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ABSTRACT

A computer-assisted instruction (CAI) module on polymers was used to introduce chemistry teachers (n=64) to the variety of possibilities and benefits of using courseware in the current chemistry curriculum in Israel. From an analysis of a pre-and post-attitude questionnaire regarding the use of computers in chemistry teaching, it was concluded there was a positive change in teachers' attitudes toward CAI and using computers in their classrooms. Teachers indicated that they intended to incorporate the polymer module into their curriculum mainly due to the three-dimensional polymer models, the animation, and the visual effects that explain polymerization and the stretching processes. (PR)

In-Service Chemistry Teachers Training: The Impact of Introducing Computer Technology on Teachers' Attitudes

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Abstract

A successful introduction of computer aided instruction as a tool for enhancing ch· nistry teaching depends on positive attitudes of the teachers. The research investigates the effects of in-service training and teachers' self-developed mini-courseware on broadening CAI use for chemıstry. It involves follow-up of in-service teacher training aimed at strengthening the confidence of the chemistry teacher in his/her ability to use computers in the classroom.

We developed a CAI module on polymers, which was used to introduce the teachers to the variety of possibilities and benefits of using courseware in the current chemistry curriculum in Israel. It was presented as a source for mastery learning, enrichment material, problems and their solutions.

As a research tool, the teachers answered pre- and post-attitude questionnaires regarding the use of computers for chemistry teaching in general, and the polymer module in particular. The analyzed data indicated a positive change in teachers' attitudes toward CAI and using computers in their classrooms. As for the Polymer module, the teachers indicated that they intend to incorporate it within the curriculum mainly due to the three dimensional polymer models, the animation and the visual effects that explain polymerization and stretching processes.

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The use of computers in the educational curriculum began in the 70's, but barriers to their widespread use in schools were mainly the lack of applicable software and the high cost of the systems (Dillashow & Bell 1985; Wise & Okey 1983). The breakthrough came with the appearance of low-cost, compact micro-computers, which currently help to improve the learning process and increase students' motivation (Tucker, 1985).

The introduction of microcomputers to education, in general, and to science teaching, in particular, has increased awareness among teachers and students that computers can be a productive tool in developing new methods and learning environments (Green & Flinders 1990).

Some difficulties that hamper a more massive usage of this tool in schools include the variety of computers and languages and the need for appropriate courseware. According to Bitter (1984), the main obstacle in fostering computer usage for educational purposes is the lack of teachers' training to adequately use computer aided instruction (CAI). Moreover, there is an urgent need for trained developing teams which are capable of authoring state-of-the-art courseware.

The idea of teachers writing their own software has some supporters and some opponents. Giesert & Futrell (1990) argue that software developed by teachers is very simple and is valuable only in the teacher's own classroom. They claim that the development of courseware should be done only by professional and skillful teams.

On the other hand, Lockard et al. (1990) list several reasons that support teachers developing their own CAI modules. These include the inability to find appropriate software, budgetary considerations and personal preferences of experienced teachers who write their own educational aids.

Using Computers in Science Teaching

The use of computers in science teaching has various advantages. Among them is the ability to provide for individual learning and advanced options for simulation and graphics, and to demonstrate models of the micro world of molecules, atoms and sub-atomic particles. Computers enable students to solve a variety of problems while doing their own search at their own pace. Another important use of CAI is in the micro-computerized laboratory (MBL) because of its ability to simulate experiments, especially when experiments are expensive or hazardous if conducted in an actual laboratory setting (Krajik et al., 1986; Lehman,1985; Meuchenry,1983).

