CHAPTER IV

FINDINGS AND ANALYSIS

This chapter reports the results of Phases 1, 2, and 3, including the design development of the pedagogical model for 11th grade chemistry teaching through computer assisted guided inquiry. The results appear in consecutive order based on the accomplished research phases.

Observations and Interviews in Classroom (Phase 1)

This phase includes three pre-observation interviews, three post observation interviews and ten consistently videotaped sessions of classroom observations, the details of which appear in the following sections. At first, the researcher described some general outcomes related to computer access and the resources used within the context of computer use. Secondly, she recounted the role of each participant in the classroom and then described the different ways chemistry classes were observed as the research emphasizes the role of the computer in teaching and learning of the subject. Later, she analyzed those roles and interactions in order to present the perceived image of the in-classroom practice.

Computer lab and access. It is undeniable that the presence of computer is essential at school, but some schools do not have enough facilities to welcome this technological necessity. For example, at Ferasat School, Afsaneh, the biology teacher has one computer lab. Consequently, they have problems with the availability of the computers for teaching and learning the chemistry subject as other teachers are also assigning students to this computer. The Safayeh Asfahani School does not use a computer lab, and Sedigheh uses one computer and video projector for the biology laboratory. The issue was raised by Soodabeh, Shahin and other teachers that they need special equipment and software; moreover, they need to be trained in using these facilities, as they talked about it. Due to equipment shortages, the times of the classes and exams are not the same in different high schools. These circumstances were also making it difficult for other teachers to access the computer. Even though ten ICT teams and principals supported teachers, only two ICT teams- Zohreh Hadikhn Tehrani and Saba- had good coordinators to support teachers in computer labs.

Classroom activity. The goal for the class activity was to investigate the roles of the teacher, students, and computer within the chemistry-teaching context rather than the ICT alone. Therefore, the researcher had observed and interviewed teachers such as, Laleh, who had access to a computer lab and the use of a small range of technology in the chemistry teaching context. She had the skill to use some software such as: a) PowerPoint, Word and Excel to prepare presentations or to display information for the students, and b) Video projector, to present lessons.

The Report showed that they needed much more materials and training. For example, Mandana and Roghayeh, at Narges and Farhang School both had very limited opportunities to use a computer in chemistry teaching. They faced many limitations in their teaching, as they did not have access to computer and the Internet.

Experiences of using computer in Chemistry teaching. In this study, the researcher observed the use of computers during teaching and interviewed teachers both before and after her observation. This section recounts the ten teachers' knowledge and experience in using computers and the pedagogy that they adopted and used in the classrooms.

Afsaneh: An experienced teacher who has taught for 16 years

Afsaneh has been teaching for several years. She knew something about ICT, Word, and some CD ROMs. She tried hard for learning and using computer in her classrooms. She described that: "According to my experience….I knew that people love this". She worked hard, but she liked it. Students are very happy.

Laleh: An experienced teacher who has taught for 11 years

She said that she had a good feeling about computers; she knew MS. Word, Excel and Internet. She used Intranet and Internet resources in her own classes, but her students used papers because they did not have sufficient abilities as required by their teacher. The teacher used the computer for discussing teaching and the new materials.

Mandana: An experienced teacher who has taught for 11 years

At first she could not use the computer, so she did not have a good feeling about that. But after some special courses, she liked and used it as a facility for teaching.

Shahin: An experienced teacher who has taught for 20 years.

The lack of facility was her first problem in using the computer because most of the classes did not have computers and some staff and students needed some training courses for using them in the classes.

At first, new material was shown as a film, and then the teacher explained them to students and divided the class into some groups for doing their assignments.

Soodabeh: An experienced teacher who has taught for 20 years

She believed in the important role of computer in teaching but she needed some special training courses for preparing herself.

Sedigheh: An experienced teacher who has taught for 20 year

She had used the traditional way of teaching for a long time, but she changed her methods and tried to be innovative in her teaching. She taught new materials and discussed them, but she needed more skills for using the computer in her classes.

Roghayeh: An experienced teacher who has taught for 16 years

She believed in an important role of the computer (PowerPoint), but she did not use it all the time and instead used scale models for teaching.

Ladan: An experienced teacher who has taught for 9 years

She believed that she did not have enough time for using the computer in her classes.

Mandana: An experienced teacher who has taught for 7 years

She thought that she needed more training courses for using computers in her classes.

Mooghgan: An experienced teacher who has taught for 15 years

She explained that most of the students like computers because it was new for them, but they needed some more skills. She taught and explained new materials by using computers.

Commentary on Observations and Interviews

Although the scope of this study is limited as there were only ten observations and interviews, the results showed the different experiences and different views of implementing computers in classrooms. Examples of such various perceptions and attitudes are presented immediately after this introduction. The participants are the same as in the aforementioned observation report.

Afsaneh tried to use a computer in her teaching. According to her, she found the best resource for teaching and she achieved the best result at last. Laleh used computer in her teaching. Although, she had daily access to computer lab, she used the computer once a month. She explained that she did not use it for all subjects. She was not sure about using a computer and said she needed more training courses.

Mandana used a computer, but she did not have enough self-confidence and promising skills in using it. Although Shahin used a computer in the classrooms and had more skills and confidence in using the computer, she had some limitations when using the computer. She needed more equipment. However, she presented the new materials by using the computer and tried to motivate her students to participate in class activities.

Soodabeh faced some limitations. She could only use a computer once a month. Therefore, she did not have enough abilities in using the computer and it was very unusual for her.

Sedigheh used the computer for presenting the lessons and helping students to do their assignments by computer. She said that she liked the computer but she could not use it all the time.

Ladan and Mandana could use computer only once a month; because of this limitation they had to use CDs in their classes. On the other hand, Roghayeh did not have enough confidence to use computer. She was surprised that her students liked the computer and could learn their lesson by using it.

Mooghgan asked her pupils to use PowerPoint and other skills, because she had exposed them to advantages of this software during her teaching. She found the role of computers in teaching surprising. It motivated learners to learn better.

Robitaille (1996) reported codes of pedagogical practice that should be observed in classroom activities such as teachers' roles, students' roles, their interactions, and the role of technology. However, the present researcher has attempted to verify these factors and their presumed roles in the current research.

Analysis of Classroom Observations

The collected data so far has been used to answer the following research question: *"What is the current chemistry learning status with the use of computer-based activities in the 11th grade of Iranian high school"?*

Analysis in this section has been categorized into three parts: a) the teacher's role, b) students' roles, their interactions, and c) technology. The role of group working was very essential in class activities, but the only one who used it in her classroom was Shahin. She used it as a part of her teaching. She also used CDs to reinforce her teaching. In another class, Sedigheh used a computer only for presenting the materials. Although Sedighed asked her students some questions, their interaction was minimal. The role of group working and class activity were interesting in Laleh's class. She asked a question and tried to motivate her students to participate in class activity, and then she used a CD for completing her explanation. She said that motivation is very important in learning, so that she tried to motivate her students by asking some questions. Afsaneh and Roghayeh used text for teaching the new materials. Mandana used examples to clarify her explanations, but the role of interaction in her classes was still very weak. Shahin said that the computer changed her teaching. She added that she used it, but she needed more skills and training courses. Ladan used the computer in her classes; she said she could find some useful questions on the Internet and asked students about them, but only a few learners could answer her questions. They needed some courses and training in order to use computer.

The researcher believes that her observations of computer-based learning were not incorporating the students' ideas. Moreover, these implementations did not seem successful in enabling them to share the learning. Furthermore, researcher believes that all the observed roles of the inclusion of computer into the classroom activities were undeniably essential, yet the students needed special courses and training to learn effectively from a computer. Some of the interviewed instructors did emphasize such a point of view, however.

Laleh believed that both learners and teachers needed additional computer courses. Sedigheh sometimes used a computer when teaching. She uses PowerPoint occasionally in her classes. She is an example of a moderate user of ICT and technology.

On the other hand, some teachers used the computer willingly and to some extent effectively. Mooghgan reported that the computer changed her teaching. She added that she needs more skills on the presentation of the materials via software. She used the computer to prepare her classroom material. She told the researcher about the way she used to prepare her material prior to her intimacy with computer, but now she could spend more time making her classes more attractive. Mooghgan, another participant in this study, said that the courses they need for their classes would be learning about how to connect a computer to the projector, and using new ideas by using a new resource from the Internet.

However, she could use a CD-Rom as a potential resource of "real integration". The teacher should motivate the students by using new ideas in teaching and learning, she believed. Undoubtedly the lessons could have been taught without using computers, though they may have not been as successful. The users did not believe that there was a difference between using PowerPoint and the computer in their teaching and the teaching without these technology resources. They believed that it was a method in their educational system. That is to say, the inclusion of ICT, in this particular case the computer, is a personal choice that will not affect the act of teaching drastically in case of withdrawal.

McLoughlin and Oliver (1999) defined the pedagogical roles of teachers in a technology-supported classroom as setting joint tasks, rotating roles, promoting student self-management, supporting meta-cognition, fostering multiple perspectives and scaffolding learning. The researcher observed all classes but she could not find any evidence to assess these issues in practice. The cases of Sedigheh and Shahin are different in that both of them used presentations and CDs and tried to integrate ICT into teaching, but instead they followed a traditional educational program. The researcher believes that the inclusion of an undigested ICT facility into the classroom would not work unless foundations of such timely intrusion are conceived through training and remedial teaching of the crew.

The UK Office for Standards in Education (2002) reported two weaknesses in teaching ICT, namely the lack of clarity of purpose, and the use of glossy computer graphics with no real learning goals. The researcher reported that Afsaneh and Mooghgan used multimedia to meet their needs.

Yet, the students should be aware of the instructional goals, and the teachers needed more skills when using multimedia in their classes.

Selliger (2001) states that scaffolding is a useful instructional technique when using ICT. He describes the teacher's role as one in which she is supporting and scaffolding learners to assimilate new information, turning it into knowledge and understanding within a nurturing and supportive environment. She confirms that the teacher usually controls the computer. In some observed cases, as narrated above, the teacher was obedient to the needs of the software as it was run in the classroom.

Laleh and Roghayeh used presentation for the purpose of teaching, but they did not teach students to think critically. Smith (1999) suggested that the success of any approach when teaching with ICT depends on "presenting challenges and opportunities for the pupil, the quality of the teachers' insight into learner's interactions, and the ability to intervene appropriately". This was definitely neglected in the cases described above.

Soodabeh used CDs for teaching and she had prior knowledge on how to use a computer. Shahin and Sedigheh used group working in their classes and they tried to teach Ionic Bonding and Covalent Bonding respectively. It was taken for granted that students in groups would perform this way. Contrary to this supposition, both teachers and students did not have adequate knowledge in using the computer so the whole activity was a total failure.

Cox et al. (1999) have cited the issues in teachers' use of ICT as: a) Implementing ICT may reduce learning and increase monitoring progress, b) The ICT classroom has different organization, c) Teacher and students might be less autonomous as they just try to implement other ideas, d) ICT facilities are more often difficult to access, e) Teachers and student suffer from the lack of proficiency in using of ICT, f) Implementing ICT may bring changes in working habits, g) The teacher's role will change from transmitter of knowledge to enabler of learning, and h) In implementing ICT, pupils' questions to gain knowledge may undermine the traditional authoritarian role of the teacher.

