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ABSTRACT

In an effort to improve students' interests in science and science courses, a study was conducted in Israel to evaluate students' attitudes towards science relative to two chemistry curricula. These curricula were Chemistry for High Schools (CFH), and Chemistry--A Challenge (CAC). The CFH program was mainly designed for science-oriented students and is based on inquiry techniques, concept formation and laboratory investigation. The CAC was developed in an attempt to meet the needs of a population of students that are more heterogeneous, both in their cognitive ability and their scientific interest. Major findings of the study indicated that: (1) CAC students' tendency to choose science as a future career was significantly higher than that of CFH students; (2) CAC students appreciated scientists in general and chemists in particular more than CFH students; (3) chemistry was considered significantly more important to CAC students than to CFH students; and (4) CAC students regarded chemistry as a school subject to be more interesting, more important, and less difficult than CFH students. It was concluded that a curriculum geared to the needs and interests of students can help in developing positive attitudes toward science. (TW)

HOW TO DEVELOP POSITIVE ATTITUDES TOWARDS SCIENCE AND CHEMISTRY THROUGH A NEW CHEMISTRY CURRICULUM

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How to develop positive attitudes towards Science and Chemistry through a new chemistry curriculum

Introduction

The development of scientific attitudes and interest has become, in recent years, one of the basic goals for science education, not less important than their cognitive counterparts (Shulman and Tamir, 1973; Welch and Hofstein, 1984). Generally speaking "attitudes towards science" include one's emotions and reactions to the world of science as it is reflected at school, society, everyday life and the scientific professional world. Research findings, highlighted the importance of interest in and attitudes towards science and their influence on cognitive learning (Taylor, 1974; Shulman & Tamir, 1973). Thus, developing students attitudes and interest were one of the important goals of several science curriculum projects: e.g. Harvard Project Physics and The Australian Science Education Project (Gardner, 1975). Yet, despite the recognition that attitudes towards science are important outcomes of science teaching, only little is known about the curriculum variables that effect students' attitudes towards science (Hofstein and Scherz, 1984; Gardner, 1984). The effect of students' involvement in a particular science curriculum on their attitudes towards science seems to be inconsistent (e.g. Kempa & Dube, 1974; Novick & Duvdevani, 1976; Steinkemp and Maehr, 1983; Shibeci, 1984). Some studies did not reveal any significant change in attitudes as a result of implementing a certain

curriculum (Kempa & Dube, 1974; Novick & Duvdevani, 1976). Other studies reported a positive significant change in students' attitudes towards science, due to their enrollment in a new science curriculum (Tolman, 1979; Hassan, 1985). The authors of this paper, however, believe that one of the main goals of science curriculum development today should be to enhance positive attitudes towards and interest in science in order to increase students' interest and their enrollment in science courses (Hofstein and Scherz, 1984; Milner et al, 1986).

The present study was undertaken in order to evaluate students' attitudes towards science and chemistry, as a result of studying two chemistry curricula 'Chemistry for High School' and 'Chemistry a Challenge' (Ben-Zvi and Silberstein, 1983) which differ in several characteristics: order of subjects introduced, methods of representations, goal of teaching (i.e. the emphasis on improving students' attitude towards school chemistry) and the nature of the intended target population:

The curricula

"Chemistry for High Schools" (CFH) that was developed in Israel in the late sixties and early seventies was highly influenced by the 'golden age' of chemistry curriculum development in the world (e.g. CHEMStudy in the USA, 1965; Nuffield A level Chemistry in the U.K., 1972). It is based on philosophy of the structure of the discipline and concept formation. This curriculum was mainly designed for science oriented students and therefore is highly based on inquiry techniques, concept formation and laboratory

investigation.