According to Ellis & Kuerbis (1991), it is imperative that we teach students at all levels to manipulate information and extend knowledge through the use of computers. The benefit from the partnership among students, teachers, and technological advances is becoming more and more commonplace. One such approach has been successfully implemented by Linn & Songer (1991) and by Linn et al., (1993). Based on the finding (Eylon & Linn, 1988; Songer & Linn, 1991) that the learner is characterized, among other things, by his/her views of science, they developed a "Computer as Lab Partner" (CLP) curriculum that explicitly motivates students to construct understanding and integrate information from various sources. Another approach was devised by Dori et al. (1993) for improving teaching an undergraduate human physiology course in large classes. This was done by using a set of intelligent computer aided instruction (ICAI) modules (1993A, 1993B) which enables easy navigation among at least three layers of knowledge depth and complexity.

The use of computers in science teaching was investigated by some researchers (Hauben & Lehman, 1984; Lunetta & Hofstein, 1989; Reed & Judkins, 1986; Sady, 1989; Smith & Jones, 1989, Dori & Yochim, 1990). Most of them found better achievements and attitudes toward science and computers with the computer aided instruction.

In-Service Teacher Training

Most in-service programs for science teachers are based on the assumption that participating teachers will learn concepts and skills that will increase their professional expertise. This will enhance their ability to increase the quality and quantity of science taught at K-12 level (Spector, 1987). Clermont et al. (1993) have found that science teachers' pedagogical content knowledge in chemistry can be enhanced through intensive, short-term in-service programs. They found that the training increased teachers' awareness of the complexity of chemical demonstrations and the benefit of simplifying them to promote science concept understanding.

The frequent changes in technology make it a necessity for each teacher to update and refresh his/her knowledge. The main purposes of teacher training from the viewpoint of the education system are: to change the attitudes and behavior of teachers, to enrich their knowledge, and to expand their teaching skills (Unesco, 1981). Cronin-Jones (1991) found several categories of beliefs, which appeared to influence curriculum implementation: beliefs about how students learn and their ability level in the particular age group, a teacher's role in the classroom and the relative importance of content topics.

According to Hord & Huling-Austin (1987), educational change is a long and tedious process that does not end with the adoption of a new curriculum or approach to teaching. They found that it takes three or more years for teachers to make a substantial change in teaching.

Developers are responsible for designing programs that will help teachers to use new approaches to teaching. For a teacher's training to be effective and influential, the following recommendations have been compiled from the studies of Joyce & Showers (1980) and Ellis (1990):

– The training should be conducted in a comfortable and relaxed environment that is conductive to change. The theory and rational behind the innovation and its detailed description should be explicit.

– The new teaching behavior and opportunities should be demonstrated over a period of several weeks or months to practice the behaviors with fellow teachers and to discuss and receive corrective and supportive feedback.

– The training should incorporate guidance from teachers who have mastered the new teaching method and assistance with solving problems associated with its implementation. The logistic of handling hardware, software, and learning materials must be carefully planned and assisted by dedicated personnel.

These recommendations were taken into account while preparing the in-service chemistry teachers' training to use computers in the classroom.

The "Computer Applications in Chemistry Teaching" Training

The use of computers in chemistry instruction is not prevalent in Israel, because most of the teachers were not exposed to the methodology of Computer Aided Instruction and because of a lack of appropriate software. The in-service teachers training involved using CAI for teaching chemistry, while practicing with available courseware (Barnea & Dori, 1992; Cohen, 1992) and developing new CAI modules. The course emphasized a variety of possibilities for using courseware in chemistry as a tool for tutoring, illustrating and demonstrating chemical processes and phenomena at the molecular level, and diversity of teaching methods.

The purpose of the in-service training was to increase the teacher awareness and to strengthen the confidence in his/her ability to use the computer in the classroom.

In order to show all the benefits students gain while using computers, we developed a prototype of a CAI module on polymers that may serve for mastery learning, enrichment, and a source for problems and their solutions. Figure 1 is an activity-product diagram, representing the major activities (recorded within ellipses) and their products (recorded within rectangles). Arrows running from activities to products represent the activities that yield the products, while those from products to activities are the objects needed for an activity to take place.

The Polymer module (Dori & Barnea, 1993), as well as the trainees mini-modules, were developed on Macintosh™ computers in the authoring environment.