However, it is important to notice that these issues are more or less interactional issues which are not directly related to the general framework of the classroom. The researcher has attempted to look at these issues from the closest position to the whole teaching-learning context to which she has been attached for the period of data collection. Furthermore, the issues raised by Cox et al. (1999) apply to the conditions where the implementation of ICT is assured and the contextual elements, both human and technology, are balanced and appropriately situated. The context of the current research, as has been repeatedly mentioned, is far from such assertion.

In this research, the researcher faced some limitations in realizing the real situations of teachers who shared their teaching and knowledge openly. Through observations and interviews, the researcher understood that Sedigheh was able to share her knowledge in a friendly and intimate condition. Almost all other teachers liked to use a computer in their teaching but it depended on the teacher's preferences of pedagogy, skills, and access to new technology. The participating teachers in this study seemed to have been provided with the basic requirements and had taken the initial steps to use the computer in their teaching, yet they were struggling to be acquainted with technology.

Conclusion

This phase (phase one) included three pre-observation interviews, three post observation interviews and ten videotaped sessions of classroom observations. The analyzed data show that the role of teachers, students, and computer are as important as the interactions among them. The class whose teachers use computers in order for presenting and practicing materials demonstrate some similar factors such as 1) provided images, grounds or context for discussion, i.e., there is a prepared common ground for the interlocutors to communicate their meaning, 2) motivation, i.e. the students who were exposed to the implemented ICT seemed to be more motivated compared to normal classes without ICT technology, although the degree of implementation observed in this study varied across a small sample, 3) utilizing CD ROM for reviewing purposes and/or understanding some chemical concept, i.e. the observed cases were all interested in using CD ROMs in their teaching, and 4) collaborative work among students, i.e. students showed to do a "hands-on" experience where the minimum ICT was utilized to the context of education. The limitations due to the current educational system or the demands of the stakeholders are the other factors that would have led many of these steps taken to frustration. The teachers faced some limitations such as time, ability, and facility; therefore, they preferred to use a traditional model for teaching. This preference was not, however, the teacher's alone, rather the affiliated system, overtly and covertly, was observed to have encouraged them to act invariantly in spite of the ICT facilities included.

Despite these limitations, the implemented computer not only helped learners to better understand some abstract concepts, but also aided teachers to use it as a facility for their teaching. Some other issues that should be attended based on the observations conducted are: 1) Lack of proficiency in ICT. It was frequently observed that, whatever available as far as ICT facilities are concerned, the teachers were inexperienced and awkward in using them. This would lead to questioning the necessity or the rationale of providing such expensive and redundant equipment. Tools, no matter how primitive, need skilled, tool-wise users to prove usefulness. 2) Lack of infrastructure. The foundations improvised in 1998 in the new ICT reform declaration still need time to approach schools practically. The available infrastructure, both in terms of equipment and the macro-level policies are far from suitability and fertility for the inclusion of ICT in the current educational system as it was observed in the context of the present research. 3) Lack of resources. By resources, here the researcher refers to all those pre-conditions most urgently required to implement any ICT initiative in the current educational setting to promote the teaching of chemistry subject. This would be multi-faceted as there are numerous resources lacking in the context of the current research, a few of which are just software, hardware, and human development factors; needless to say the context of education in general is the prime factor.

However, in accordance with the formulated hypothesis, using the computer depends on the teacher's ICT skills, pedagogical skills and the constructs to be delivered for one part, and the students' pertinent proficiency and their achievement for the other. The researcher did not know the ability of students prior to the exposure; therefore, she did not have enough evidence to support this hypothesis. The evidence collected helped her to recognize the problems and elaborate on them hoping for better description that would inform future research. In the second phase, the researcher attempted to use the classroom situation for future development of the research intention.

Interviews with Principals and ICT Teams (Phase 2)

The second research question asks: "What are the factors contributing to the success of computer-based activities in the classroom?" The purpose of phase two was to determine some of the important factors involved in computer-based activities in the 11^{th} grade chemistry classrooms. The emergent factors were clustered around two logical domains: the school principal, and the school ICT team. Each domain was analyzed separately to illustrate emergent factors that had affected the classroom practice. Interviews were conducted in schools with the principal and ICT teams in an attempt to answer the second research question. The results of the analysis provided an opportunity to develop the pedagogical models for chemistry teaching in Iranian high schools. The following discussion explores the principals' perception and point of views of the issues raised.

Stories of principal at the school. This section recounts the ten principals' views on the development of the teacher and staff, ICT developments in the school, and difficulties of implementation of ICT at school levels.

Tahereh: A principal with 15 years of experience.

Most Iranian schools did not have enough facilities and budget, she said.

Sakineh: A principal who has 14 years of experience.

She tried to develop their facilities by calling ICT team to fix some computers in their computer lab. She believed that if she had money, she would have prepared a suitable situation for teachers and students.

The researcher found that most of the principals had a "limited picture" about using computers in education, and they liked to follow their traditional educational systems. The Ministry of Education persuaded schools to decrease their expenses. On the other hand, teachers and students liked to use computers in their classrooms; hence, some persistent problems had developed for the principals.

Zohreh: A principal with 8 years of experience.

She mentioned the role of time in using technology in the school, because staff as well as teachers needed time to be trained. She needed some professional teachers and facilities, she said.

Tahereh: A principal with 12 years of experience.

She was familiar with this topic. She persuaded her teachers and staff to learn about computers, but she needed more facilities to reach her goals.

Through the interviews, the researcher found out that most of the principals agreed that they need computers in their schools, yet they voiced their urgent need for trained teachers who are familiar with the new technology.

Tooran: A principal with 10 years of experience.

She liked the implementation of ICT, because she thought it would be a good way to reach the world's level. She needed a site (lab space), but she did not have enough space in her school. She explained that if she had enough money, she would start to train her teachers.

Fatemeh: A principal with 18 years of experience.

She talked about her problems and the attempts that were made in the past years, but she was not supported by her managers. She was alone and busy. She needed somebody to help her, she said.

Moazam: A principal with 6 years of experience.

Clearly computer is better than other materials, she said. She tried to develop some materials for the classroom, but they did not have enough time to do it. They had a coordinator, but she was not qualified.

The researcher believes that all those schools needed to restructure. However, there were many fundamental problems that schools using computers needed to solve.

Commentary on Interviews with Principals

Several issues were encountered in this phase. The principals seemed to have focused on several prevalent themes such as the professional teacher and budget for developing and using computers in education. The expectation of a plan, policy, and the expected support were very important to teachers and the administration. The pedagogical practice was found focused around the issue of ICT implementation. For example, a primary issue was the recognition of the appropriate use of computer in education based on the status of the current affairs, namely the teacher's knowledge and experience, curriculum's match or mismatch with computer implementation, the time and support offered, and so forth.

Nevertheless, the principal's views were found to be influential factors in this regard in such a way that they seemed to still follow the traditional routine. However, interviewing ten principals was a small study, but it was a reflection of the principals' different visions in using computers. Following this discussion a few examples are presented.

Tahereh: We tried to use computer in our school. She believed that she found the best way. She tried to prepare suitable facilities for her school. Her perceptions of ICT implementation sound limited.

Sakineh: We used computer in our school. Although, school has had access to computer lab every day but teacher used computer once a month. She said they did not use the computer for all subjects. They did not have professional and experienced teachers. She was not satisfied with the current deployment of ICT at her school.

Zohreh: We also used computers. We did not have enough self-confidence when using computers in our school.

Tooran: We used computer in school. She had skills and confidence to use the computer but she had a limited computer laboratory and needed more budget for developing it.

Fatemeh: I tried to support the school but had a problem with coordination, she said. It seemed that she had enough experience with computers and surprised the students by making them use computers in their activities.

Moazam: It was constructive to use ICT, but it should not affect our regular time schedule, the time of the students' exams, because changing the time makes the students worried. She tried to use computers in their spare time instead.

Zhila, and Fereshteh said that they needed some special training, and Tahereh has a lack of confidence in using the computer. She followed a traditional system but her students liked using a computer in their classes. Zhila and Feresteh tried to persuade her staff to use computers in their classes. However, the researcher was surprised to have found a principal who used computers in school and used to encourage staff to use them.

Marsh (2001) illustrated that the important factors which support teachers in their classroom are resources and psychological supports. As Kozma (1999) reported, ICT practices have to be studied within the three concentric contexts: micro level (classroom), meso level (school), and macro level (community). This research tried to show the outcome of using computers in schools. In this way, the researcher has tried to illustrate briefly, through interviews, and the data presented above that the implementation of ICT would be dependent on the perceptions and attitudes of the principal of the intended institution or school. Such perceptions, in positive and constructive situations, will boost the transformation of the traditional schools even to smart ones, whereas, in case of negative perceptions, this will definitely barricade such transformation and modernization.

Analysis of Interviews with Principals

A major factor in the adoption of change was found to be the school principal (Fullan, 1998; Sarason, 1993), the principal or leader of the project supplied the vision, clarified the joint goals for the benefit of the staff, and allowed resource allocation to be conducted in the agreed directions (Meier, 1995; Rosenholtz, 1989).

Based on this description of the authoritarian position of the principal, it is conceivable that such a position is capable of positively or negatively affecting the implementation of ICT at large. Conducting the interviews with the principals in this study revealed a number of most influential attitudinal factors. Visions and budget issues were the most common themes drawn from these interviews. Therefore, there were inadequate planning and late implementation of computer-based activities due to these controversies.

However, there were other issues observed to have been noted by these principals. Among these issues, the varied levels of staff at school, lack of progress in using the network, and some negative student perspectives about computers which led to frustration and concerns about their classes were just a few.

Some supporting batches of data are presented below:

Zohreh said “These projects never went as quickly as we wanted, but we had to support our school, because we had many problems in it”. “I think it could affect my school…. I need to plan …to be able to use it for something, while students had problems and wanted us to solve their problem [problems related to implementing computers]”.

Although Tahereh and Fatemeh had implemented computers in their schools and had integrated computers in the teaching and learning process, they followed traditional ways of teaching.

Sakineh and Tooran said their schools had already implemented computers but the researcher observed that they did not have any prior plan; therefore, their actual use of ICT potentials, like e-mail service, was frustrating. When the researcher asked them to use personal email accounts for discussion related to their normal activities, they responded that they did not have time to manage these affairs. There was a computer in their office that was not used, probably due to their inefficient qualifications to use them. Through interviews, the researcher felt that Zhila and Fereshteh had a plan and a strategy to support their schools unlike some other principals.

However, the researcher realized that many principals were interested in inserting the use of computers in the school curriculum but this was dependent on the policy and the ability to access new technology. The principals provided the initial steps for using a computer in their schools, even though it was not the right step at the right time.

Conclusion

In order to answer the second research question, this analysis included 10 interviews as well as 10 written answers by principals. The final account of the collected data in this phase reveals that the participants (principals) had implemented some kind of ICT facilities, especially computers, in their school curriculum and had nearly similar ideas and interests on corresponding issues related to ICT implementation, necessity and usefulness. The consensus was that the participants' attitudes towards implementing computers in order to be transferred into reality needed qualified, knowledgeable teachers' support. The principals confirmed that using the computer had changed the classroom practice to a noticeable degree. However, the analysis of the collected data reveals that the conclusions drawn are still incapable of supporting any single answer to the second research question. The researcher believes that the issue requires a more rigid data set stringent in terms of elicited attitudes and endured perceptions on the part of the principals. It might be not far from reality to state that these participants were guarding their implemented decisions. The presence of computer at school was sine qua non in the sense that they have contributed enough and the success or failure of implementation, to them, depends on the performance of the other colleagues.