Following the 'golden age' of curriculum development, the late 70's and the early 80's could be regarded as the years of 'crisis in science education'. (Dvoretzki, 1983; Nation at Risk, 1983; and Yager, 1980). One of the obvious characteristics of this crisis is the low enrollment of students in the physical science courses (Welch et al, 1984). This situation was undoubtfully a call for both curriculum developers and science education researchers to redefine and reevaluate the goals for science education and to develop science curricula to educate not only "future scientists" but what is fondly called "future citizens". As a result of this situation, a chemistry curriculum "Chemistry - A Challenge" (CAC) was developed in Israel following a national reform in the educational system. One of the outcomes of this reform was that Chemistry became a compulsory subject for all first year senior high school students (10th grade, age 15). "Chemistry - a Challenge" was designed in order to meet the needs of an heterogenous population in the 10th grade. This population, is heterogeneous both in their cognitive ability and in their scientific interest. The following are the main features of this project:

a. The level of the chemistry course is cognitively adequate for heterogeneous unselective population. On the basis of a prior diagnostic research, an attempt was made to overcome several students' difficulties and misconceptions within the chemistry subject matter (Ben-Zvi et al, 1983).
b. The curriculum emphasises the relevance of chemistry to

students' everyday life and surroundings, e.g. the 'Dead-Sea' as a source for minerals and its contribution to industry, formation of stalagtites and stalagmites in one of the caves in Israel and the chemistry of the copper minings in Timna region by king Solomon at the biblical time and nowadays.

c. A humanistic-historical, yet scientifically correct, approach to chemistry concepts is used. This is done, with reference to the stories behind the chemistry e.g. the story of Mary and Pierre Curie, and the historical development of models which describe the structure of the atom.

RESEARCH QUESTIONS

Three main questions were addressed in this study:

(1) How are students' attitudes towards science and scientists in general, and chemistry and chemists in particular, influenced by the curriculum studied?

(2) What are students attitudes towards chemistry studies at school following each of the two curricula?

(3) Is there a difference in students' preference concerning future careers, based on the type of chemistry curriculum studied?

RESEARCH METHODS

Sample

The sample consisted of 1958 students from 52 10th grade classes in 17 academic high schools in Israel. 1380 students out of the total sample studied chemistry according to the CFH curricula and 578 of them studied chemistry according to the new

CAC curriculum.

Testing domain:

1. Achievement pretest Students initial ability in science in general and chemistry in particular was measured using a multiple choice test (Arzi et al, 1983). The results of this test were used as an indication of students prior knowledge of chemistry related topics. This test was originally constructed to assess students' achievement at the end of the Junior High School.
2. Interest, easiness and importance of science subjects at school: Students were asked to respond to a Likert type questionnaire in which they had to express their opinions concerning level of interest, easiness and importance of several school subjects. Only results concerning chemistry as a school subject will be reported here.
3. Attitudes towards science, scientists, chemistry and chemists: Students' attitude towards science in general and chemistry in particular and their feelings about science and chemistry as a profession were measured using a semantic-differential questionnaire (Osgood et al, 1975). This questionnaire consists of four concepts (scientist, chemist, science and chemistry) and 8 scales for each concept. A factor analytical investigation followed by varimax rotation procedure reduced the number of scales into three subscales for each concept. (Table 1)

Insert Table 1 about here

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4. Career choice questionnaire: A special questionnaire that was originally developed as individual career choice counseling tool (Meir, 1975) was used in this research in order to assess the career expectations among students. The questionnaire consisted of a list of 72 different professions related to 8 different fields: art, business, culture, civil service, organization, outdoor activities science and technology. Each field has 9 levels. The student can rank each profession as follows: 2 points for yes, 0 points for No and 1 point I do not have an opinion.Thus the student can score maximum 18 points on each of the fields. In our computation 18 points were translated to 100%. In the present study we report the results for the 'Science' and 'Technology' fields only.

STATISTICAL ANALYSIS

Several studies conducted in the past have shown that occasionally, there is a certain relationship between students' achievement and their attitudes towards science (Campbell and Martinez-Perez, 1977; Simpson and Wasik, 1978). Pearson correlation coefficients computed between students' achievement in the pretest and their attitudes towards science verified the existence of such a relationship in our sample. Due to the fact that significant (although low) correlations were obtained ($r \sim 0.10-0.24$, $p < 0.001$) it was decided to use a Multi Variate Analysis of Covariate (MANCOVA) technique for each set of attitude

variables. The MANCOVA technique was adopted in order to statistically control unavoidable initial sampling differences between the two research samples (CFH and CAC), caused by different learning experiences prior to the 10th grade. The dependent variables were students' scores in the attitude questionnaires and the independent variable was students' score in the initial ability test in science and chemistry.