Research Goal and Population

The research goal was to find out if an appropriately designed in-service training course can increase teachers' awareness of the computer as a useful tool in chemistry teaching.

The sample of teachers included an experimental group and a control group. The experimental group consisted of 39 chemistry teachers divided into two sub-groups. Sub-group 1 included 22 teachers who came to the training on their own initiative. Most of these teachers teach chemistry in high schools and have several years of teaching experience.

The other 17 teachers in sub-group 2 were new immigrants from the former USSR, who participated in a retraining chemistry course. The control group included 27 chemistry teachers who attended a summer training program in chemistry. The summer training did not include any topic related to CAI. Table 1 lists the teachers' education, teaching experience, and experience in preparing students for matriculation examinations (a set of examinations taken by high school seniors at the national level in Israel).

As Table 1 shows, the average age in the control group was lower than that in the experimental group. Moreover, the control group teachers, on average, were less experienced than the experimental group teachers in preparing students for matriculation examinations. This finding is in accord with our expectation that teachers in the early stage of their career are primarily concerned about basic training and so have less time for topics that are considered "advanced" or enrichment, such as the use of new technologies.

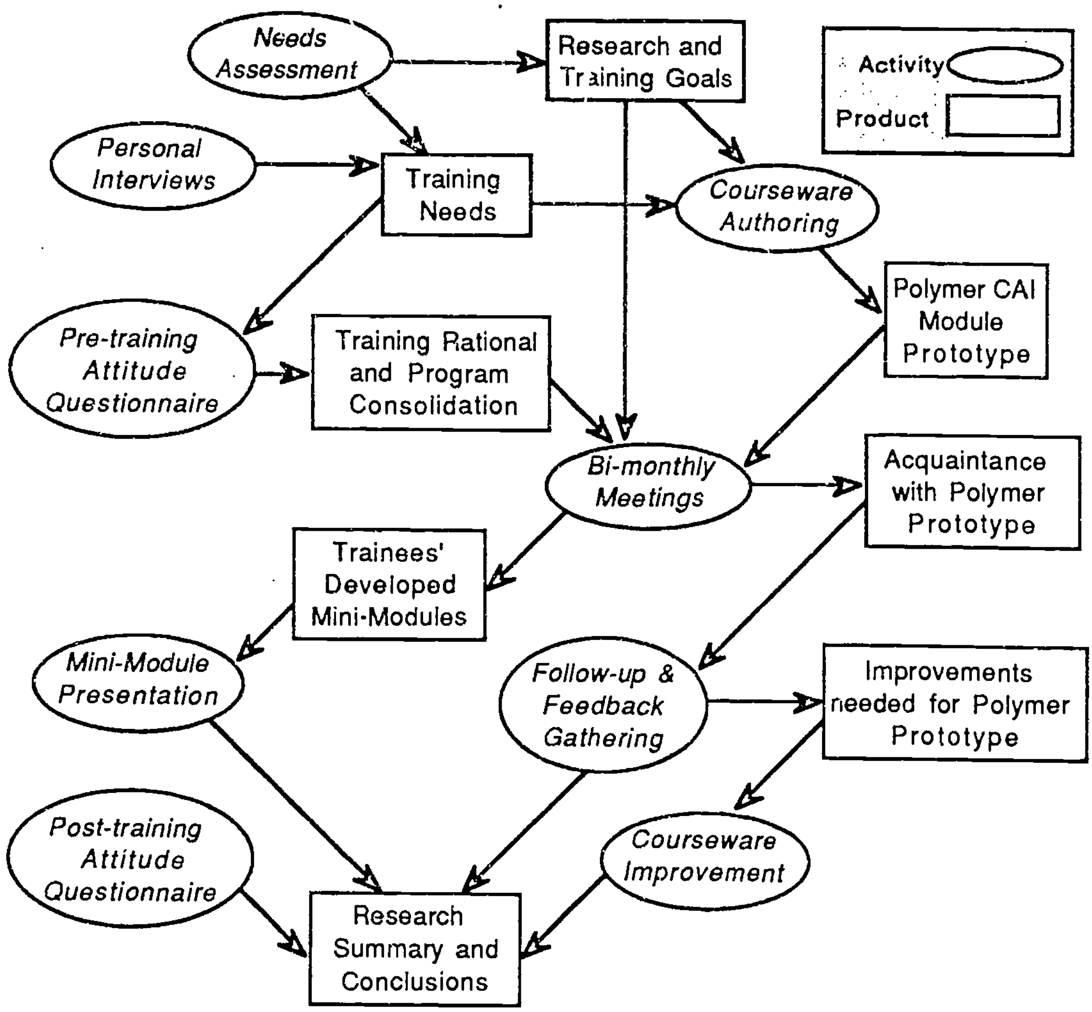

Figure 1 Activity-product diagram of the research and in-service training

Table 1 *Sample description: the experiment and control group*

Description	Experimental Group		Control
	Sub-group 1	Sub-group 2	
Sample size	22	17	27
Position in school			
mentor	3	3	3
teacher	15	6	23
other	4	8	1
Education			
Ph.D	2	–	1
M.Sc	7	15	12
B.Sc	12	2	13
other	1	–	1
Age			
20-30	7	2	8
31-40	8	8	14
41-50	3	7	4
over 50	4	–	1
General teaching experience			
average	12.63	9.00	8.11
s.d	11.72	7.72	6.16
Chemistry teaching experience			
average	11.05	7.88	6.42
s.d	10.59	7.19	5.80
Experience in preparation for matriculation examination			
average	7.05	6.17	1.92
s.d	8.13	7.94	2.96

Research Instruments

The assessment of both the training and the courseware was done using three tools: a pre- and post-training attitude questionnaire, observations of the training teachers and a CAI polymer module questionnaire.

The attitude questionnaire

A questionnaire, consisting of 24 items assessed the teachers' attitudes toward CAI before and after the training. A similar methodology of using questionnaires to assess teachers' attitudes toward computers has been employed by Woodrow (1987) and Ronen (1990).