Stories of ICT Team in Schools

The observation showed that many ICT teams could not support teachers in the classroom, and teachers needed more advice and support. Audit trails are provided below.

Maryam: Has been a member of the ICT team for 3 years

They had 15 computers in their schools, but they needed more. Hardware was very expensive and they needed more budget and facilities, she said.

The importance of using computer in classes was the researcher's concern during her study. However, this importance may not be affected with the quantity of the facilities provided under the condition that the users are aware of such crucial role of these facilities.

In some cases in this research it was realized that in spite of the presence of technology the teachers did not have any fixed timetables or weekly programs to use them, while they believe they needed more computers in the smart lab. For example, in one of the days of observation once the researcher arrived at the appointed laboratory she faced the empty room. When she asked the ICT team member where the students are, she smiled and answered, "I do not know"!

Fataneh: A member of the ICT team for 2 years

I was alone, but I used Photoshop, Flash, and sometimes we could support our teachers but we know that it was not enough. They needed more educational software, and we should develop school hardware and software. My problem was with a teacher who could not match her lessons with a computer. Sometimes I trained her, but I did not know if she was affected.

Safieh: A member of the ICT team for 2 years

The researcher told them that they were not using related software. They were using Macromedia to train their students. They started to teach Excel, Word, and database for their needs. Safieh described that "the computer was good for us, but we need some special training courses". They tried to learn but they did not have proper time and textbook.

Noushin: A member of ICT team for 5 years

"It[computer lab] was new, I'd liked it. I improved the site. Now 100 students use it". Many students use the software and do their projects. There were twenty computers in her school. But they needed a multimedia designer software for example, she said. Teachers in her school did some projects with the computer.

Asmat: A member of the ICT team for 3 years

She said, "Our team was active. Sometimes, the teacher used the site. We prepared a suitable place for them. We are connected to the Intranet, one site includes 11 computers with different servers, and teacher used MS, Office 2000, Photoshop, and Visual Basic for teaching. If I had more money, I made another site, we need more space". Their systems needed to be updated. They did not have a suitable server nor an advisor to help them make the best use of their facilities.

Atousa: A member of the ICT team for 5 years

This site included two members. They were computer teachers. They had 14 computers, and available software was Macromedia Flash, Microsoft Office, and some staff knew how to use them. Students did their projects with the help of their teacher. They wanted to buy some new computers and develop their space.

Shadi: A member of the ICT team for 5 years

The researcher asked her about the number of computers in her school. She replied: “There were 27 computers in our school. We have two sites”. But teachers do not use them. Teachers need more training, and their information is observed to be very limited. They followed traditional systems. The excuse was the shortage of staff and not enough time to learn how to use computers. Students and teachers needed to be motivated.

Commentary on Interviews of ICT Team

Several technology factors were encountered in this phase. The need of available supportive systems such as a CD-Rom was apparent. Some teaching issues were the result of hardware and software problems that affected the credibility and effective use of computers in the chemistry classroom as well as coordination.

Safieh: The researcher asked her about the importance of using software in the classes. She smiled, and answered, “I am very young in this field. I should be supported.”

Maryam: She used to prepare texts for teachers, and do something for the principal. She was also in charge of providing exam texts. The big problem was that they were the members of ICT team and should support teachers in the classroom. It was obvious that they did not know their duties in school.

Asmat: She told the researcher that none of the teachers use the computer in their classes. The researcher asked them about facilities that they should prepare for the teachers before she arrives, but they did not have any ideas as they were not informed prior to the sessions.

The role of the ICT team is a school-wide responsibility that involves the development of ICT as a tool for teaching and learning as well as the development of ICT key skills (Kennewell, Parkinson, & Tanner, 2003). Therefore, its members should be active all the time. It is important that they keep up-to-date with new developments, and disseminate this information properly. The researcher observed Shahla's activity, but she could not provide software for the teachers in the computer lab. The researcher asked her about her responsibility, and she looked at the researcher and then answered, "I need too much information about hardware and software, I need some special training courses, but I go to class instead."

The National Council of Educational Technology (1998) suggested that the role of ICT coordinators in secondary schools includes: a) resource allocation, b) system maintenance, c) coordination and monitoring of ICT usage, d) staff training, and e) classroom support for staff (Russell, 2001). Not only Masoomeh but also the other members of the ICT team believed that they needed more training courses themselves. Therefore, the main reason teachers use traditional methods are the lack of support and knowledge from the ICT teams at schools.

Analysis of Interviews with ICT Team Members

Pedagogical elements, the principal, and the ICT Team are important factors that influence the results of ICT implementation as mentioned before. However, these elements may serve as barriers to system implementation. The barriers are related to lack of confidence, lack of experience, inefficient training, and lack of access to reliable technology resources (Dawes, 2001).

Interviews with the principals and ICT teams show that the weakness in placing policies and plans at school level is still unattended and needs immediate concern. The principals are in charge of providing initiatives and/or encouraging teachers to implement ICT. A few of them did show their concerns but they did not know how to interfere and perform their duties as principals.

Maryam said that both the teacher and the students are not able to use the computer for their class activities. She said she did not know how she could support them.

Fataneh believed that the teachers did not have an ideal teacher as a role model, but she also did not assume the position of role model and support the teachers. The ICT teams did not support the teachers and they did not have a suitable laboratory. They also had inadequate time for planning and implementing computers in the classroom.

The researcher asked Atuosa if she had problems with the network. She said it was disconnected and they could not use it. This was the situation even though the ICT team is available and reported on duty.

Shadi said they had plan and the students used computers but the researcher observed them while they were still learning about technology, becoming computer literate, and trying to discover ways to incorporate technology into the district's school. However, in other cases it was observed that the ICT team wanted to support the teachers in the classroom, but they were not timely and the students waited for a long time. From another perspective, an ICT team believed that it is the teacher who must pursue training and show interest in learning new skills.

Asmat said that, "we are very active and we have tried to teach other staff what to do and how to use the computers, but unfortunately staff cannot connect and work with the computer, I wonder why".

Noushin felt that she could help the teacher in the classroom, but she said, "my computer experience is not enough and I need to attend more training courses".

Venezky and Davis (2002) illustrated crucial factors contributing to the promotion of the innovation in these infrastructure resources. These factors are: a) hardware, in terms of the number of computers in the school available for students and teachers for educational purposes, and b) the quality and functioning of equipment (speed of processors, operating systems, peripherals and access to the Internet), as well as c) available software, general and educational.

According to the researcher's realization, all the members of the ICT team were young and needed more experience in this field. Meanwhile, throughout the study, the researcher tried to ensure that there was a good connection among some essential factors such as pedagogy, the principal, and the ICT team, but unfortunately, they were not cooperating and they were not connected to each other technically speaking.

Conclusion

This analysis included 10 interviews, and 10 ICT teams' open-ended handwritten answers to the second research question. This study had attempted to reveal aspects of pedagogical approaches that are used in the 11^{th} grade classes of high schools by chemistry teachers who tried to use them as suitable facilities. The extent of sustainability, and further development and dissemination of practice indicated that the substantial levels of investment in school ICT provision might be paying off. However, teachers and subject departments depend on adequate access to reliable resources (and technical support) for administrating those plans. A principal outlook about the development of ICT and the ICT team was mentioned as expanding resources and practice, thus the process was complex and iterative rather than linear. These 'internal' factors also played a critical role in the processes of both developing and disseminating new training.

Modified Delphi Technique (Phase 3)

Data result and analysis. The current research tried to develop a pedagogical model of teaching chemistry via ICT implementation. In order to come up with a working model which is comprehensive enough, a wide range of both pedagogical and environmental factors were analyzed and weighted to confirm their load and maintain their roles in the final model. The final model is the result of the interactions and the roles these elements play per se in building up the general factor which is teaching chemistry. However, these elements are being questioned and examined in the research question:

"What are the essential features for the development of a model of teaching chemistry subject with the aid of computer to the Iranian high school students in grade 11"?

A Delphi study, consisting of open-ended questionnaire followed by one question, was conducted to collect data to answer this question. The participants in this study were members of panels in the Ministry of Education and higher education professionals who had extensive experience as teaching-learning practitioners and/or authors in related areas. This chapter describes the procedures used and the results obtained from the analysis of the data obtained in the third phase of the study.

The first round of this study consisted of a questionnaire designed to collect demographic information about the panel participants and to develop a list of agreement on features of teaching chemistry (noted in Appendix G).

For the second round, participants were sent a list of 55 statements, compiled by the researcher from the results of the first round, and they were asked to rate the statements as they would agree with the content of items on a Likert-type scale. The 32 statements were rated by the panel as either “strongly agree” or “agree” and were used for the third and final round. Participants were given the mean rating of each item and were asked once again to rate the agreement to each of the remaining items.

Descriptive Data of Round 1

Demographic and open-ended questionnaire: The study panel represented a range of different types of organizations. The panelists (100%) had a minimum of five years public organization service. There was a similar range of working experience differences across the reported size of the participants; from among university faculty members about 40% of the total sample with at least five years of teaching and researching experience. Another 40% of the participants were from the department of chemistry of the Ministry of Education, and about 20% were selected from schools, teachers and instructors of chemistry subject. Having confirmed the collection of their demographic information, for the second step, the respondents were asked to identify [*determine, recognize and evaluate as influential attributes or features playing significant roles*] the pedagogical model for teaching chemistry that they strongly believe must be practiced and be recognized as the practice code. All of the twenty panelists listed at least two features or characteristics in response to the first open-ended question.

The question was:

"In your opinion and based on your experience of teaching chemistry through computer, what are the essential features (contributing factors) of teaching chemistry through computer? The question is intended to determine the components of such a model from the perspective of the point of view of this group of participants. However, the average number of responses given was five (noted in Appendix G).

Descriptive Data of Round 2

The 55 statements generated from the open-ended questionnaire in Round 1 were presented to the panelists in the two categories that had emerged from the literature review:

a) The pedagogical features, and

b) The technological features.

The panelists were asked to rate each statement as: 5) *Strongly agree*, 4) *Agree*, 3) *Disagree*, 2) *Strongly disagree*, and 1) *no opinion/do not know* with the development of a pedagogical model for teaching chemistry through the computer. The mean, mode, standard deviation, and range were calculated for each statement, along with the level of agreement or consensus among the participants that the statement was either "Strongly agree" or "Agree." For the purposes of this study, the percentage of respondents who rated the statement as "Strongly agree" or "Agree" would be utilized to denote agreement or consensus.

