of reading, in the first years at school (Glover et al., 1990). Learning through reading is subject to extensive research concerning the ways in which readers acquire knowledge from written material (e.g. Just & Carpenter, 1987; Glover et al., 1990) and is one of the most important skills in learning science in the U.S.A according to Stake&Easley (1978), Harms (1981), Thelen (1984), Guthrie (1984) and others. Ausubel (1961) and Schwab (1963) claim that understanding science from written materials is very important and teachers are advised to teach students how to do it.

A similarity can be seen between the approach of investigators dealing with strategies of improving learning (Gagne, 1965; Mayer, 1977; Ausubel, 1968) to the researchers who try to improve the ability of students to understand and analyze written materials (Novak, 1976; Andreson, 1984; Bransford, 1984; Andre, 1987; Glover et al., 1987).

Ausubel's learning theory (Ausubel et al., 1978) is based on the assumption that meaningful learning occurs when new concepts are linked to familiar concept existing in the learner's cognitive structure. Learning strategies, like the "advance organizer" suggested by Ausubel (1968) can bridge the gap between the new knowledge and the concepts existing in the cognitive structure of the "learner-reader" and enhance understanding of texts (Blanton & Tuinman, 1973; Dinnel & Giover, 1985; Corkill et al., 1988; Rubin & Tamir, 1988 ;Yore et al., 1991). "Schema" (Mayer, 1977) is another learning strategy that

is applied to enhance learning through reading by activating knowledge in the memory of the reader (Anderson & Pearson, 1985; Glover et al., 1987; Palinscar et al., 1987).

Mortimer (1969) finds a tight connection between reading ,learning and discovery "The art of reading includes all the same skills that are involved in the art of discovery in science: keenness of observation, readily available memory, range of imagination ,and of course a reason trained in analysis and reflection....."

Reading comprehension and learning science has mutual influence. Willman (1978) reviews the work of researches that report positive correlation between participating in science programs and acquiring and developing reading skills. Carin & Sund (1980), Dempster (1984) and Friend et al., (1989) demonstrated improvement of science achievement as a result of practicing reading instruction. Although reading is considered to be a central skill in learning science, there is very little evidence that teachers use or teach specific strategies when dealing with science texts in class (Yore & Denning ,1989; Shymansky et al., 1991; Yore, 1991).

Following the outcomes of the research in the areas of learning and reading raised the question how can we develop a strategy that might help student learn from written articles. We found different strategies recommended by teachers, lecturers and investigators that included reading scientific articles in their classes (Epstein, 1970 ; Baumel & Berger, 1976 ; Waterman & Rissler, 1981 ; Gurley, 1982 ; Blum & Izenkot, 1985 ; Tamir, 1986). Among the different strategies used to advance the ability to understand texts there are the traditional SQ3R (Robinson ,1941; ABAL 1987) and methods like the graphic organizer (Thelen, 1976), rewriting the books in several levels (Gage, 1974; Feely, 1975), analyzing articles according to guiding questions (Tamir ,1986), concept mapping and Vee mapping (Novak et al ., 1983 ; Novak & Gowin, 1984).

The curriculum published by the Israeli Ministry of Education requires to teach students in junior high how to read scientific materials. High school students who major in biology (two levels of examination are offered: three points, five points) are required in the matriculation examination to analyze an unseen research report. The achievement of the students in the unseen research section compared to other parts of the test, are quite law.

Table I. Mean scores for the unseen research report in the matriculation examination (5 points) in Israel.

		Inquiry skills scores in the unseen			
		conclusions	planning experiment	Unseen research	Test whole
The year	N	X̄	X̄	X̄	X̄
1983	3370	62	53	58	69

1984	3880	76	49	67	70
1985	4302	68	55	59	73
1986	5091	71	57	66	75
1987	5661	75	61	72	68
1988	6527	75	61	62	64
1989	7135	75	55	70	69
1990	6970	75	51	54	69
1991	7709	76	51	61	67

These results arise the question how can we help students to acquire the skills to read and analyze scientific articles followed by planing a continuation of the research. In our study we use the term "meaningful reading" to describe the skills of analyzing a research or a scientific text and plan a continuation of the research.

