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Author: Barnea, N. & Dori, Y.J.

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To introduce the teachers to the variety of possibilities and benefits of using courseware in chemistry, we have developed a CAI module on polymers. It may serve for mastery learning, enrichment material, and as a source of problems and their solutions. As part of the training. each team developed a mini-courseware.

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 questionnaires have indicated a positive change in teachers' attitudes towards CAI . The feedback on the polymer module was also very favorable.

The results indicate that teachers' attitude towards computers and the rate of using computers can be positively changed by an in-service training. Teachers prefer CAI modules that can be integrated into the existing curriculum.

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In-service Chemistry Teachers Training:
Introducing Computer Technology as a Teaching Aid

N. Barnea and Y.J. Dori
Department of Education in Technology and Science
Technion, Israel Institute of Technology
Haifa 32000, Israel

ABSTRACT

The use of Computer Aided Instruction (CAI) for chemistry is not prevalent in Israel and only few teachers use this tool to improve teaching. The research determines the effects of in-service training and teachers’ self-developed mini-courseware on broadening CAI use for chemistry. 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.

To introduce the teachers to the variety of possibilities and benefits of using courseware in chemistry, we have developed a CAI module on polymers. It may serve for mastery learning, enrichment material, and as a source of problems and their solutions. As part of the training. each team developed a mini-courseware.

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1 INTRODUCTION

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 (Wise and Okey 1983; Dillashow and Bell 1985). 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 the awareness of teachers and students that computers can be a productive tool in developing new methods and learning environments (Green and 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 computers 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, capable of authoring state-of-the-art courseware.

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

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.

2 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, advanced options for simulation and graphics, demonstrating models of the micro world of molecules, atoms and sub-atomic particles. Computer enable students to solve a variety of problems while doing their own search at their own pace. Another important feature of CAI is the micro-computerized laboratory (MBL) and the ability to simulate experiments, expensive or hazardous as they may be had they been conducted in an actual laboratory setting (Meuchenry,1983; Lehman,1985; Krajik et al., 1986; Mintz,1990).

According to Ellis and 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 and Songer (1991). Based on the finding (Eylon and Linn, 1988) that the learner is characterized, among other things, by the ability of learning self monitoring skills, they developed a "Computer as Lab Partner" (CLP) curriculum that explicitly motivates students to construct understanding.

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

3 IN-SERVICE TEACHERS TRAINING

The frequent changes in technology make it a necessity for each teacher to update and refresh his/her knowledge. The alignment of teacher training is the main function responsible for the progress and development of teachers. The main purposes of the training from the view-point of the education system are: changes in attitudes and behavior of teachers, enrichment of their knowledge and expansion of their teaching skills (Unesco, 1981).

According to Hord and Huling (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 use new approaches to teaching. For a teachers' training to be effective and influential, a number of recommendations have been compiled from the studies of Joyce and 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.

We have taken into account these recommendations while preparing the in-service chemistry teachers training to use computers in the classroom.

4 RESEARCH GOAL AND POPULATION

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

The sample of teachers included an experiment group and a control group. The experiment 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 a teaching experience of several years.

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

Group		Experiment Group Sub-group 1	Experiment Group Sub-group 2	Control
		N=22	N=17	N=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

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 in chemistry. The summer training did not include any topic related to CAI. Table 1 lists the teachers' education, teaching experience, and their experience in preparing students for matriculation examinations.

As Table 1 shows, the average age in the control group was lower than that of the experiment group. Moreover, the control group teachers were, on the average, less experienced than the experiment 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.

To compare the experiment and control groups, an ANOVA test was performed based on the attitude pre-test questionnaire (discussed in Section 6.1). The results of the ANOVA test are summarized in Table 2.

The results in Table 2 show that there is no significant difference among the attitudes of the three groups at the beginning of the training. Therefore, we joined the two sub-groups into one experiment group. The separation between the experiment 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) experiment group and the control group, is shown in Table 3.

Table 2 *Analysis of variance 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	Pr>F
Model	2	0.210	0.105	1.24	0.297
Error	67	5.701	0.035	1.24	0.297
Corrected Total	69	5.911			

Table 3 *Analysis of variance between the (joined) experiment group and the control group*

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

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

5 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 lack of appropriate software. The in-service teachers training involved using CAI for teaching chemistry, while practicing available courseware 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 in 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 have 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 and Barnea, 1993) as well as the trainees mini-modules, were developed on Macintosh™ computers in the HyperCard authoring environment.