Table 4.1

Round Two, Analysis of Expert's Consensus by Studying Description Indicators of Pedagogical and Technological Features

Statement	Mean	Median	Mode	*SD*	Range
Global ICT Website and materials	4.050	4.000	4.00	1.099	4
Curriculum Website	3.950	4.000	4.00	1.050	4
Computer Lab	4.200	5.000	5.00	1.056	3
Chat Room	3.700	4.000	4.00	0.656	3
Increased access to hardware	3.700	4.000	5.00	1.260	4
Technical support	3.550	4.000	4.00	1.234	4
Support from school management	3.750	4.000	4.00	1.069	3
IT advisors	4.250	4.000	5.00	0.850	3
ICT coordinator	4.350	5.000	5.00	0.933	3
Courseware	4.150	4.500	5.00	1.089	4
Educational software	4.100	4.000	5.00	1.119	4
Better search function to find doc	3.900	4.000	4.00	1.020	4
Putting up samples of complete Proj	4.150	4.000	4.00	0.745	2
Research reports	4.300	4.000	5.00	0.732	2
Storing and sharing information	4.100	4.000	4.00	0.788	2
Accessing work-related resources	4.150	4.000	4.00	0.670	2
Online support	4.100	4.000	5.00	0.911	2
Access to computer at home	4.400	5.000	5.00	0.882	3
Video projection	4.100	4.000	4.00	0.788	2
LCD	4.200	4.500	5.00	0.951	3
Scanner	4.300	4.000	4.00	0.801	3
Network	4.250	4.000	5.00	0.850	3
School Net	3.900	4.000	4.00	1.119	4
Digital camera	3.850	4.000	5.00	1.039	3
List of Web sites for topic areas	4.150	4.000	4.00	0.933	3
Internet sites	4.300	5.000	5.00	0.923	3
Printer	3.750	4.000	3.00	1.118	4
Intranet access	4.400	5.000	5.00	0.820	3
Internet access	4.300	4.000	5.00	0.732	2
Video camera	3.950	4.000	4.00	0.998	3
Laptop computer	4.050	4.000	5.00	1.099	4
Data projector	4.050	4.000	5.00	1.050	4
Supports diverse	4.100	4.000	4.00	1.020	4
Incorporates appropriate info. tech	4.000	4.000	5.00	1.025	3

Note. *SD*=Standard Deviation

(Table 4.1 continued)

Statement	Mean	Median	Mode	*SD*	Range
Large screen computer monitor	3.650	3.500	3.00	1.039	4
Includes activities	3.850	4.000	5.00	1.136	4
Responds to multiple lear. style	3.800	4.000	4.00	1.056	3
Supports stud-cent. learning	3.850	4.000	4.00	1.182	4
Constructivism	4.600	5.000	5.00	0.502	1
Behaviorism	4.450	4.500	5.00	0.604	2
Learn new pedagogical skills	3.750	4.000	4.00	0.444	1
Student engagement in learning	3.850	4.000	4.00	0.812	3
Focus on original sources	4.100	4.000	4.00	0.718	3
Students develop confidence	4.100	4.000	4.00	0.911	4
Learning occu. outsi. classroom	4.050	4.000	5.00	1.050	4
Develop different learning styles	4.150	4.000	5.00	0.988	3
Problem-based approach	3.950	4.000	4.00	0.944	4
Inquiry approach	4.300	5.000	5.00	1.080	4
Task based approach	3. 850	4.000	4.00	0.875	4
Expository approach	3.750	4.000	4.00	0.966	4
Resource-based inductive	3.550	4.000	4.00	1.099	4
Accreditation with examinations	3.850	4.000	4.00	1.039	4
Instructor emph. relation,…	4.050	4.000	5.00	0.944	3
Time for planning ,…	3.900	4.000	4.00	1.071	4
Using subject-specific learning	3.850	4.000	4.00	0.988	3

Note. *SD*=Standard Deviation

From the total of 55 statements received from the participants, the statement on "Constructivism" was rated as the highest with a mean of *M*=4.60 and *SD*=0.502. It is observed that the median and mode for this statement across the distribution were both 5 and the range was 1. The lowest mean of the rating was observed for the statement on "technical support". The mean was *M*=3.550, and standard deviation was *SD*=1.234. The Median and the mode of this statement were both 4.00, and the observed range was 4. Table 4.1 also shows that, as expected, the panelists have confirmed that they agree with the statement on constructivism. However, the range (difference between the highest and lowest scores received by the statement) was distributed as shown in Table 4.2.

Table 4.2

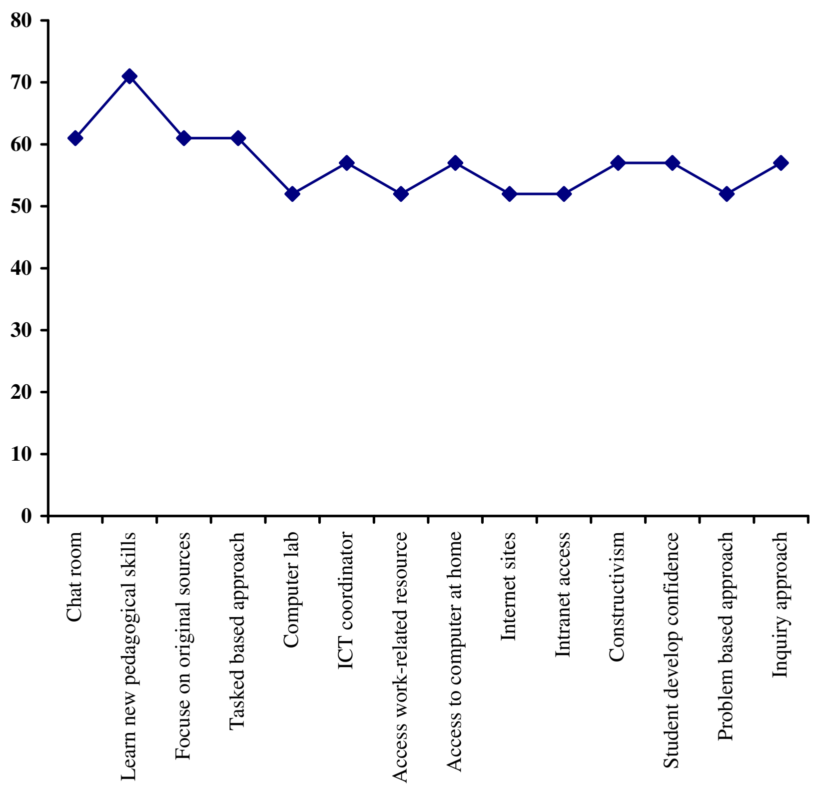
Range in Questionnaire 2

Range	1	2	3	4	Total
Number of statement	2	7	22	24	55
Percent of total	3.63%	12.73%	40%	43.64%	100%

Note. *SD*=Standard Deviation

The frequency distribution of 55 statements that received a strongly agree to no opinion/know were considered as shown in Figure 4.1.

Round 2 (consensus on strongly agrees and no opinion/know)

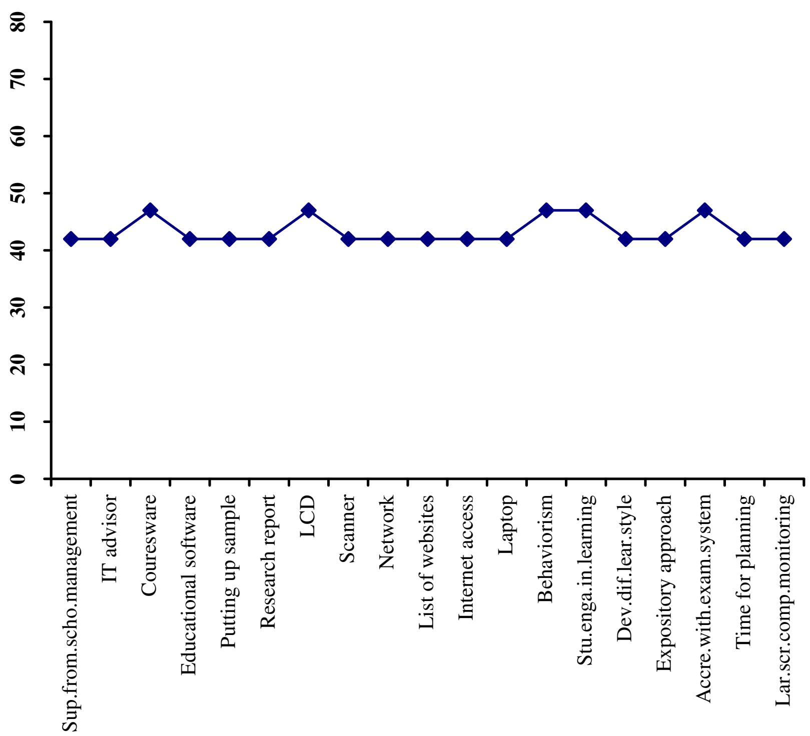


(Figure 4.1 continued)

Figure 4.1 shows that more than 71% of the respondents selected strongly agree on "learn new pedagogical skills." Between 60-70% (cumulative value) of the respondents decide to strongly agree or agree on chat room, focus on original sources, and task based approach.

Furthermore among 50-60% (cumulatively) of the respondents agree on computer lab, accessing work-related resource, access to computer at home, Internet sites, Intranet access, constructivism, student develop confidence, problem-based approach, ICT coordinator, and inquiry approach.

Round 2 (consensus on strongly agrees and no opinion/know)

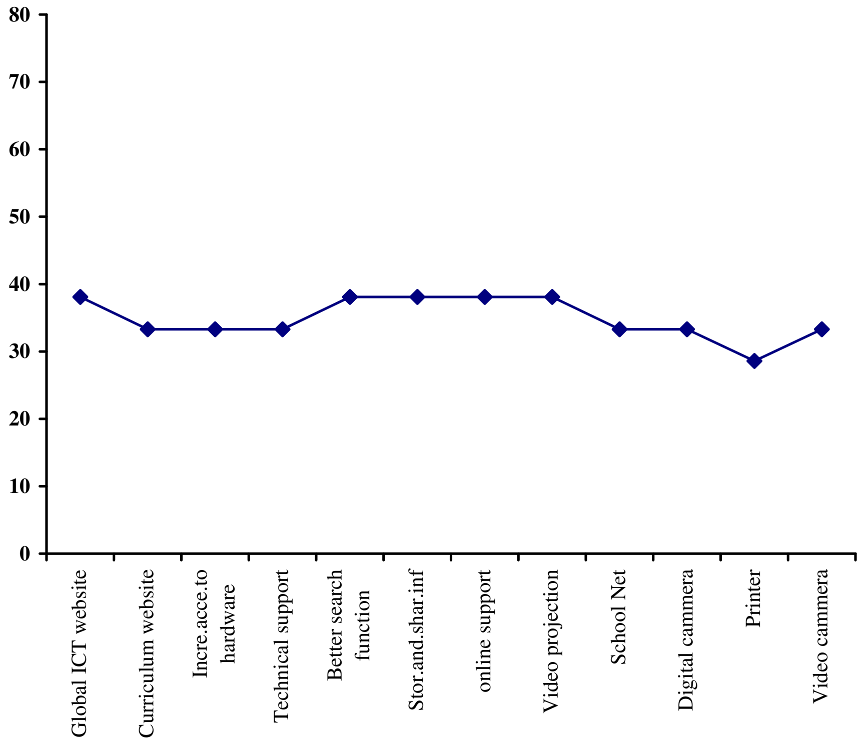


(Figure 4.1 continued)

The second cumulative value is estimated to be around 40-49% of the respondents who have voted for the second group of elements as emerging in developing a pedagogical model for teaching chemistry. These elements are as listed below: rated the time for planning, and collaboration with schools, accreditation with examinations system, expository approach, development of different learning style, student engagement in learning, behaviorism, laptop computer, Internet access, list of web sites for topic areas, Network, scanner, LCD, research reports, putting up samples, educational software, courseware, IT advisors, large screen computer monitor, and support from school management.