Table 2

Teachers' attitudes towards computers and CAI - factors, items and Cronbach- α reliability

Factor	Sample Item	No. of items	Cronbach-α reliability	N
1. Computer confidence	*I feel comfortable with computers*	3	0.65	60
2. Advantages of using CAI	*The use of computers enables the individual to advance at his own pace*	3	0.71	53
3. Willingness to implement CAI in class	*I am willing to integrate computers in chemistry teaching*	3	0.71	61
4. Readiness to invest time and effort practicing and programming	*The need to engage in authoring courseware will help me use computers for teaching*	3	0.56	60
5. Students attitudes towards using computers	*Students are interested in computerized experiments*	4	0.59	56
6. The entire questionnaire		24	0.85	38

The items in the questionnaire were Likert type and were composed following the training needs that were identified in the needs assessment and the personal interviews during a preliminary session with chemistry teachers (see Figure 1). The items in the questionnaire involved the subjects/factors of the computer as a learning tool, writing computer programs, and students' achievements and self study.

The questionnaire's reliability was statistically tested and the items were divided into factors by factor analysis. The Cronbach-α reliability values were calculated for each factor separately as well as for the entire questionnaire. These results, summarized in Table 2, show that the entire questionnaire is highly reliable (Cronbach-α = 0.85), with individual factors having Cronbach-α coefficients ranging from 0.56 to 0.71.

Pre-attitude group comparison

As noted, originally the teachers in the experimental group included two sub-groups: 22 chemistry teachers who came to the training on their own initiative and 17 new immigrants. The control group included 27 chemistry teachers who attended a basic summer training with no exposure to new teaching technologies.

To compare the two experimental groups and the control group, an ANOVA test was performed, based on the attitude pre-test questionnaire. The results of the test, summarized in Table 3, show that there is no significant difference in the attitudes of these three groups at the beginning of the training. Therefore, we joined the two sub-groups into one experimental group. The separation between the experimental group and the control group was done on the basis of the treatment (i.e., participation in CAI training course). Another analysis of variance between the (joined) experimental group and the control group is shown in Table 4.