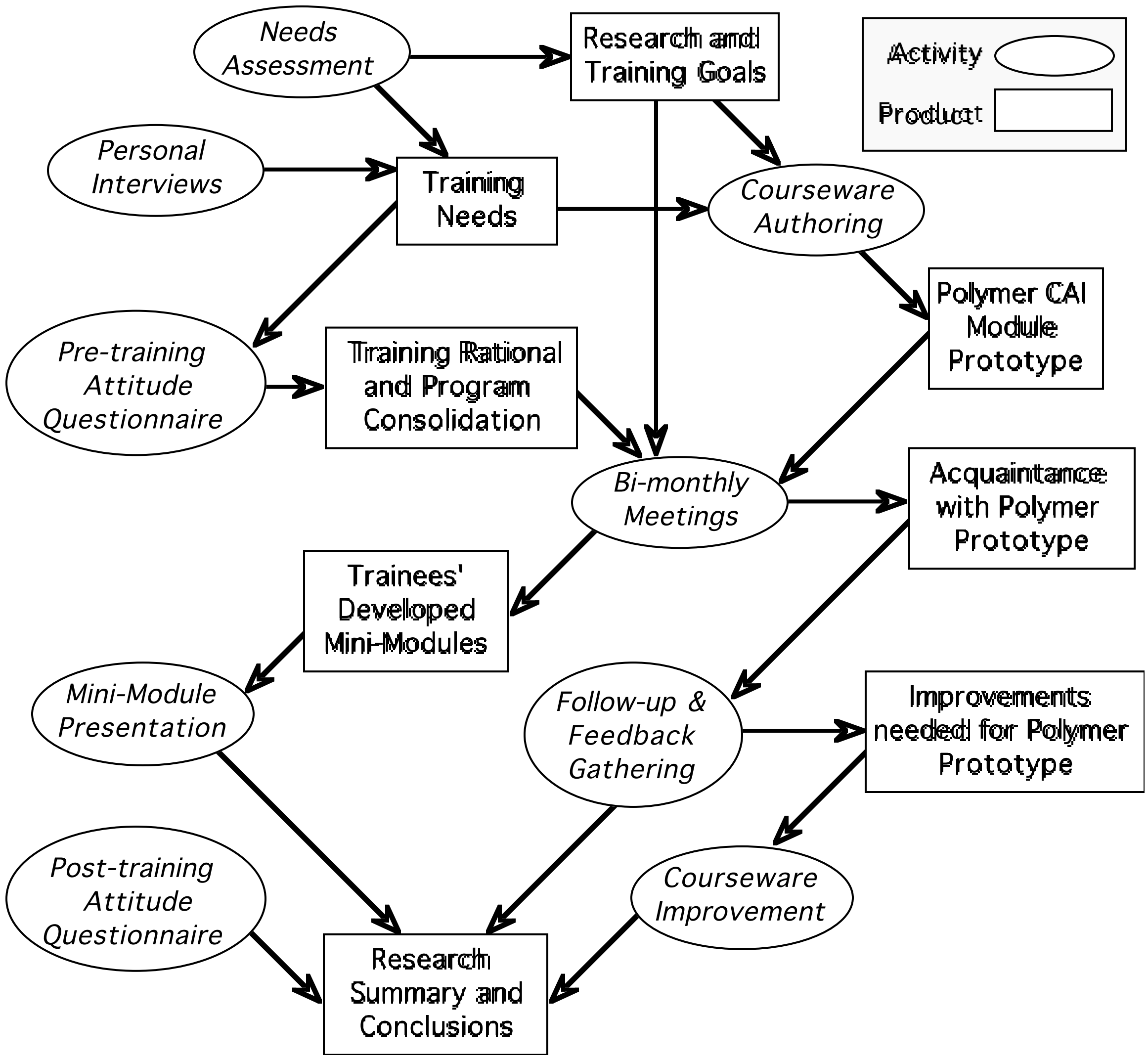

Figure 1 *Activity-product diagram of the research and in-service training*

6 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.

6.1 Attitude questionnaire

An attitude questionnaire, consisting of 24 items concerning various areas examined the teachers' attitudes towards CAI before and after the training. A similar methodology of using questionnaires to assess teachers' attitudes towards computers has been employed by Woodrow (1987) and Ronen (1990).

Table 4 *Teachers' attitudes towards computers and CAI - factors, items and a-Kronbach reliability*

Subject/Factor	Item Type	No. of items	α-Kronbach	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 Lykert 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 regarded 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 subjects by factor analysis. The α-Kronbach reliability values were measured for each factor separately as well as for the entire questionnaire. These results, summarized in table 4, show that the entire questionnaire is highly reliable (α-Kronbach = 0.85) with individual factors scoring α-Kronbach in the range 0.56 to 0.71.