Therefore, these elements are considered influential in developing a pedagogical model for teaching chemistry subject based on the experts views.

Round 2 (consensus on strongly agrees and no opinion/know)



(Figure 4.1 continued)

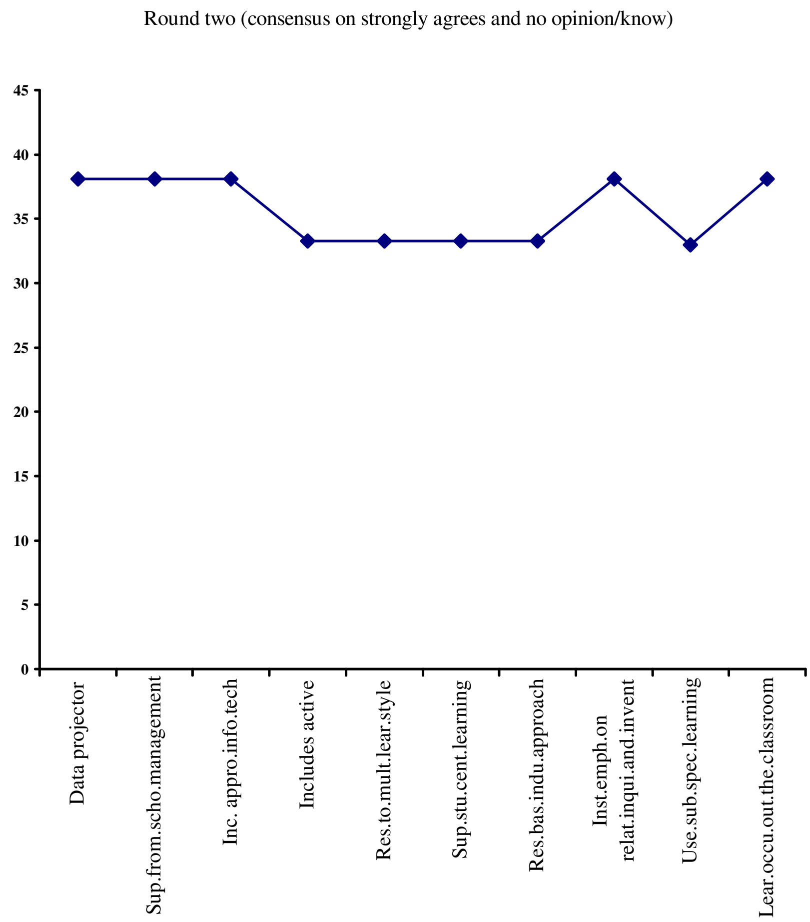


Figure 4.1. Round Two consensus on "Strongly Agree" and "No opinion/Do Not Know", by statement (N=20)

The third group of features which have been rated by experts as the third important group of variables, with the cumulative value of less than 40%, consists of: the respondents selected using subject-specific learning, learning occurs outside the classroom, resource-based inductive approach, responds to multiple learning style, supports student-centered learning, includes active, incorporates appropriate information technology, supports diverse, large screen computer monitor, video camera, data projector, printer, technical support, digital camera, school net, online support, storing and sharing information, better search functions, curriculum website, increased access to hardware, technical support, global ICT website, and instruction emphasis on relation inquiry and invention.

Out of the total of 55 statements, 32 statements received a mean score of *M*= 4.00 or higher, and the mode for all the 32 statements was either 5 representing “strongly agree” or 4 representing “Agree” choices.

Finally, in order to narrow down the number of statements representing features of a pedagogical model of teaching chemistry through the third round of the Delphi method three criteria were employed: 1) statements that had a mean of 4.0 or higher, 2) statements that had a mode of either 4.0 or 5.5, and 3) statements that had an agreement level of 60% or higher but were not included because they had mean scores of less than 4.0.

Round Three: Question 3: The 32 statements were once again presented in the two categories and participants were again asked to rate their agreement with each statement. Once again, the mean, mode, standard deviation, and range were calculated for each of the remaining statements, as well as the percentage of the respondents who rated the statement as “strongly agree” or “agree” which would be utilized to denote agreement or consensus.

Table 4.3

Round 3, Analysis of Experts' Consensus by Studying Description Indicators for Pedagogical and Technological Features

Statement	Mean	Median	Mode	*SD*	Range
Global ICT Websites and material	4.550	5.000	5.00	.510	1
Computer Lab	4.800	5.000	5.00	.410	1
IT advisors	4.400	4.500	5.00	. 680	2
ICT coordinator	4.800	5.000	5.00	. 410	1
Courseware	4.4500	5.000	5.00	.686	2
Educational software	4.600	5.000	5.00	.598	2
Putting up samples	4.550	5.000	5.00	.604	2
Research reports	4.600	5.000	5.00	.502	2
Storing and sharing information	4.400	4.500	5.00	.680	2
Accessing work-related resource	4.500	5.000	5.00	.688	2
Online support	4.600	5.000	5.00	.502	1
Access to computers at home	4.900	5.000	5.00	.307	1
Video projection	4.150	4.000	5.00	.812	2
LCD	4.550	5.000	5.00	.510	1
Scanner	4.500	4.500	4.00	.512	1
Network	4.600	5.000	5.00	.598	3
List of Web sites for topic areas	4.550	5.000	5.00	.510	1
Internet sites	4.600	5.000	5.00	.502	1
Intranet	5.000	5.000	5.00	.000	0
Internet access	4.400	4.000	4.00	.502	1
Laptop	4.150	4.000	4.00	.587	2
Data projector	4.250	4.000	4.00	.550	2
Supports student-centered learning	4.450	5.000	5.00	.686	2
Incor. appro. Info. technology	4.450	5.000	5.00	.686	2
Constructivism	4.800	5.000	5.00	.410	1
Behaviorism	4.000	4.000	4.00	.648	2
Focus on original sources	4.550	5.000	5.00	.686	2
Students develop confidence	4.500	4.500	4.00	.512	1
Lear. occu. outside classroom	4.300	4.000	4.00	.656	2
Development different learning	4.350	4.000	4.00	.587	2
Inquiry approach	4.950	5.000	5.00	.223	1
Instruction emphasizes inquiry and invention	4.450	4.000	4.00	.510	1

Note. *SD*=Standard Deviation

For the third round the 32 statements were rated by the participants. For the statement referring to the feature “Intranet” [necessity and usefulness of Intranet] it was found that the third round participants have a perfect level of agreement with this statement. They have selected “strongly agree” for this statement and the observed mean is *M*= 5.00, standard deviation of *SD*=0.00. Therefore, the median and the mode were 5.00, and the range was observed to be 0.00. The lowest mean of ratings of the statements belonged to the statement about “video projection, and laptop”. The observed mean was *M*=4.150, and the standard deviation was between *SD*=0.812-0.587. The median and the mode of these statements were 4.00-5.00, and 4.00-4.00 with a range of 2.

Therefore, this table shows that, as expected, the panelists strongly agreed with the statement uttered about the necessity and usefulness of implementing the Intranet. As the table shows, the range of scores went from a low of 4.800 (Statement “constructivism” which had previously received a 4.600 mean of scores) to a high of 4.000 (“behaviorism” previously scored a 4.450). Therefore, the average standard deviation decreased across the two rounds from 0.444 to .000. This fluctuation could be an indication of convergence. There was a noticeable pattern in the way the mean scores changed across the second and the third round. See Table 4.4 for details.

Table 4.4
Analysis of Means Scores among Round 2 and Round 3

Means Scores Round 1	Mean Scores Round 2
3.73	3.94
4.75	4.50
4.45	4.38
4.11	4.41
4.96	4.38
4.16	4.44
4.18	4.78
3.98	4.88
4.36	4.91
3.87	4.91
2.89	4.28
4.18	4.09
4.35	4.88
2.56	4.22
4.16	4.00
4.20	4.69
3.98	4.16
3.64	5.00
3.73	4.27
4.38	4.91

Table 4.4 shows that the mean scores across Round One and Round Two are changed. These changes are significant. The range (difference between the highest and lowest scores received by each statement) was distributed as shown in Table 4.5.

Table 4.5
Range in Questionnaire 3

Range	0	1	2	Total
Number of statement	1	15	16	32
Percent of total	3.13%	46.87%	50%	100%

All of the 32 statements had a mode of either 4.0 or 5.0. This represents the fact that the internal consistency does exist across the individuals participating in the panel.

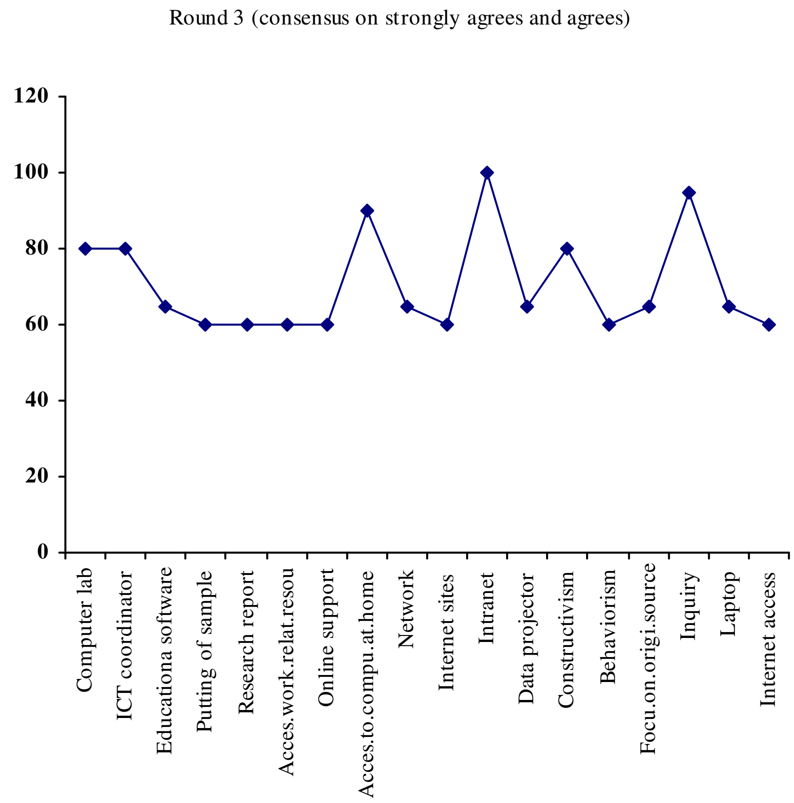


Figure 4.2. Round Three, consensus on "Strongly Agree" and "Agree", by Statement (N=20).

Figure 4.2 shows that 100% of the respondents have ranked the statement on "Intranet" as "strongly agree". Moreover, more than 95% of the respondents have depicted that they either strongly agree or agree with the implementation of the inquiry approach. Figure 4.2 also reveals that between 80-90% of the respondents have rated access to computer lab, ICT coordinator, access to computer at home, and constructivism as important features to include in a pedagogical model of teaching chemistry.

The next group of the included features has received agreement by 60-70% of the respondents. These participants have voted for putting up samples of completed project including standard forms, cases for support, budget proposals, breakdown of funds and so forth, research reports and presentations, educational software, Internet sites, online support, network, focus on original sources (good books, classics, and primary sources), accessing work-related resources, behaviorism, data projector, laptop, and Internet accesses as important features.