PURPOSE OF THE STUDY

The purpose of this study was:

1. To develop a learning unit that will assist students to develop skills that would help them to comprehend research reports and scientific texts, and to extract scientific knowledge from them.

2. To compare the reading comprehension gain of students that used the unit to that of those studied using other strategies. Following are the measures used for evaluation:

a. Analyzing an unseen research report.

b. Defining the concepts of the scientific research.

c. Success in analyzing the unseen research report in the matriculation examination (level 5 points) in 1991.

3. To find out the effect of the unit on attitudes toward reading and analyzing articles.

UNIT DEVELOPMENT

A unit was prepared that explains the nature of scientific research and guides the analysis of scientific text with the aid of the categories taken from Gowin's Vee and concept mapping.

The unit includes the following Topics:

1. Historical introduction.
2. The relation between science and research articles.
3. Scientific articles structure.
4. Theoretical and practical aspects of research.
5. Gowin's categories used to analyze articles.
6. Concept mapping.

The main features of the unit which are congruent with Ausubel Novak and Gowin's learning

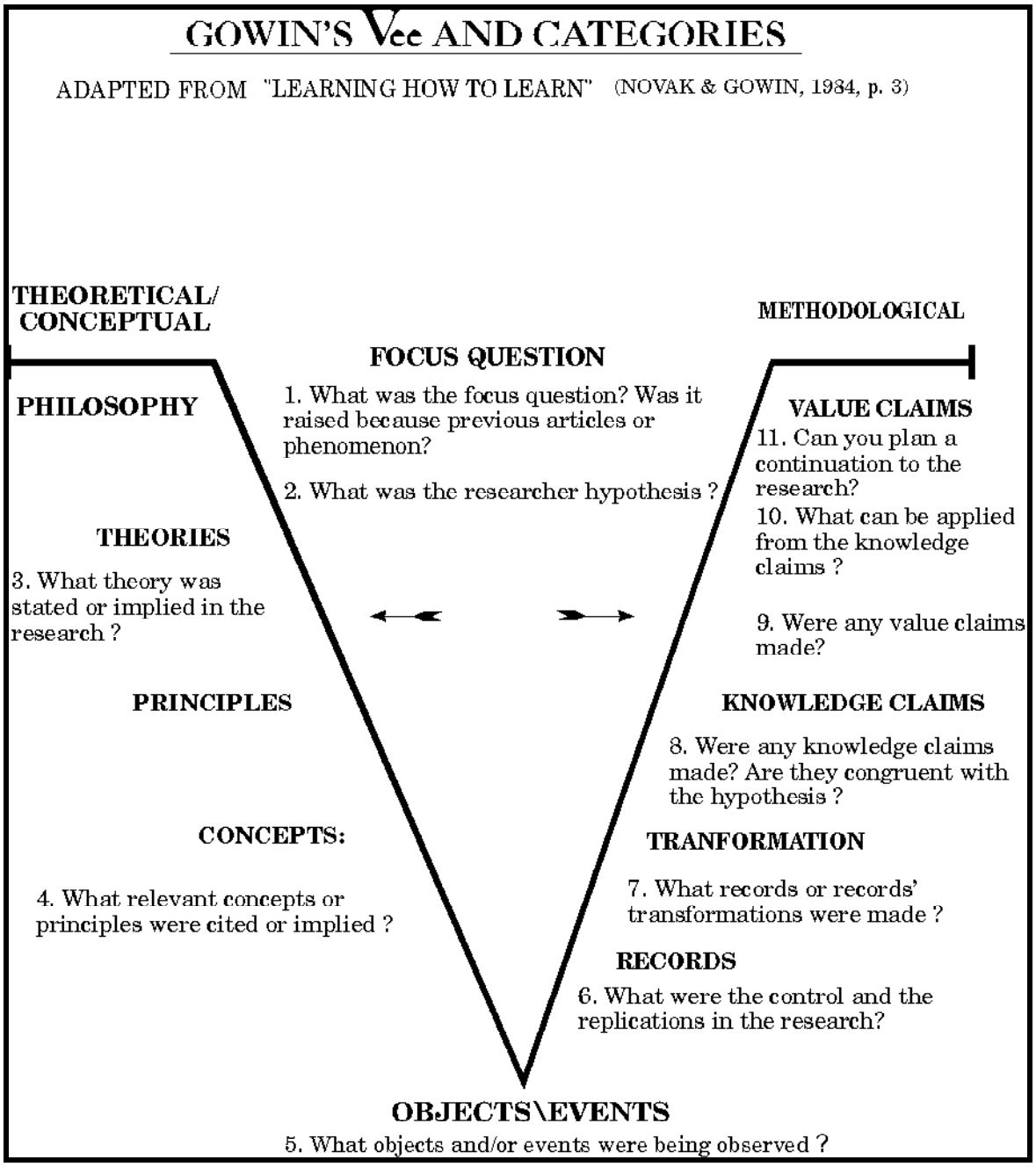
theory are as follows:

According to Ausubel (1968) an "advance organizer" might be established by presenting a general preview of the target concepts, their definitions and role in the scientific research and articles. It might bridge the gap between what we presume the learner already knows and the new knowledge he needs before learning new information from scientific articles (Topics 1, 2, 3, 4).

According to Gowin (1981) Vee map strategy is designed to help students better understand the nature and purpose of laboratory activities and how knowledge is attained from experiments (Novak & Gowin ,1984). Using Gowin's categories as guiding questions (figure I) is congruent with Gowin's learning theory how to help students in their quest for new knowledge. Searching for the answers might help the student identify the complex relationship between the various parts of the inquiry. The questions (1-11) guide students' following the procedure of the investigation from the focus question through the concepts, events and transformations of the records to the new knowledge. At the end of the process students might be able to come up with individual questions about the research and design an experiment that might provide an answer to it (Topic 5).

According to Novak (1981) concept mapping is a process that involves the identification of concepts in study materials and their organization from the most to the least general, more specific concepts. Concept maps (CM) have been used to help students in gaining better and more comprehensive understanding of the written material (Gurley ,1982; Barenholtz & Tamir, 1992). Assuming that concept mapping might enhance students' learning research articles we recommend to use them in analyzing scientific articles (Topic 6).

Figure I: Gowin's Vee and categories



DESIGN OF STUDY

The study involved high school students in the year 1991. Subjects were chosen according to the following criteria:

(1) Student representing various types of schools and located all over the country.

(2) Students who study for matriculation examination (level 5 points) in Biology.

(3) Students whose teachers were interested in adopting the strategy for reading articles.

The experimental group comprised of 78 students, the control group included 54 students all in grades 11 and 12. The 5 teachers who took part in this study, had a Bachelor degree, and 5-10 years of teaching experience.

The study continued for nearly half a year. During this time teachers chose 3-4 articles according to the subject taught in the biology classes. In the experiment classes the students analyzed articles using the guiding questions and concept mapping as part of their homework. Articles were read and discussed in the control classes were using different strategies. The 12th grade control group used the unseen research reports from previous matriculation examination.

INSTRUMENTS

A variety of data sources was used in the study:

ACHIEVEMENT TEST. These included (a) Concept definition. Respondents were asked to choose and define 2 out of 10 concepts . The definitions were assessed by the researcher who examined the connection between understanding the concepts and being able to apply them correctly in the open ended question; (b) Open ended questions. Questions were taken from the matriculation examination which were designed and validated by a committee of experts. Data analysis was carried out using SPSS program. Means and standard deviations were calculated and the results were submitted to T test, gain of possible gain and effect size; (c) Self Report Knowledge Inventory (SRKI). A list of concepts was presented and the respondents were asked to estimate their level of knowledge and understanding of each concept on a 5-point scale: 1 = I don't know; 2 = understand partially; 3 = Know; 4 = understand well; 5 = can explain to a friend (for more details see Young & Tamir, 1977).

Two measures were used to estimate the progress made during the study period ,gain and gain of possible gain. Gain was obtained by subtracting the pre-test from the post -test score. Percentage gain of possible gain was obtained by dividing the gain by the difference between the pre-test score and 100 (Thiele, 1938). The use of gain of possible gain rather than simple gain was introduced to overcome the ceiling effect.