RESULTS AND DISCUSSION

The results of a set of MANCOVA analyses are presented in Table 2. It is seen that after accounting for the initial differences between the two groups, significant differences on all sets of affective variables exist between the groups. The MANCOVA analyses were followed by ANCOVA tests in order to further investigate the source of differences in each of the scales.

Insert Table 2 about here

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1. Attitudes towards school chemistry: The CAC students rated significantly higher both the interest and the importance scales. These findings are especially interesting since no significant difference was obtained in students' perception of the level of easiness of chemistry. It seems, therefore, that the main goal of CAC, namely, 'to make chemistry more interesting' was attained. It is important to note that this goal was attained without compromising with an acceptable cognitive demands on behalf of the students.

2. Attitudes towards Science and Chemistry: CAC students rating of the importance and attractiveness of science and chemistry, was significantly higher than that of CFH students.

3. Attitudes towards Scientists and Chemists:
Students from both chemistry curricula perceived positively the importance of scientists and chemists. CAC students had a significantly higher image of the 'social status' and 'personality' of scientists and chemists, as compared to their CFH counterparts.

4. Science as a future career: One of the important goals of a science curriculum is to present science as a possibility for future career. Our findings show clearly that students who studied chemistry using the CAC program found the 'science' field (measured by the "Career Choice Questionnaire") more attractive than the CFH group. Since the two groups are taught in the academic high school in which technology is not a part of the school curricula no significant differences were obtained on this field.

DISCUSSION AND SUMMARY

In recent years, there is much concern with the problem of low enrollment in science courses (Welch et al, 1984). A correlational study conducted recently (Milner et al, 1986) showed clearly that one of the most predominant and influential factor concerning students' enrollment in physical science courses is the one that deals with student interest in and attitude towards science studies in high school. These findings are in fact a call for reevaluation and redefinition of the goals of science

teaching. Research findings as well as information obtained from schools show clearly that future developments in science curricula should aim to meet with students' needs both in the cognitive and in the affective domain. In the past, it was claimed that "if we teach science as it is known and understood to scientists it must be inherently interesting to all the students" (Harms and Yager, 1981).

Now 25 years later, it is clear that the affective component of science education i.e. students' interest and attitudes were neglected in science curriculum development. Ronneberg (1970) believes that many projects in science education developed at the 'golden age' of science curriculum development drove many students away from science. He claimed that the approach and treatment of many science curricula were not related to students interests, experiences and future needs. According to Ronneberg the next generation of curriculum material should attempt to present courses which are teachable and interesting to the majority of high school students.

Kempa (1983) suggested that in the past, in the context of high school chemistry most of the curricula development seeked to provide what he calls education in chemistry rather than "education about chemistry". According to Kempa education about chemistry will include issues and concerns such as ..." image of chemistry which one wishes the students to acquire. How is the student to see the subject? What is he to recognize as its main features and concerns? How is he to view chemistry as regards its usefulness and societal role?" (Kempa, 1983, p. 5).

This could be achieved by using facets of chemistry other than those that were usually used in the chemistry curricula. Amongst these facets are the technological manifestation of chemistry, a personally relevant subject, the cultural aspects of chemistry and the societal role and implications of chemistry.

The chemistry curriculum "Chemistry - a Challenge" recently developed was tailored for students with diverse interests and cognitive ability. It is suggested, that some of the facets mentioned by Kempa (1983) were included and thus, this helped in developing positive attitudes towards science in general and towards chemistry in particular.

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Table 2

Analyses of covariance for differences in attitudes towards chemistry between CFH (N=515) and CAC (N=332) students. Covariate: students' score in initial scientific test.