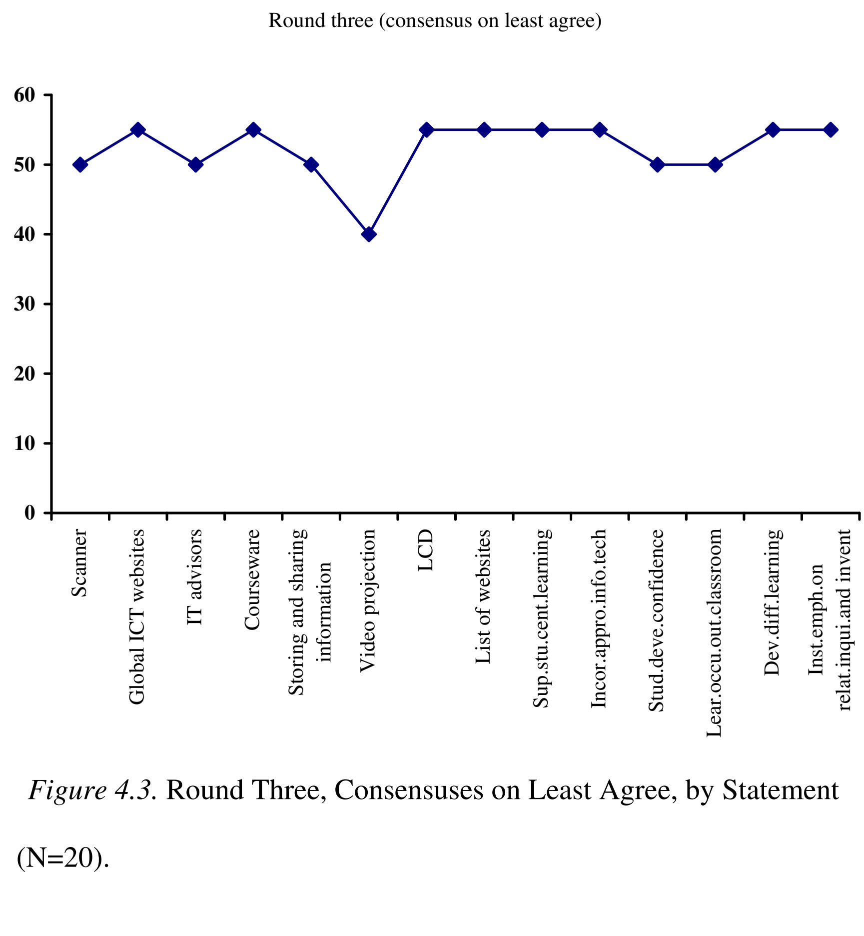


Figure 4.3. Round Three, Consensuses on Least Agree, by Statement (N=20).

Figure 4.3 shows that around 50%-59% of the respondents have voted for including: instructional emphasis on relation inquiry and invention, students developed confidence, development of different learning, learning occurs outside the classroom, support student-centered learning, incorporate appropriate information technology, list of web sites for topic areas, scanner, LCD, storing and sharing information, IT advisor, and global ICT website. Less than 50% of the respondents have rated video projection. However, the criteria to have been included is the same as in the previous rounds (i.e., those statements which have been marked with "strongly agree" or "agree" are considered "voted for" or "rated" in this discussion).

Analysis of Model Features by Category

In order to further analyze the results of this study, each category of features will be considered separately. The two categories are Pedagogical and Technological Features.

Technological Features: Table 4.6 lists the statements that were included in this category along with the mean scores, range from Questionnaires number 2 and 3.

Table 4.6

Results for Technological Features

Statement	Mean s.1	Mean s.2	Range s.1	Range s.2
Global ICT Websites and material	4.050	4.550	4	1
Computer lab	4.200	4.800	3	1
It advisor	4.250	4.400	3	2
ICT coordinator	4.350	4.800	3	1
Courseware	4.150	4.500	4	2
Putting up samples	4.150	4.550	2	2
Research reports	4.300	4.600	2	1
Storing and sharing information	4.100	4.400	2	2
Accessing work related resource	4.150	4.500	2	2
Online support	4.100	4.600	3	1
Access to computer at home	4.400	4.900	3	1
Video projection	4.100	4.150	2	2
LCD	4.200	4.550	3	1
Scanner	4.300	4.500	3	1
Network	4.250	4.600	3	2
List of Web sites	4.150	4.550	3	1
Internet sites	4.300	4.600	3	1
Intranet access	4.400	5.00	3	0
Laptop	4.050	4.150	4	2
Data projector	4.050	4.250	4	2
Supports student centered learning	4.100	4.450	4	2
Internet access	4.300	4.400	2	1
Incorporate appropriate info tech	4.000	4.450	3	2

Only 32 out of the 55 statements in this category were maintained into the third and the final round. In this category statements that met the three criteria (4.0 or higher mean score, 60% or higher, and mode of 4.0 or higher) were maintained for the third round. The overall mean for "strongly agree" had increased from 4.400 to 5.000, and the range shows an increase from 1 to 0.

The mean scores for many of the statements show a noticeable increase in this category. It is believed that these statements have been applicable to environmental learning. It is suggested that environmental learning has the greatest benefits in the use of computer programs in education (Venezky & Davis, 2002).

Pedagogical Features: Statements below were categorized as Pedagogical Features. Table 4.7 lists the statements that were included in this category along with the mean scores, and range from the Questionnaires number 2 and 3. Table 4.7 displays the mean scores, and range for these 8 statements.

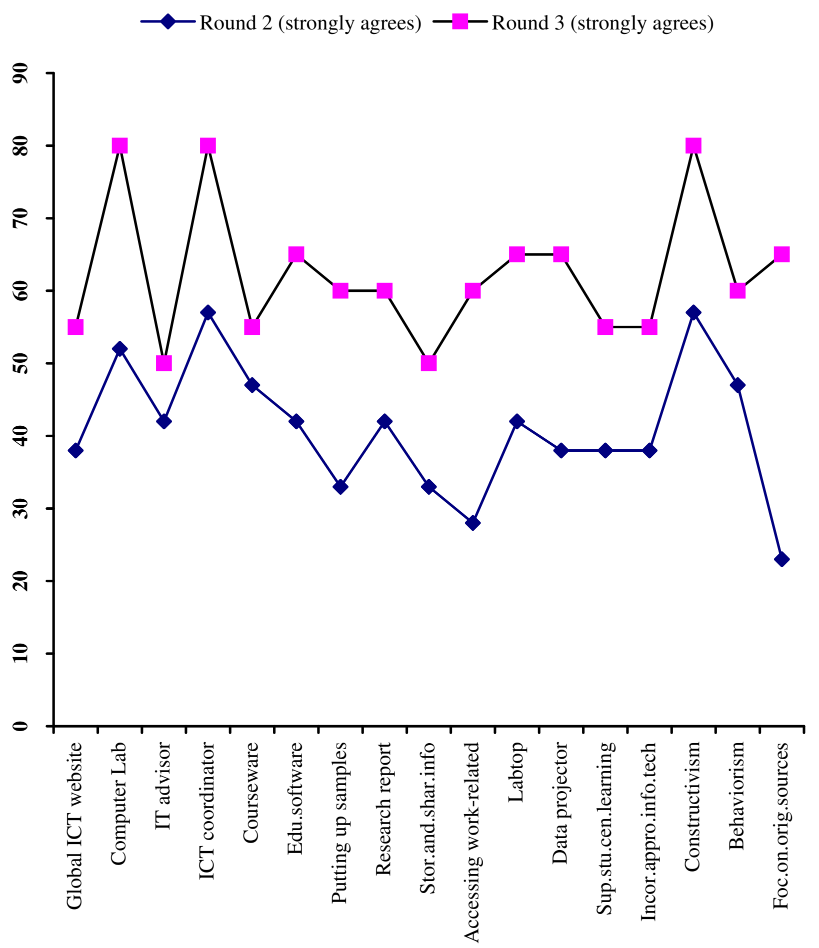
Table 4.7

Results for Pedagogical Features

Statement	Mean s.1	Mean s.2	Range s.1	Range s.2
Constructivism	4.600	4.800	1	1
Behaviorism	4.450	4.000	2	2
Focus on original sources	4.100	4.550	3	2
Student develop confidence	4.100	4.500	4	1
Learning occurs outside the class	4.050	4.300	4	2
Development different learning style	4.150	4.350	3	2
Inquiry approach	4.300	4.950	4	1
Instruction emphasizes relationship inquiry and invention	4.050	4.450	3	1

In this category, eight statements met the three criteria (mean score of 4.0 or higher, mode of 4.0 or higher and frequency percentage higher than 60%) and were maintained after the second questionnaire. The overall mean scores had increased for the “strongly agree” choice from 4.300 to 4.950, and the range has increased from 4 to 1.

There were other mean scores observed to have increased as they were applicable to classroom practice, based on the intuitions of the panelists. This shows that the use of educational technology needs to be designed within the curriculum (Bennett, 2002). However, many other participants rated these statements as “strongly agree” or “agree" once again while emphasizing the need to develop a chemistry curriculum pedagogical model. A comparison between rounds two and three is shown in Figure 4.4.



(Figure 4.4 continued)

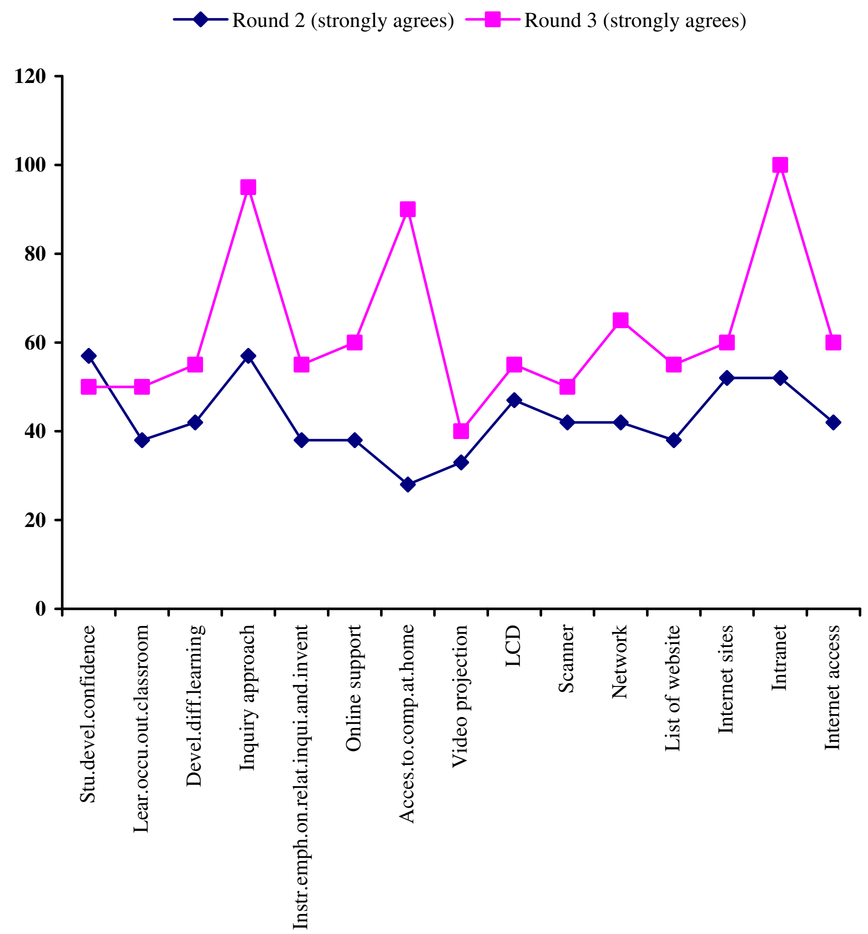


Figure 4.4. A comparison of experts' consensus in Round 2 and Round 3.

