CHAPTER I

The advances in computer use represent great changes in technology, politics and global economic development. In such progress, education is not an exception and may face drastic changes. In fact, the school curriculum needs to be adjusted according to the "information age". Computer aided instruction (CAI) and computer assisted learning "CAL" are accepted methods in teaching and learning. Information and Communications Technology (ICT) can support the learning process (Denby, 2002; Roschelle et al., 2001; Russell et al., 1997; Webb, 2005).

Furthermore, the consensus is that the use of ICT will enhance the quality of teaching and learning technique (Cox et al., 2004; Heck, Kedzierska, Rogers, & Chmurska, 2006).

Information and Communications Technology is defined for curriculum purpose as “the range of tools and techniques relating to computer-based on hardware and software; to communications including both directed and broadcast; to information sources such as the use of multimedia and the networks and services based upon them; and to associated technologies such as video-conferencing, robots, and digital TV,” (Van Damme, 2003).

ICT in this study refers to applications found on most desktop computers, tools, etc. that can be used to enhance chemistry teaching in the classroom. In addition to the use of ICT to improve learning, in recent years,

the emergence of the knowledge economy has also brought a much greater emphasis on educational and master plans on ICT in education. These plans have been produced in many countries.

According to Collis (1993), all citizens of the European Union should have the possibility of acquiring so-called key skills, which include digital literacy and higher order skills. Such master plans detailed not only implementation strategies, but more importantly, had embedded the plans within a broader framework of chemistry education reform aimed at developing student capacity for self-learning, problem solving, information seeking and analysis, critical thinking, and the ability to communicate, collaborate and learn via the Internet (Hollingworth, 2002). These abilities had figured less importantly in the school curriculum prior to that (Paul, 2002; Russell, 2001).

Therefore, schools cannot ignore the impact of technology and the changing face of the curriculum. Furthermore, Bennett (2002) addresses the actual changes that must take place for technology usage to make a difference in curriculum design, and start the alteration to Symonds "High Tech High"(2000).

Bennett suggests urgent changes in the roles of teachers, students, and computers. Students would interact collaboratively with teachers and technology. Computers would deliver and remediate lessons, while the teacher would be a facilitator and a mentor (Bennett, 2002).

Harris (2002) notes that educators have to accept changes in their interactions with students, and they have to support students as their roles change too. Those who have done research on how technology applications

in science will affect high schools are able to see vast changes occurring. In particular, it provides new opportunities for chemistry teaching (Kennedy & Finn, 2000), and provides opportunities for interaction and communication (Miller, Lehman, & Koedinger, 1999).

An international study of classrooms innovated with ICT in many countries has found a very wide variety of applications and pedagogy. The common theme was an emerging paradigm of lifelong learning (Pelgrum & Anderson, 1999). A number of large-scale studies (e.g., Hennessy & Deaney, 2004) had stated that the students' uses of technology have increased their skills, aided by the current favorable policy environment.

The situation in Iran is not much different. The Iranian Ministry of Education has planned basic education reform since 1998 which aimed at diffusing ICT in Iranian schools. Compared to our country, in other countries, there have been substantial government initiatives to put computers into schools, with major reports extolling the virtues of using ICT in classrooms, whereas Iran lacks such substantial government mentoring in such areas. From the Computer Assisted Learning (CAL) plan in 1998 until the current time, the use of network in education and the enthusiastic comments are the same, in spite of the endeavors undertaken.

However, a series of statistical bulletins show that the number of computers in schools and the number of teachers who report using them have increased regularly. In 1998, emphasis was placed on the necessity of one computer in every high school. Fortunately, there were 3 per school two years later. In 2003, the average number of pupils per computer in the high schools was 5 (Statistics book, 2006). It might have been under the

influence of major new initiatives as the Minister of Education refers to: "Moving schools into an Information Age" at that time (Jahangard, 2004). Major hardware and software initiatives have been launched in Iran, from computer and printer purchase to purchasing various laptops, and CD Roms leading to the launch of the national electronic network for schools which provides staff and pupils with access to the network (Roshd Network, 2004). These days, technology plays a substantial role in many Iranian schools, replacing traditional practices, and contributing to changes in the curriculum, as well as changes in teacher-student educational transactions.