Tables 3 and 4 show that since there is no significant difference between the experimental and the control groups, one may compare the post-attitude questionnaires of the two groups and correctly infer the effect of the CAI training.

Courseware questionnaire

Polymers is a subject studied as an elective unit by senior high school students in Israel who major in chemistry. Motivated by lack of adequate means to model and simulate dynamic processes and three dimensional structure of polymers, the hazard and cost of experiments with polymers, and the need for different complexity levels, we chose this subject for the CAI module (Dori & Barnea, 1992).

The module consists of three topics and three "information organizers". The topics are organic chemistry, polymerization and structure and characteristics. The "Organizers" are concept maps, data base, and library. The program enables the student to select any topic without imposing any predetermined learning path, enabling students with a variety of knowledge levels to engage in effective learning without loss of time.

Highlighted terms within the text can be further explored by clicking at them in order to obtain more details or to refresh one's memory. Each topic ends with a set of problems, for which immediate responses are provided, rewarding with a pleasant sound and a title for a correct answer, and explaining the correct answer if an incorrect one was given. This prompt feedback is very instrumental in that it provides for remedial learning of the "weak" points. Use of graphics and animation enables vivid display of molecular structure and polymerization processes.

Table 3 *Analysis of variance of the pre-attitude among the three groups - two subgroups of the experiment group and one of the control group*

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	0.210	0.105	1.24	0.297
Error	67	5.701	0.035		
Corrected Total	69	5.911			

Table 4 *Analysis of variance of the pre-attitude between the (joined) experiment group and the control group*

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	1	0.014	0.014	0.19	0.668
Error	64	4.871	0.076		
Corrected Total	65	4.885			

To assess the CAI module on polymers, a feedback questionnaire was administered to the experimental group. The results of this questionnaire were used as a basis for improvement of the polymer module.

The questionnaire consisted of eight questions such as:

"Is the courseware friendly and easy to use?"

"How can students benefit from the polymer module with respect to the following characteristics: content, exercises, graphics, animation, library and concept map?"

"What additions or alterations would you suggest in the polymer module?"

Table 5a *Analysis of covariance of teachers' post attitudes*
Factor 1 – computer confidence

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	9.84	4.92	28.1	0.0001
Error	63	11.0	0.17		
Corrected Total	65	20.8			

Table 5b *Analysis of covariance of teachers' post attitudes*
Factor 2 – advantages of using CAI

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	3.72	1.86	9.79	0.0002
Error	63	12.0	0.19		
Corrected Total	65	15.7			

Table 5c *Analysis of covariance of teachers' post attitudes*
Factor 3 – willingness to implement CAI in class

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	12.9	6.47	43.7	0.0001
Error	63	9.32	0.18		
Corrected Total	65	22 3			

Table 5d *Analysis of covariance of teachers' post attitudes*
Factor 4 – readiness to invest time and effort practicing and programming

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	1.66	0.83	3.65	0.03
Error	63	14.34	0.23		
Corrected Total	65	16.0			

Table 5e *Analysis of covariance of teachers' post attitudes*
Factor 5 – students' attitudes towards using computers

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	0.45	0.23	1.90	0.16
Error	63	7.46	0.12		
Corrected Total	65	7.91			

Table 5f
Analysis of covariance of teachers' post attitudes – the entire questionnaire

Source	DF	Sum of Squares	Mean Square	F Value	P
Model	2	1.76	0.88	23.4	0.0001
Error	63	2.36	0.04		
Corrected Total	65	4.12			

Research Findings

The research results were based both on a quantitative investigation (the questionnaire analysis), and qualitative evaluation (observing the trainees and gathering feedback on the polymer module).