Figure 4.4 shows that there is an increase from a low level of agreement to "strongly agree" in round 2 and up to the level of "agree" in round 3. This increase was observed across the statements, all of which were representations of a consensus on the development of a pedagogical model of teaching chemistry by implementing computer for the current curriculum.

However, the present result does not show the low scores because nearly all members of the expert panel chose the responses "Strongly agree" or "agree" as shown in Figure 4.4. The researcher believes that this could be a catalyst for the conception of views and policies that will contribute to shaping the future. This study can start a process, which is a process of joint thinking about the strategy for the policy today. Interest was expressed by experts for the use of computers in education.

Analysis of Participant Comments

The first and final questionnaire in this study ended with an open-ended question posed to the participants. That question was worded as follows:

"The curriculum has changed in the past few decades for the department of the Ministry of Education and has caused an increase in teaching chemistry through computer. In your opinion, will this change continue over the next decade? Why or why not?"

Nineteen panelists answered the question. Sixteen of those answered yes, the change will continue, and two were not sure. All of the panelists gave detailed answers to back up their opinions. Since all of the participants were high school professionals and/or experts on learning programs, their answers were based on both knowledge and experience, and are worthy of analysis as we try to learn more about the change in learning chemistry, and the learning environment. It can be stated that, according to the written replies provided by the experts, it is assured that the wind of change will continue blowing for the next decade the results of which might be new horizons in implementing ICT in general and computer specifically for teaching chemistry to the high school students.

Summary of Experts' Consensus on Pedagogical Model

A Delphi study was conducted for the purpose of collecting data to identify the agreement components of the development of teaching chemistry to 11th graders through the computer. The study consisted of three rounds, including an initial survey and one open-ended questionnaire. A panel of experts, all high school/university professionals with extensive teaching learning experience, participated in the study. The first round of the study was designed to collect demographic information about the panelists and to elicit a list of features of learning to be used in the subsequent questionnaires. Analysis of the demographic data revealed that there was a variety in the types of organizations represented, the primary role of the participants within the teaching learning environment, and the specific types or models of teaching learning that participants had experienced. A list of 55 statements was compiled from the responses to the initial survey.

In the second round of the Delphi procedure, participants were asked to rate the importance of each statement derived from the first round using a five point Likert-type scale. The features were presented in two categories: Pedagogical, and Technological. The arithmetic mean, mode, standard deviation, and range were computed for each of the 55 statements. The level of agreement or consensus, defined as the percentage of respondents rating an item as either "strongly agree" or "agree," was also computed. Statements that met the following criteria – a mean score of 4.0 or higher, a mode of 4.0 or higher – were maintained in the next questionnaire.

In the third and final round, participants were asked to once again rate the remaining 32 statements. This time, as is customary in the Delphi procedure, the mean score from the previous round was shown for each statement. At the completion of the study, statements were analyzed by category. Within each category, specific statements were identified that had been rated poorly as well as those that had been rated highly.

Conclusions

The Delphi method was used to investigate the experts' opinions in the development of a pedagogical model for teaching chemistry in Iranian high schools. The goals of the Delphi technique allowed a group of well-known experts to illustrate qualified chemistry teaching-learning context. The employed method, however, has some advantages such as the possibility to structure the survey which was used to anticipate which factor should be considered the most important factor (loading on the general factor).

However, the researcher faced some delimitation in her research such as the time, which was extended over a month for the participants who did not answer the questions quickly. Moreover, there was always the need to spend extra time on discussions in the Delphi process to clarify the statements that participants were asked to rate.

Finally, the researcher realized that there were some overlaps in the statements which might have caused confusion in this research. Therefore, in order to reduce the risk of confusion and misunderstanding a round was devoted to removing these confusions and clarifying the overlapping statements. It was done by rating their similarity as described by Dalkey (1972) whose study focused on investigating quality of life, where participants were asked to rate the similarity of all possible pairings of items in order to reduce the number of items from 250 to 48.

From the results of the current study, it was realized that there are six statements that are essential to the development of a pedagogical model for teaching chemistry using a computer: 1) ICT coordinator, 2) computer lab, 3) Internet, 4) accesses to computer at home, 5) constructivism and 6) inquiry approach. The first statement of these six features describes the essential role of environmental features which should be prepared by the Ministry of Education. The last two statements describe the role of curriculum, reform, or changes, and continuity in post education. The last two are the most useful guidelines for the Ministry of Education. The Ministry of Education is in charge of developing and enhancing the teaching skills and learning environment.

Specifically, the chemistry department must develop proper conditions for better teaching of the chemistry subject. Teaching chemistry by using a computer is new and it needs special facilities and consideration. The current researcher had realized that the chemistry department needs a pre-planned program to manipulate successfully and translate objectives into success.

Model of Computer-Assisted Guided Inquiry

On the basis of the previous research results (classroom observations, principal and ICT team interviews, and Delphi technique), and the literature review, the prime objective was set as the development of a pedagogy model for chemistry through computer-assisted guided inquiry in Iranian High Schools. The pedagogical model was selected based on both the guided inquiry and the previous research on the pedagogical models (see Chapter 2) of inquiry-based learning, teamwork, workgroup and discussion, cooperative learning, learning cycle, and mind tools. The following perceptions, derived from the theoretical background of the current study, (see Chapter 2) were kept in mind during the development of a pedagogical model to obtain the following identified learning goals: a) learning environment should be engaging and keep students active, b) the environment should be constructive and reflective, c) authentic problem solving must be utilized, and d) the material used in cooperative learning is important (Jonassen, Peck, & Wilson, 1999) and they should encourage students to learn chemistry.

According to Brandsford et al. (2000), students formulate new scientific knowledge by modifying and refining their current concepts and adding new concepts to what they already know.

Narode et al. (1987) have stated that this should encourage students to do inquiry by providing opportunities to develop critical thinking, thus facilitating and developing chemistry understanding. Such a model should be based on encouraging questions and discussion and the teacher is expected to provide support for students.

A prototype model of guided inquiry was used in this study to assess the needs for the development of a pedagogical model for teaching chemistry through computer-assisted guided inquiry at Iranian High Schools.

Guided Inquiry: According to Igelsrud and Leonard (1988), the guided inquiry is suitable, particularly when it requires development practices. This study was applied to this model. In a guided inquiry, the teacher typically decides what question is to be explored. The students may generate their own hypothesis and then develop an experimental procedure to be used. After the teacher had approved the procedure, the students carry it out, analyze their data, draw conclusions, and propose additional questions that could be explored. In a prototype of the guided inquiry the chemistry teacher posed a question:

"What facilities do blind people use for understanding their environment?"

(see Appendix "Guided inquiry CD"). She has created a situation in the classroom in which students were to formulate their own ideas, state their opinions on an important issue, or find things out for themselves. It is an interactive teaching model in which the teacher engages the students to learn science information or skills. In this scenario, the student is encouraged to ask questions, analyze their data, draw conclusions, make inferences, or generate hypotheses. In short the student is viewed as an inquirer, a seeker of information, and a problem solver. Teamwork, work group and discussion, learning cycle, cooperative learning, mind tools, and concept maps are used in this model. During the work group, every student can share their thoughts and what they learned from each other and reflect on their learning. Working in small groups, students complete investigations in the classroom.

Five groups with four students in each group were formed in this study. Different roles, selected by students (such as leader, computer assistant, and assistant working with chemicals) were assigned to the group members. "Rutherford’s atomic model: Gold foil experiment, using mind tools" was one example of the tasks given.

A Study of Students’ Views Regarding Learning Using Computer: The goal of this study was the development of a pedagogical model for chemistry through computer-assisted guided inquiry at Iranian High Schools.

The sub- research question was:

“What are students’ views on the use of computers in learning chemistry?”

Methods: A triangulated mixed method (Descombe, 2001) was used to answer the sub-research question. This prototype study was conducted in chemistry instruction classes in 11 high schools located in urban areas in Tehran. The study was carried out with the help of the chemistry teacher of the class. The unit of lesson was *“Rutherford’s Atomic Model: Gold Foil Experiment”*. At the beginning of the study, the researcher told students about the investigation and the research. The whole class was divided into five small groups; each of them included four students. Five groups worked with computers. The chemistry teacher's role was to pose the question, hence guiding the students. The survey was completed both before and after the guided inquiry (noted in Appendix H). This study was completed in about 2 hours (between 8.15 am to 9.45 am). Details of the prototype study are presented in the following sections.

Students' background. A class of 30 students (girls) in Grade 11 participated in the study. Their background information was collected through a questionnaire with multiple–choice which was collected before the study (noted in Appendix H). Data were analyzed using the SPSS software acquiring percentages and means for each multiple-choice question. According to the chemistry teacher's information, all of the participants had studied chemistry lesson 10 at high school level before this study. Therefore, all students knew basic chemistry concepts.

However, the students were novices in practical work. This showed that few had done practical experiments before this class. According to the collected background information, about 50% of the students use a computer every day, 90% of them use word-processor software and had done a teamwork task before. They were also novices in using computers in their chemistry class. The students showed they have rarely worked cooperatively with other people (35%) in the research study conducted before this one.

However, 50% of the students agreed to (or were interested in) using computers in learning chemistry before experiencing the guided inquiry. Some mean scores for their computer skills and activities were: student's using the skills of a word processor (M=1.100), spreadsheet (M=1.550), email (M=1.400), database (M=1.600), graphic (M=1.650), web (M=1.850), presentation (M=1.800), web browser (M=1.750).

Results and Discussion: The collection of data and the data analysis followed this procedure: a) Conducting observation from all practice groups, b) video-taping the session ongoing for later transcription and analysis of all practice groups, c) and distributing the questionnaires among group members before and after the guided inquiry. The analyses as well as the details of the procedure are presented in the following section.

A) Observation: The atmosphere of the class was inquiry, and a cooperative learning environment was created in class. The students were engaged in their investigations (Driver, 1989). This class was interesting for some students and the experience was new to them, as the teacher described it. According to the teacher, the class was much more active compared to previous chemistry classes. Students started to cooperate with their group during the class. All groups used different computer programs (e.g., use of database, spreadsheet), but had problems with the software. Their skills were quite poor (Flick & Bell, 2000), particularly students' planning skills for the inquiry was practically insufficient. This might have been the result of their uncooperative and inactive participation in their previous daily classes.

However, the students started to practice. For example, group 1 was able to complete its practice. Students first did not understand the role of tools in their study. For example, when they started to use the database they could not use it in their practice. It showed that they did not have the skills to use the tools (Jonassen, 1992). When their teacher asked them how they could use the computer, the students began to think about how to use the software. The students trusted the inquiry, and many of them did not evaluate their results during practice. However, the researcher realized that the students and the teacher did not have enough information on how to use a computer.