However, such school reform is believed to have started in 2000 with a multimedia project in high schools organized by the Educational Technology Department (a unit in the Ministry of Education). In this project, seventh and eighth grade students received computers for their personal use throughout the project. Thus, participation was voluntary for both students and teachers. The participating teachers were provided with both technical and pedagogical training and consultation for both groups and individuals. This two-year project showed that a reflective and creative community was created with good pedagogical results (Roshd Network, 2004).

Several elements have been considered and were emphasized in the on-going reform: 1) teacher training, both pedagogical and technical, 2) developing the teacher community, 3) supporting classroom activities, and 4) developing technical resources, equipment, help and support. The initiative has been developed with the cooperation among the schools and the Human Resource Development Organization, High Educational

Assistant, and ICT Assistant Ministry of Education. This cooperation includes: 1) consulting and research on the hardware, software and on the computer-supported learning, and 2) teacher training by the Human Resource Development Organization. The Ministry of Education was supportive. Initially during the multimedia project, there was resistance to the use of computers. Sometimes there was a strong resistance even though teachers participated voluntarily in the project. Part of the resistance was silent protest (i.e., some teachers just ignored ICT).

Furthermore, the resistance was diminished for several reasons, such as national plan policy, curriculum, time, equipment, and leadership implemented. Today, in some schools teachers use the computer as a tool for planning and lesson preparation as well as learning. Some teachers know how to use computers for word processing and they know the basic functions of E-mail and the Internet. It seems that ICT is mainly used as a tool for writing, information search, and calculating. Computers are used for word processing and teaching foreign languages, although not frequently. Information searching is used for project learning, for example by the teachers of humanities, science, and mathematics.

Moreover, the skills are assumed to be heterogeneous. The Network is used for seeking information and for E-mail. The use of World Wide Web seems to be the next step in the teaching and learning process.

In a general review of background of the status of ICT in Iran, the 1998 reform is the landmark of change in curriculum. The goal was to provide a student-centered curriculum which focuses on both deeper learning and better understanding. This curriculum provided six common

skills as the axial skills: a) critical thinking, b) problems solving, c) scientific research d) creative thinking e) entrepreneurship f) communication, and using ICT (Arshadi, 2004). Even, the name of the "Science Education" course was switched to the "Science Education and ICT" course. At this point the educational system saw the need to use technology, and believed that it is the right way to improve student learning. But the question was how computers should be used in chemistry instruction; this new technology may be less successful, or even doomed to failure.

Therefore, there was a need to consider and find out where the problems are in the current pedagogical practice of teaching chemistry and its future development.

This study typically is from Chemistry classes in middle-class suburban high schools in Tehran, Iran. The story of conducting this research began when a Chemistry teacher was interested in computer technology and the use of computers in chemistry classrooms. The teacher became aware of the use of ICT in a teaching-learning conference in 1998. He became interested in and continued his personal studies until he decided to contact the coordinator at the Ministry of Education in Iran in 2007. His school was invited to join the project. Joining the program, the chemistry class in that particular school received one computer, one video projector, and several software packages.

In pursuing the research, there was no certain template or model to follow. Unfortunately, the national network had not been completed by the time the research was picked up. The teacher faced the tasks of teaching

chemistry to the class, inventing an ICT teaching template, lack of computers for all the students, and lack of a national support network. The results were total failure. Hence, the current study is conducted to document those issues that a teacher might face in using computer-based activities in a real context of teaching of chemistry.

Therefore, the development of a pedagogical model depends on different experiences and viewpoints of specialists in the use of ICT in education. Thus, it is not simply a case of technological adoption, rather it is a process of digesting technology which requires a national plan--the infrastructure support for schools--as well as cooperation among teachers, school principals, and ICT teams to ensure success.

Consequently, there are three major themes in this study. The first theme is "Pedagogical practices in the classroom" which reports on the results of the analysis on data collected on chemistry lessons that make use of the ICT adopted. The second theme is the "Influence factors that impact teaching practices" reporting on the results of the analysis on data collected at the school level. The third theme is the "essential features" which are the results and findings of the analysis of data outside of the school.

Statement of the Problem

There are, however, many challenges in chemistry teaching with the use of computers, and studies (e.g., Jones, 2004) show that ICT classroom implementation by chemistry teachers has been lagging around the world. The emphasis in chemistry teaching, as it is practiced, has often been on

facts, definitions, and algorithms rather than on critical thinking through practical work or inquiry (Holbrook, 2005). Practical activities are often on applied chemistry, and little emphasis is on thinking about chemistry principles.