6.2 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 3D 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 and 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.

To assess the CAI module on polymers, a feedback questionnaire was administered to the experiment 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?”

7 RESEARCH FINDINGS

The analysis of the research results was based both on quantitative – the questionnaire analysis, and qualitative evaluation – observing the ttrainees and gathering feedback on the polymer module.

7.1 Teachers' Attitudes towards computer aided instruction

The quantitative evaluation involves the difference between teachers' attitudes before and after the training. Through factor analysis we have found several factors that affect teachers’ attitudes: (1) computer confidence, (2) advantages of using CAI, (3) willingness to implement CAI in class, (4) readiness to invest time and effort practicing and programming, and (5) students' attitudes towards using computers.

As Table 5 shows, a positive change in teachers' attitudes of the experiment group was found to be significant for most factors, while the changes found for the control group (with the exception of factor 5) were non-significant.

Table 5: Factors' differences in teachers' attitudes towards CAI between Pre and Post test

Factors	Group	N	Average of differences	S.D.	Type of test (s/t)*	Significance
1	experimental	39	0.27	0.52	t=3.25	p<0.002
	control	27	-0.08	0.34	t=-1.23	n.s
2	experimental	39	0.25	0.49	t=3.20	p<0.003
	control	27	0.17	0.59	t=-1.41	n.s
3	experimental	39	0.15	0.40	s=5	p<0.003
	control	27	-0.09	0.40	s=-2	n.s
4	experimental	39	0.18	0.63	s=7.5	p<0.008
	control	27	0.06	0.38	s=2.5	n.s
5	experimental	39	0.08	0.53	t=0.95	n.s
	control	26	0.14	0.31	t=2.23	p<0.03
The entire question.	experimental	39	0.16	0.20	t=4.94	p<0.001
	control	27	0.05	0.25	t=-1.04	n.s

*The s test was used when the distribution of the group was not normal.

Comparing the differences between pre- and post-attitude questionnaires for each factor, we have found the following significant changes in the individual factors.

Factor 1 – computer confidence – shows that the training strengthened the confidence of the experiment group in using computers in their classrooms.

Factor 2 – 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 3 – 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 wasting time. After the training the teachers are ready and willing to integrate computers in their classes.

Factor 4 – 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 5 – 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 experiment group. (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 experiment 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 has been found to be highly significant ($p<0.001$) for the experiment group and non-significant for the control group.

A similar analysis was done on separate items. Negative items and their respective scores were inverted 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 roll of computers in society.

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

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.

__Table 6:__ Items' differences in teachers' attitudes towards CAI between Pre and Post test

Item #	Group	N	Average of differences	S.D.	Type of test*	Significance
1	experiment	39	0.26	0.59	s=5	p<0.002
	control	26	0.03	0.40	s=2.5	n.s
6	experiment	39	0.26	0.67	s=4	p<0.03
	control	27	0.03	0.65	s=0.5	n.s
9	experiment	36	0.58	0.97	s=8	p<0.0009
	control	24	0.17	0.70	s=1.5	n.s
11	experiment	36	0.66	0.98	s=7	p<0.0004
	control	25	0.16	0.75	s=1	n.s
16	experiment	36	0.18	0.63	s=5.5	p<0.005
	control	25	0.06	0.38	s=-0.5	n.s
19	experiment	35	0.46	0.91	s=6	p<0.007
	control	24	0.0	0.59	s=0	n.s
21	experiment	33	0.58	0.63	s=4.2	p<0.02
	control	23	0.17	0.49	s=2	n.s
22	experiment	22	0.63	0.84	s=5	p<0.004
	control	24	0.41	1.10	s=2	n.s

*The use of the s test was done when the distribution of the group was not normal.

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.

7.2 Observing teachers using the CAI polymer module

Feedback on the CAI polymer module was obtained both through observations and a questionnaire.

We have observed the teachers while using the module. The teachers used the time efficiently through group-work and discussions. A noticeable difference between the experiment sub-groups (non-immigrants and immigrants) has been 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.

7.3 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."

8 DISCUSSION AND FURTHER RESEARCH

Teachers, like most humans, fear changes because of the uncertainty element involved (Hebb, 1958; Joyce and Showers, 1980). To overcome this fear of new teaching strategies, we have conducted an 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 have examined the attitude change of the trainees. This change, if found, is a first step towards eliminating computer anxiety and foster 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 (Hupert and Lazarowitz, 1990; Ellis, 1990).

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

Some of the teachers who took part in the training have 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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