Change in teachers' attitudes toward computer aided instruction by factors

Through factor analysis (Table 2), several factors that affect teachers' attitudes were found: (a) computer confidence, (b) advantages of using CAI, (c) willingness to implement CAI in class, (d) readiness to invest time and effort practicing and programming, and (e) students' attitudes towards using computers. Following this, analysis of covariance was performed on each one of the factors and on the entire questionnaire. This was done to compare the experimental and control post-attitude results with the pre-attitude as covariant.

Tables 5a through 5e are analysis of covariance of teachers' post-attitudes in each one of the factors (a) through (e), while Table 5f is the analysis of covariance of the entire questionnaire. All but Factor (e) were found to be significant, and the questionnaire as a whole was also found to be significant.

Factor (a) – computer confidence – shows that the training strengthened the confidence of the experimental group in using computers in their classrooms.

Factor (b) – advantages of using CAI — deals with two advantages of using computers for teaching purposes: individual learning pace and students' achievements. At the beginning of the training, teachers were not aware of these advantages of CAI. Rather, they thought that this type of learning might be a waste of time. At the end of the "treatment," after they had experienced the CAI module on polymers, their attitudes changed: they realized that this teaching method is suited to individual learning and improves the learner's achievement.

Factor (c) – willingness to implement CAI in class – refers to the lack of anxiety of integrating computers in class. Prior to the training, teachers were reluctant to introduce computers in their curriculum because of computer anxiety and the impression that this will be a cause of the wasting of time. After the training the teachers are ready and willing to integrate computers in their classes.

Factor (d) – readiness to invest time and effort practicing and programming – has also increased for teachers who participated in the training, but showed no significant change for the control group. This can be explained on the grounds of the mini-courseware modules developed by the experiment group members, which they enjoyed and took pride of.

Factor (e) – students' attitudes towards using computers – refers to the teachers' expectations of their students' attitude toward CAI. This factor is the only one in which no significant change was found for the experimental group. Rather, it was the control group that showed a significant change. This result is natural, since at the time of filling in the post-attitude questionnaire by the teachers, their students have not yet been exposed to CAI, so there is no reason to expect that the experimental group will be in a better position than the control group to anticipate the students' responses to CAI.

The difference between pre- and post-attitude questionnaires as a whole for the experimental group was found to be highly significant ($p<0.0001$). In summary, it is safe to say that the in-service training had an overall profound impact on the teachers that took part in it and influenced them in a variety of ways, discussed above.

Separate attitude items that changed between pre- and post-test

Pre-post differences in teachers' attitudes were calculated for separate items in the attitude questionnaire. This analysis was made possible on the basis of the finding that there was no significant difference between the experimental and control groups prior to the treatment (See tables 3 and 4). Negative items and their respective scores were reverse scored prior to their statistical analysis in order to obtain uniformity and meaningful results. Some of the items have been found to show a significant change between the pre-test and the post-test. These items are listed below, with inverted items denoted by an asterisk, and are summarized in table 6.

Item 1: High school students should be aware of the role of computers in society.

Item 6: I feel that integrating computers into chemistry teaching will enhance the motivation of my students.

Table 6: Item differences in teachers' attitudes towards CAI between Pre and Post test

Item #	Group	N	Average of differences	S.D.	S test*	Significance
1	experiment	39	0.26	0.59	5.0	$p<0.002$
	control	26	0.03	0.40	2.5	n.s
6	experiment	39	0.26	0.67	4.0	$p<0.03$
	control	27	0.03	0.65	0.5	n.s
9	experiment	36	0.58	0.97	8.0	$p<0.0009$
	control	24	0.17	0.70	1.5	n.s
11	experiment	36	0.66	0.98	7.0	$p<0.0004$
	control	25	0.16	0.75	1.0	n.s
16	experiment	36	0.18	0.63	5.5	$p<0.005$
	control	25	0.06	0.38	–0.5	n.s
19	experiment	35	0.46	0.91	6.0	$p<0.007$
	control	24	0.0	0.59	0.0	n.s
21	experiment	33	0.58	0.63	4.2	$p<0.02$
	control	23	0.17	0.49	2.0	n.s
22	experiment	22	0.63	0.84	5.0	$p<0.004$
	control	24	0.41	1.10	2.0	n.s

*The use of the s test was done because the distribution of the scores was not normal.