However, the effectiveness of ICT tools depends much on teachers' understanding of how to use them (Bransford, Brown & Cocking, 2000; Ertmer, 2005). Teachers often fail to adapt to an ICT innovation because it is not easily integrated within school-level activities in teaching chemistry. Moreover, designers are often too far away from school practice and the final users (Linn, 1996).

Therefore there is a need for designing a model that encourages chemistry teachers to implement ICT effectively in chemistry classrooms. To promote scientific understanding of chemistry requires an increased focus on secondary-level students' critical thinking (Anderson & Krathwohl, 2001). This includes understanding scientific content, the scientific enterprise, and having the ability to apply methods of science to construct or to evaluate explanations of natural phenomena (Flick & Bell, 2000).

On the other hand, students also often lack interest in studying chemistry (Osborne, 2003). In incorporating the use of ICT into students' learning activities, the teacher needs to ensure that it is the pedagogical requirements that take priority and that these clearly justify the use of ICT.

Nevertheless, we need to be aware of the educational possibilities of the new technologies and their advantages.

In Iran, there is a big literature gap on teaching chemistry through the use of computers. As stated by Arshadi (2004), the main problem relates to the diffusion of ICT-based practices in schools, which is supposed to be due to the lack of an efficient model to engage teachers and students in using technology at the classroom level.

However, there are some common computer uses in teaching chemistry in the current practice. These practices were not interested in classifying and analyzing the relationships between teachers' roles, students' roles, and the roles of technology as factors that contribute to the practice in the classroom. Thus, these factors are essential features of teaching chemistry through computers.

There does not appear to be an accepted model or common set of chemistry teaching features currently recognized. Little is known about teaching chemistry through computers. Consequently, there is the lack of the skills in teaching chemistry with use of computer across the current practice. Eventually, as a solution to these problems, the development of a pedagogical model of teaching the chemistry subject through computer-assisted inquiry is proposed in this study.

Purpose of the Study

The purpose of the present study is to provide an in-depth study of chemistry teaching with the use of computer-based activities in an Iranian school. The study is concentrated on what the current pedagogical practices are in the classroom. The emphasis is on the elements of the teachers' roles,

students' roles, and the interaction between them. Moreover, the advantages and issues associated with technology-mediated learning and the student learning outcomes are included. Based on an in-depth understanding of the current practice, the study has developed a pedagogical model for chemistry teaching in the high schools in Iran.

Research Objectives

The objectives of this study are three fold:

1. To deepen the current understanding of teaching chemistry with the use of computer-based activities to the 11th grade learners;
2. To describe and examine the important factors involved in computer-based instructional activities observed in current practice; and
3. To identify the essential features of teaching chemistry through computer in the Iranian High Schools.

Research Questions

The above objectives are translated into the following research questions:

1. What is the status of the computer-aided teaching of chemistry subject in the 11^{th} grade of the Iranian High schools?
2. What are the contributing factors to the success of computer-based activities in classroom in teaching chemistry to the 11^{th} grade students in the Iranian high schools?

3. 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?

Rationale of the Study

Nowadays, ICT, particularly the use of the Internet and the World Wide Web (WWW), has increased around the globe. Research shows that these new technologies have improved education and had changed schools' teaching and learning methods. The reports by UNESCO have shown that the use of these new technologies promote international socioeconomic progress and educational changes, both inside and outside the classroom (UNESCO, 2006).

Countries from England to Brazil and from Malaysia to United States have all set their national goals and policies that identify a significant role for ICT in improving their education systems and reforming their curriculum. The situation in Iran is not different. Iran's curriculum, as stated in the Curriculum Framework (Curriculum Council, 1998) regarding the curriculum contents has underpinned the required level of knowledge, skills, and values. These are consistent with the expectations of the educational policies recognized nationally (Zahraei, 1993), and internationally by UNESCO as far as the use of ICT in general education is concerned (UNESCO, 2002). Implicit in the explanation of curriculum policies is the expectation that education systems and schools will assume responsibility for technology development.