B) Videotape: The total class time was around 2 hours. During the investigation, the students chose the following roles: student A used a database, student B used Internet, student C was the leader of the group, student D used software, and student E used PowerPoint for presenting the report. During their exploration phase, group A used 3 minutes to read the work's procedure and design their investigation at the start of their inquiry. They used 1 hour of their whole working time familiarizing themselves with the computer, as well as the chemistry materials and to prepare the program. It showed that students lacked the strength required in practical work. Much of the discourse exchanged was about using tools in their practical work. The students, however, were most active in student-student discourse. The teacher supported the students in practical work, though. The students interacted with their teacher at all stages. The interaction with their teacher was about how to use tools, for example, spreadsheet, information software, PowerPoint, and so forth. In addition, the teacher encouraged them during their practical work. The students started to learn about the negative film because “a teacher” encouraged them to think about chemistry by asking the question (as in Barton, 1997), “What facilities do blind people use for understanding their environment?” The students’ interpretations, in recorded videotape, also show some prior knowledge which they had used in their explanations. Most of their discussion refers to the use of tools such as database, word-processor, information software, and the use of computerized databases to facilitate the development of students’ inquiry skills and support practice (Schank & Kozma, 2005). However, most of the activities observed were entirely student-student discussion.

C) Reports of Investigations: The goal of the report was to support critical thinking in chemistry when they started the investigation. During the investigation, a student (one student) constructed the mental framework that adequately explained his experiences, and reflected the constructivist model of learning (Osborne & Freyberg, 1985). Students’ notes to their teacher described how to write a report of their investigation. A report must include the name of the investigation, their action in different stages of the investigation, conclusions of the results, and an evaluation of their study and its reliability.

Finally, each group wrote a report. Five reports were expected but only four groups provided their report; the fifth did not submit it (See Appendix Educational film). Most of the reports were short. The reports show that the students did not understand the procedures utilized in the investigation, and they were not written based on critical thinking skills

(Narode et al., 1987), and/or cognitive development (Germann, 1991). The students did not analyze, evaluate or synthesize many of their results. The reports also showed that the students did not understand the procedures given. The students in their reports mainly presented their procedural knowledge (e.g., the order of their working) regarding their inquiry (as in Tapper, 1999). Each group wrote about knowledge, skills, and their experience about questions, not their use of calculation.

D) Students' Views Regarding Their Learning with Computer Use: The students' views regarding teamwork and practical work with a computer were examined in this study in order to develop a pedagogical model. The collected data were analyzed using SPSS in order to prepare descriptive measures that were means and standard deviations (Table 4.8). The means of the two performances were compared using the non-parametric test of mean differences, or Wilcoxson's signed ranks test. The acquired values are presented in Table 4.8. A questionnaire with Likert-scale was used to test and retest to better understand the students' views towards computer use in learning chemistry. Two experts from the Chemistry Department and the Ministry of Education provided the prototype questionnaire. A Likert-scale instrument with statements, each with five choices ranging from strongly agree to no opinion/do not know, was used to assess students' views about computer use. The question was closed-ended (noted in Appendix H). The result of the study is presented in Table 4.8.

Table 4.8

Students Views of Learning Chemistry with Computer Use

Statement	*M**	*S D**	*M ***	*SD* **	*Z*	*Sig. (2-tailed)*
1. Use of computer is useful for team work	3.150	.670	4.050	.825	-4.025	.000
2. Use of computer is useful for increasing responsibility/ self-esteem independence	3.150	.875	4.050	1.145	-3.338	.001
3. Team work is a suitable method for encouragement	3.166	.785	4.000	.973	-2.853	.004
4. Feedback is applied to correct any mistakes in chemistry learning process	3.150	.875	3.900	1.252	- 2.686	.007
5. I'd like team work in studying chemistry, it's an investigation work	3.105	.737	4.050	1.356	- 2.682	.007
6. Investigate enhance understanding of chemistry phenomenon	3.450	.604	3.950	1.190	- 2.013	.044
7. Collaborations upgrade my knowledge and skills in chemistry	3.100	.788	4.050	.944	-3.477	.001
8. Practical work with computer is a suitable method	3.300	.801	4.250	1.251	- 3.100	.002
9. I enjoy team work as I can work with other students	3.300	.864	4.200	1.151	- 2.933	.003
10. Teacher's help is adequate to improve chemistry learning	3.000	. 858	3.750	1.019	- 2.829	.005
11. Use of computer in chemistry lesson	3.200	. 695	4.100	.911	- 3.350	.001
12. Technology tools that I used in chemistry class were friendly	3.263	.805	4.100	1.071	- 2.925	.003
13. Computer can be quite useful in chemistry concept	3.150	.812	3.900	1.119	- 3.120	.002
14. Computer establish communication with others	3.050	.825	4.050	1.190	- 3.233	.001
15. Overall, I have found the chem. lesson with computer interesting	3.100	.788	3.650	1.268	- 1.883	.060

Note. There were five choice ranging from strongly agree (=5), No idea (=3) to strongly disagree (=1) in each statement. *means before guided inquiry, ** after guided inquiry. *** *z*, $p > 0.05$ (not significant,), $p<0.05$ (almost significant), $p<0.01$ (significant), $p<0.001$ (very significant). Wilcoxson signed ranks test was calculated.

In this study, statements 6 and 15 were not significant. Many students agreed, at the end of their inquiry, that "The use of a computer in chemistry class helped me to understand chemical concepts." (Statement 13, Table 4.12). Moreover, many students had the view that, "The use of a computer in a chemistry lesson helps me in my study" (Statement 15).

Conclusion

The goal of this study was to examine the students' views regarding computer use when learning chemistry. This study showed that the students' views were positive. Computer use had succeeded in engaging students well in an inquiry. This study shows that the use of computer had many advantages. It engaged students with an inquiry activity (as in Tabak & Reiser, 1999) which is essential for critical thinking. Students were active in making investigations and nearly successful in computer use in their data gathering, although their inquiry skills were observed poor. The classroom activity engagement helped students in the learning process, skill development, and the use of devices to aid skill development (Germann, 1991). The use of a computer in the classroom was interesting for all students as expressed at the end of the inquiry. Students also were interactive and cooperative with each other and with the teacher.

However, much of the students' discourse was descriptive, and students need to have many and varied opportunities for collecting, sorting and cataloging, observing, note taking and sketching, interviewing, polling, and surveying in their future education (Rutherford & Ahlgren, 1990).

This study showed that the teacher's role is crucial to support students and shows that students need support in their inquiry skills, especially on how to plan a study (Hegarty-Hazel, 1990), as well as in which tools to use at the start of the study. There were, however, many problems in the practice/classroom phase, according to the results. The use of a computer was not easy for all students, although the researcher observed that all the students used the computer. Therefore, there is a need to develop the learning environment, teacher's pedagogy and skills, and student skills.

A Guide for Chemistry Teaching through Guided Inquiry of this Study: Lesson Unit: Rutherford Atomic Models - Gold Foil Experiment

Design: Students have a problem in grasping some concepts of science because some concepts and processes are not visible to the eye or tangible to their senses and students often enter the lesson with negative feelings toward the subject. A number of strategies could be developed to address this problem including: a) visualizing the concept, b) presenting content within an interesting context, c) students' active role share d) cooperative learning, e) addressing students' misconception, f) problem solver, and g) engaging students in inquiry- based learning.

Model Design

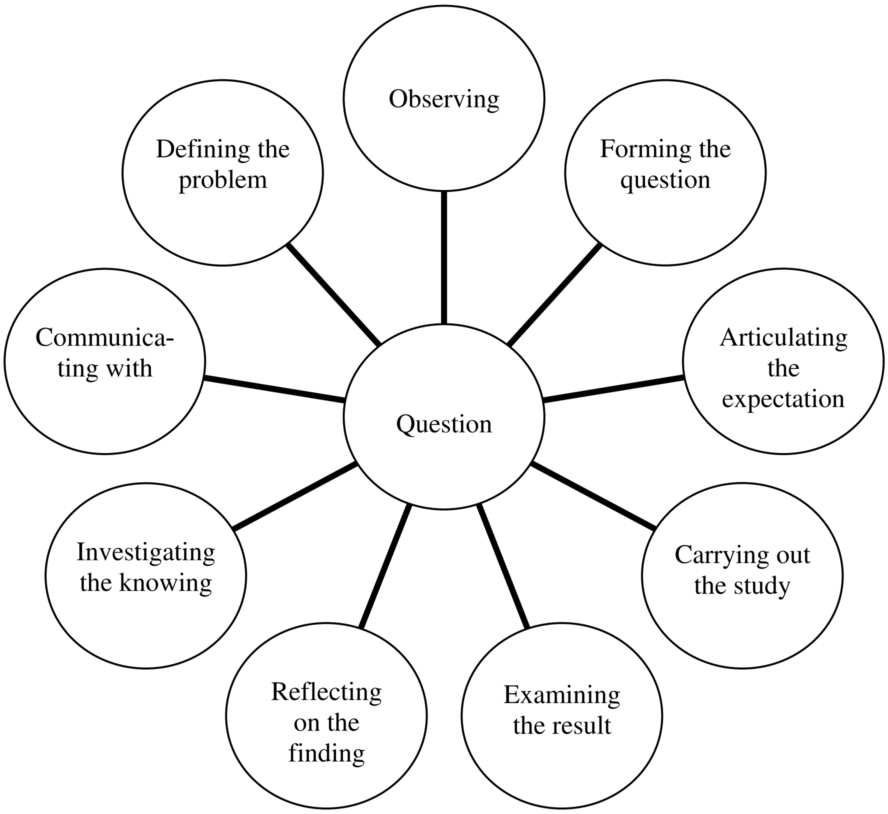


Figure 4.5. A model of Guided Inquiry.

Activities

Activities include: a) posing questions, b) designing and conducting investigations, c) using technology; d) formulating and revising explanations, e) communicating ideas, and f) understanding scientific inquiry.

Assessment

Assessment includes: a) giving opportunity to demonstrate their achievement and understanding, b) assessing students' understanding as well as knowledge, c) improving classroom practice and planning curriculum, and d) developing self-directed learners.

Table 4.9

Lesson Plan

Date	Duration of lesson: 8.15-9.45	Lesson within topic: 1-5
Unit: Rutherford Atomic Models: Gold Foil Experiment Aims of the unit: - Students learn how to construct hypotheses and methods for evaluating/testing hypotheses. - Students consider relationship between hypotheses construction and theory building. - Students engage in measurement as an inquiry strategy. - Students experience peer and collaborative aspect of a science work community. - Students understand how resources are used to condense and communicate key data or information. - Students learn to use database, word-process, PowerPoint to produce their assignment. Objective of this lesson: Students should: - use technology tools, pair work, - be able to produce a presentation Resources: Network PCs, Data base, Prior knowledge: Pupils could use Windows PCs Possible difficulties Some students' passwords may not be set up so they will be unable to log on Assessment opportunities: observing them work,	Total: 25 Girls	Age: 15-16
Timing Teacher activity	Pupil activity	Resource
Explain that in this lesson we are going into your area data base… Demonstration of logging on to the system, using a student's ID. Question, Answer, Instruction,… Place student Rotate round class quickly checking on student progress, collect data.	Attention, ready to take notes to log on. Take note on one's user name and password. Answer questions and move to collect data. Log on and creating directory. Answering questions; group work; and write homework and presentation.	Data base,… One computer for four students, video projector