Effect size was calculated in order to estimate the educational significance of differences. Effect size (d) is obtained by subtracting the smaller mean score from the larger and dividing the product by the standard deviation of the control group (Cohen, 1969). It is commonly accepted that:$d<0.2$ standard deviation means no effect;$d=0.2$-0.4 SD implies small effect; $d=0.4$-0.6SD medium effect;$d=0.6$-0.8SD large effect ; $d>0.9$ very large effect .

Z test was used to estimate the significance of difference between two proportions (Brunning & Kintz, 1977). Z having value grater than or equal to 1.96 is considered significant at the 0.05 level using two tail t test.

ATTITUDE INVENTORIES. Students' attitudes towards reading and analyzing scientific articles

were identified by response to an attitude questionnaire and by oral conversation.

RESULTS

Students estimate of their level of knowledge, understanding and opportunities to learn as appearing in their response to the SRKI.

Table II. Mean pre- and post-test for all the students of the study population.
(N = 132 - 96)

Concept	Pre-test $\bar{X}$	Pre-test SD	Pre-test Learning opportunity	Post-test $\bar{X}$	Post-test SD	Post-test Learning opportunity	Effect size
Theory	4.28	0.78	66	4.16	0.85	77	-0.14
Problem	4.40	0.79	76	4.40	0.76	93	0.00
Hypothesis	4.56	0.70	93	4.74	0.75	97	0.24
Control	4.38	0.80	96	4.44	0.83	99	0.07
Dependent variable	4.20	0.91	98	4.46	0.84	96	0.28
Independent variable	4.23	0.91	97	4.40	0.88	96	0.18
Records	4.64	0.56	88	4.53	0.72	93	-0.19
Conclusion	4.51	0.65	91	4.47	0.76	93	-0.07
Discussion	3.96	1.08	52	3.90	1.03	60	-0.05
Abstract	3.86	1.16	46	3.74	1.11	55	-0.10

The response to the SRKI indicates students' high self evaluation of understanding the inquiry concepts before and after the research period. Only in 2 concepts (hypothesis, dependent variable)effect size implies small educational effect.
Students were asked to explain two concepts according to their choice
.

Table III. Percentage of correct definitions in the pre- and post- for study groups.

Group	Pre-test	Post-test	Z
11th control (N =31-18)	49%	57%	0.76
11th experimental (N = 64-55)	51%	68%	2.12*
12th control (N = 23-9)	44%	59%	0.88
12th experimental (N = 14-11)	78%	80%	0.13

*P < 0.05

Table III reveals that according to the Z test only the differences of the 11th grade experimental group achievement in the ability to explain inquiry concepts was statistically significant. The 12th grade experimental group demonstrated high understanding of the concepts already in the pre-test, probably because the intensive work done in the laboratory before the laboratory examination.

The results of the unseen research report

The pre-test was adopted from the unseen research report in the matriculation examination 1989 and the post-test from the 1986 examination. (Table I) The choice was made after consulting researcher in the teaching center. The achievement of the study groups in the unseen are presented in table IV.

Table IV. A achievements of experimental group, control group in the pre-test and post-test.

	11th grade control (N=31) - X SD	11th grade experimental (N=69) - X SD	t	Effect size	12th grade control (N=23) - X SD	12th grade experimental (N=14) - X SD	t	Effect size
Pre-test	13.38 (4.66)	14.92 (4.53)	-0.53	0.11	15.26 (4.12)	14.92 (4.34)	0.23	-0.07
Post-test	14.48 (3.21)	18.50 (2.74)	-5.89 **	1.25	15.30 (3.61)	20.57 (3.32)	-4.53 **	1.46
% gain of possible gain	9	49			0	55		
Continuation plan to the research, pre-	4.25 (3.39)	5,06 (3.45)	-1.08	0.23	5.17 (3.07)	4.92 (3.12)	0.23	-0.08
Continuation plan to the research, post-	5.35 (2.38)	7.16 (2.00)	-4.26 **	0.81	4.78 (2.86)	7.35 (2.76)	-2.71 ***	0.89
% gain of possible gain	20	48			-8	47		

**P < 0.01; *** P < 0.001

The unseen score was 25 points, the continuation plan sub test score was 10 points.