Dependent Variable	Adjusted Means and S.E. Chemistry Curriculum				Multi-Variate F	Uni-Variate F
	CFH		CAC			
	Mean	S.E.	Mean	S.E.		
Attitude towards school chemistry						
Interest	53.01	1.40	67.20	1.74		38.90**
Easiness	55.75	1.23	58.40	1.50	14.83	1.74
Importance	57.15	1.20	65.87	1.50		19.85**
Attitude towards science						
Importance	84.09	0.63	86.34	0.79		4.84*
Understandability	51.32	0.78	52.20	0.97	8.69**	0.49
Attractiveness	68.68	0.84	75.06	1.05		21.67**
Attitude towards Chemistry						
Importance	75.30	0.75	80.60	0.94		19.07**
Understandability	52.50	0.85	55.30	1.06	12.91**	4.12
Attractiveness	59.88	0.94	69.03	1.18		35.63**
Attitude towards scientists						
Importance	80.22	0.68	81.81	0.85		0.15
Social status	54.74	0.62	59.44	0.78	7.52**	21.45**
Personality	60.54	0.63	63.55	0.78		8.70**
Attitude towards chemists						
Importance	57.72	0.75	78.31	0.93		4.52*
Social status	53.36	0.58	55.78	0.72	2.91*	6.68*
Personality	53.34	0.60	59.65	0.75		5.59*
Career choice						
Science	27.11	0.85	33.83	1.08		23.44*
Technology	20.44	0.82	20.20	1.04		0.03

* $p < 0.01$

** $p < 0.001$

Table 1

Items and reliability of subtests on semantic differential questionnaire on attitudes towards the concepts science/chemistry/scientist/chemist

Subtest	Items in subtest	Reliability coefficient
Concept: Science		
Attractiveness	beautiful, exciting, interesting, attractive.	0.81
Importance	important, helps the community, applicable, innovative, helpful.	0.78
Understandability	clear, simple, easy, understandable, organized	0.75
Concept: Chemistry		
Attractiveness	beautiful, exciting, interesting, attractive.	0.75
Importance	important, helps the community, applicable, innovative, helpful.	0.67
Understandability	clear, simple, easy, understandable, organized.	0.61
Concept: Scientist		
Importance	important, helps the community, innovative, vital, helpful.	0.68
Social status	famous, popular, rich, successful	0.62
Personality	interesting, popular, socialized, friendly.	0.57
Concept: Chemist		
Importance	important, helps the community, innovative, vital, helpful.	0.75
Social status	famous, popular, rich, successful.	0.67
Personality	interesting, popular, socialized, friendly.	0.61

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ABSTRACT

HOW TO DEVELOP POSITIVE ATTITUDES TOWARDS SCIENCE AND CHEMISTRY THROUGH A NEW CHEMISTRY CURRICULUM

The present study is based upon the authors' belief that one of the main goals of science teaching today is to develop positive attitudes towards science in order to improve students' interests in science and to increase their enrollment in science courses.

A research was undertaken to evaluate students' attitudes towards science in relationship to the two chemistry curricula: a well established concept oriented and laboratory-based programme, "Chemistry - a Challenge" (CAC), which was designed with the following main features:

a. The level of the course was cognitively proper for a heterogeneous unselective population, with special consideration of students' difficulties and misconceptions within the chemistry subject matter.

b. An emphasis of the relevance of chemistry to students' life and surroundings.

c. A humanistic and historical approach to chemistry.

The sample consisted of 1958 10th grade students from 52 classes in 17 academic schools in Israel, 578 of which studied CAC program. Students' attitudes were investigated through questionnaires aimed to identify students' appreciation of science, scientists, chemistry and chemists, their opinions about the interest, easiness and importance of chemistry as a school subject, and their consideration of science as a possible future career. Multi-variate analyses of covariance technique, for each of the dependent variables, was undertaken. Students' scores in initial tests in science served as covariates.

The main findings indicated that:

1. CAC students' tendency to choose science as a future career was significantly higher than that of CFH students.

2. CAC students' appreciation of scientists in general and chemists in particular was significantly higher than that of CFH students.

3. Chemistry and science were considered by CAC students to be significantly more important and attractive than by CFH students.

4. CAC students regarded chemistry as a school subject to be more interesting, more important, and less difficult than CFH students.

It was concluded that a curriculum geared to the needs and interests of students can help in developing positive attitudes towards science.