Item 9: My training prepared me for making decisions on computer implementation for teaching chemistry.

Item 11: Every science teacher should be able to write a simple computer program.

Item 16*: I fear that writing computer programs by myself will be very difficult.

Item 19*: Writing my own computer programs will not increase my confidence to use computers in the classroom.

Item 21: The need to write my own programs will help me explain the subject matter to the students.

Item 22*: Teaching chemistry with CAI slows down the progress pace of the students.

The above individual items in which a significant change in attitude has been detected, can be classified into a number of categories:

– the contribution of computer use for the students' education:

awareness of the roll of computers in society;

raising the students' motivation; and

individualized learning, enabling self study on one's own pace.

– writing computer programs:

is not very difficult;

increases teachers' confidence to use computers in the classroom; and

helps the teacher explain the subject matter to the students.

– decision making:

the training prepares teachers for making decisions on computer implementation for teaching chemistry.

These findings are in accord with the results obtained by the factor analysis as well as with the feedback we received from the teachers on the courseware useed throughout the training, as discussed below.

Use of the CAI polymer module by immigrant vs. non-immigrant teachers

Feedback on the CAI polymer module was obtained both through observations and a questionnaire. We observed the teachers while using the module. The teachers used the time efficiently through group-work and discussions. A noticeable difference between the experimental sub-groups (non-immigrants and immigrants) was found.

The non-immigrant teachers knew the subject matter from their own teaching experience. For this population, the training was an introduction to a new teaching strategy.

The immigrant teachers were not familiar with the polymer subject prior to the course, so they used the CAI module both as a tutorial to the polymer subject and as an enrichment material. They spent more hours than the non-immigrant teachers in computer sessions, because they studied the subject thoroughly by reading, summarizing and printing the contents of the courseware screens. The reason they gave for spending many hours in front of the computer was that the explanations and examples in the CAI polymer module were more enlightening than those in the book.

Feedback questionnaire on the polymer module

At the end of their exposure to the module, the teachers were asked to respond to a feedback questionnaire in which they expressed their opinion on the module. The teachers expressed their enthusiasm to use the CAI module in their classes. As particular reasons for this favorable attitude they indicated especially the 3-dimensional polymer models, the animation and the visual effects. Some statements given by the teachers in the questionnaires are cited below.

"The module is friendly and easy to use."

"The instructions in the module are clear, no problems were encountered in navigating through the courseware."

"The animation and visual effects are enlightening; they explain polymerization and stretching processes which are difficult to understand by reading a book."

"The module enables rehearsal of important information and individual progress."

Discussion and Further Research

Teachers, like most humans, fear changes because of the uncertainty element involved (Hebb, 1958; Joyce & Showers, 1980). To overcome this fear of new teaching strategies, we conducted in-service training for chemistry teachers, in which they were exposed to CAI through active participation in using a CAI module on polymers and designing their own mini-courseware. To verify the effectiveness of this training, we examined the attitude change of the trainees. This change, if found, is a first step towards eliminating computer anxiety and fostering the introduction of new technologies to the educational system.

Our findings, that the training has a positive effect on teachers' confidence and willingness to use computers, conform with results obtained in related studies dealing with changing teachers' attitudes towards CAI (Lazarowitz & Huppert, 1993 ; Ellis, 1990).

Walker et al. (1988) claimed that the best way to introduce computer technology is by integrating it into the existing curriculum. Following this strategy, teachers realized the advantages of using CAI while teaching the chemistry of polymers.

Some of the teachers who took part in the training recently started to use this methodology in their classes in order to get better understanding of the 3D structure of the molecules and improve their students' motivation. How this new teaching method will affect the students' understanding and achievements remains to be seen, and we intend to investigate it as soon as results become available.

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