In Table IV the achievement of the experimental group is compared to those of the control group in the pre-test and in the post -test. The results in the pre-test were not significant different. According to post-test results the 11th and 12th grade experimental groups scored higher then the control groups. The difference was statistically and educationally significant. Considering gain of possible gain the highest progress was made by the 12th experimental group.

Table V. Mean pre- and post scores for sub tests of the unseen research report.

Sub test examin-ing the ability to	11th grade control (N = 31) pre- post-			11th grade experi-mental (N =64) pre- post-			12th grade control (N =23) pre- post-			12th grade experi-mental (N = 14) pre- post-		
	$\bar{X}$ SD	$\bar{X}$ SD	t E.S.	$\bar{X}$ SD	$\bar{X}$ SD	t E.S.	$\bar{X}$ SD	$\bar{X}$ SD	t E.S.	$\bar{X}$ SD	$\bar{X}$ SD	t E.S.
analyze hypo-thesis (3 points)	2.35 1.05	2.03 0.83	1.41 -0.30	1.90 1.28	2.18 0.73	-1.70 0.21	1.73 1.05	1.82 0.83	-0.31 0.08	2.50 0.76	2.50 0.65	0.00 0.00
Phrase a problem (4 points)	2.00 1.54	2.70 1.30	* -1.97 0.45	2.18 1.48	3.48 0.92	*** -6.08 0.87	2.52 1.40	2.04 1.26	1.37 -0.34	2.07 1.43	3.35 1.15	** -3.03 0.89
Design an experi-ment (4 points)	1.67 1.57	1.74 1.21	-0.15 0.04	2.03 1.63	2.48 1.18	* -1.99 0.28	1.69 1.52	1.73 1.17	-0.12 0.02	2.14 1.79	2.78 1.18	-1.55 0.35
inter-pret records (2 points)	0.58 0.90	0.90 0.83	-1.50 0.35	0.84 0.94	1.50 0.79	** -4.29 0.70	0.95 0.92	1.00 0.85	-0.16 0.05	0.71 0.82	1.21 0.89	* -1.84 0.60

*P < 0.05 **P < 0.01 ***P < 0.001 (E.S. = Effect Size)

Table V presents the improvement in the ability of the experimental groups to apply the inquiry skills in their answers to the open questions. It reveals that no group advanced in it's ability to phrase an hypothesis. The experimental groups advanced significantly in the ability to phrase a problem, to interpret results and come to conclusions. The 11th experimental group improved statistically significant in the ability to design an experiment. Their ability to use the inquiry concepts (problem, hypothesis, depended variable, independent variable, control) was enhanced during the study. Although some of the differences were not statistically significant, effect size implies small educational effects.

Achievements in the unseen research report in the matriculation examination (Bagrut)

Table VI. Achievement of 12th grade in the unseen research report in the Bagrut examination 1991.

	Experi-mental group (N = 14)		Control group (n = 14)			
	$\bar{X}$	SD	$\bar{X}$	SD	t	Effect size
Unseen research report	19.92	4.58	13.07	3.75	-4.33***	1.49
The continua-tion of research	9.28	3.14	4.71	2.27	-4.99***	1.45

***P < 0.001 The unseen score was 25 points, the continuations sub test score was 12 points.
Table VI revels that the 12th grade experimental group succeeded mostly high in the unseen research report in the Bagrut examination.

Students` attitudes toward reading articles

At the beginning and at the end of the study students' attitudes towards reading articles were evaluated .

Table VII. Students' attitudes towards reading research articles in the experimental groups.

	11th group					12th group				
	***Research articles:**	Pre- (N = 64)		Post- (N =55)		effect	Pre- (N=14)		Post- (N =11)		effect
		$\bar{X}$	SD	$\bar{X}$	SD	size	$\bar{X}$	SD	$\bar{X}$	SD	size
1.	Are Difficult to read	1.18	0.52	1.06	0.36	-0.23	1.34	0.65	1.20	0.42	-0.20
2.	Are Interesting	2.32	0.64	2.31	0.63	-0.01	2.33	0.50	2.36	0.65	0.04
3.	Are Recommended	2.51	0.64	2.43	0.68	-0.12	2.58	0.51	2.54	0.68	-0.07
4.	Are Unnecessary	1.51	0.65	1.54	0.61	0.04	2.00	0.00	1.46	0.82	-0.65
5.	Include unknown concepts	1.41	0.63	1.38	0.65	-0.04	1.08	0.28	1.18	0.40	0.35
6.	Arise awareness to research	2.57	0.55	2.63	0.55	0.10	2.41	0.66	2.45	0.52	-0.06
7.	Include new subjects	2.78	0.52	2.78	0.45	-0.00	2.75	0.45	2.63	0.50	-0.26
	The articles we read:										
8.	Were interesting			2.15	0.49				2.11 0.33		0.08
9.	Were comprehensive			2.47	0.57				2.35 0.52		0.21
10.	Encourage more reading			2.23	0.66				2.22 0.66		0.00
	Comprehension was enhanced by										
12.	Gowin's categories			2.21	0.70				2.12	0.99	0.09
13.	Concept mapping			2.05	0.63				1.77	0.83	0.33

* Items 8-13 were included only in the post questionnaire .

We considered in our analysis mean scores less then 1.50 as not at all, 1.50-2.00 as very little, 2.01-2.50 as moderate and 2.51-3.00 as very much. Based on these criteria the following conclusions can be drawn: students find reading articles not difficult and moderately interesting task, they highly recommend to include research articles in the curriculum, it arises awareness to research in biology and includes new topics. Only to a moderate degree students think that mapping and using Gowin's categories are useful in analyzing scientific articles. The attitudes of the 11th grade experimental group were slightly more positive than those of the 12th grade group at the end of the study period.

SUMMERY AND DISCUSSION

The main purpose of this study was to enhance meaningful reading of scientific text. A learning unit was developed and used by the treatment group. The investigator attended all the lessons dealing with scientific reading in two 11th grade treatment classes. Oral discussions and conversations that were held in those lessons about class and home assignments, were vivid and relevant. Students reported spending extra time at home on research reading . They stressed the importance of coming to class well prepared and that otherwise it was impossible to benefit from class discussion .

Compared to a pretest, the experimental group did significantly better than the control group in the post test. The experimental group improved in nearly all the areas especially in the ability to plan a continuation to the research where they applied inquiry skills.The highest progress made by the 12th experimental group might be explained by the research treatment combined by the intensive work in the laboratory. In the control group no statistically significant improvement occurred. One of the 12th grade classes of the control group practiced scientific reading by analyzing "pervious unseen "from matriculate examination (they even read and analyzed the scientific unseen we chose for the post test). Even so their achievement in the post test were lower comparing to th□se of the experimental group. These findings reinforce our hypothesis that devoting time to the scientific reading in the curriculum alone is not enough. Meaningful reading might occur by using specific strategies. We are aware of the limited time teachers and students in high schools can devote to reading and analyzing articles. The success of such a program might depend on the teachers' awareness of the difficulties the students encounter, to the benefits of reading articles, and to students' willingness to invest more time at home.

Although no difference was found in the results of the self report knowledge inventory (all the students had high self evaluation of their inquiry concept understanding before and after the study), significant difference were found between the ability to define inquiry concepts and implement them in the open question only in the experimental group. This finding suggests that although the educational community assumes certain concepts exist in the cognitive structure of the 11th and 12th high school students this is not always the case (Amir ,1992 ; Friedler, 1984).

Our recommendation is to prepare a program that can be applied in junior high and continues throughout high school. Assuming that using special treatment dealing with inquiry skills in the laboratory (where students manipulate inquiry skills practically) and inquiry concepts in written materials (where they manipulate the inquiry process theoretically) might help students to improve their achievement in the laboratory as well as in analyzing scientific articles.

The unit that was developed for this research is being used in 4 classes in one junior high school. The achievement in biological studies in these classes are relatively high, and students' attitudes toward scientific reading and subject matter is mostly positive.Our learning unit is being presently revised according to the main findings of our study.

To sum up we join Tamir who wrote in 1990 " If meta-learning strategies are as important as suggested by some learning theories (e.g. Ausubel , 1968; Novak & Gowin , 1984) then much more efforts are needed to teach students how to use such strategies more effectively. Perhaps if we begin to do so early enough in school we shall be able to influence students before they consolidate their study strategies and reach a state of entrenched habits which are resistance to any change....."

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