Moreover, there are various documents that emphasize the use of ICT as one of the central ideas in the school curriculum (e.g., Jahangard, 2004; Roshd Network, 2004). It is an undeniable fact that technology development is a necessity for society. Such technology should be present in schools and be evident in the classrooms. From this perspective, the psycho-sociological environment of the school can be viewed as schools and the individual classroom as classrooms.

In other words, school and classroom reflect general social norms that need to be considered in the educative mission of schools and the pedagogical processes within classrooms. Therefore, the development and maintenance of the school and of the classroom with respect to the social values and the concepts of social interactions has led to a process called constructivist learning.

Constructivism is defined as a process by which the learner develops understanding and constructs knowledge through interaction with the environment (Savery & Duffy, 1995). Indeed, the social constructivist view of learning involves investigating classroom learning and teaching in relation to the factors influencing students' mental construction of the socio-psychological environment constituting the classroom. Thus, the notions of school and classroom are also applicable in conceptualizing educational change and innovation.

Therefore, school improvement and school renewal have been portrayed as a process of change in teaching-learning and competencies developed throughout the school education period. In particular the need to

develop chemistry instruction at the high school level has been identified by a number of research reports (e.g., Assessment Report, 2001).

Consenquently, schools need to restructure roles and reorganize responsibilities to facilitate the usage of computer in schools (Movahedian, 2002). The importance of utilizing ICT in teaching chemistry is advocated across the literature, for example Lower (1997) stated that ICT supported teaching and practice in chemistry learning. Contributing to the general factor of learning, Fullan (1993) showed that successful use of learning environments affects: a) the characteristics of innovation (e.g., need for innovation and its properties), b) local characteristics (e.g., chemistry teachers' ideas, support, and school context), and c) external factors (e.g., the national framework curriculum in chemistry).

Lewis (2003) stated that the chemistry teacher is a key factor in the reform of chemistry education. Studies have shown that the ICT classroom implementation has been noticeably low by chemistry teachers around the world (Jones, 2004).

This study needed to create a pedagogical model for teaching of chemistry in high schools. Research showed that students have problems in understanding some concepts in science because some of the concepts and processes are not visible to the eye, but students often enter the lesson with negative feeling toward the subject, and only 20% of high schools in Iran were able to describe the meaning of chemical concepts properly (Assessment Report, 2001).

Since the 1950s, computers have been used in chemistry instruction (Lagowski, 1998). Yet calls have been made for more research toward

developing pedagogical models for the teaching of chemistry. The effectiveness of ICT, however, is linked to the pedagogical models surrounding ICT activities (e.g., Bransford et al., 2000).

More research is needed at the chemistry classroom level to understand features of learning environments affecting students' motivation for studying chemistry, and enhancing their interest (Osborne, 2003). There is a need to know more about the pedagogical approach to support our understanding of ICT use in learning chemistry. In the development of a pedagogical model that will use ICT, it is important not only to choose the proper ICT tool, but also to have a clear understanding of the roles played by the teacher, the learner, and the technology. Thus, the better we know chemistry teachers' needs and their students' thoughts and actions during their learning experience, the better we can understand what to implement in ICT chemistry instruction to improve chemistry students' learning experience through the development of a pedagogical model.

Significance of this Study

Since no research thus far has been reported on classroom-based teaching of chemistry with the use of computer-aided activities in the Iranian context, this study would shed light on further explorations of computer-based activities for future development. The Ministry of Education and chemistry teachers will be the primary beneficiaries of this study. Curriculum experts, principals and the ICT teams will be the secondary beneficiaries. Specifically, the ICT researchers will benefit from

findings of this research and will be better prepared for further understanding of the potential uses of computers in teaching chemistry. However, there always are less attempted ways to take which are partly illuminated by previous research. This study attempts to show one.

Conceptual Framework

Literature review shows that researchers have categorized the educational uses of the computer according to the modes of usage, for example, as tutor and/ or tool (Taylor, 1980), as cognitive tools (Solomon, 1986) or mindtools (Jonassen, 2000). Such categorizations are very useful when one is conceptualizing the role that computers play in the teaching and learning process or when designing or selecting computer tools for education.

However, as Jonassen (1999) has emphasized, educational uses of technology that attempt to be "teacher-proof" or "learner-proof" do not fully utilize the capabilities of the technologies or the students. In designing technology-supported learning experiences, it is critical not only to select the right technological tool, but also to have proper understanding of the teacher, learner and technology roles. In fact, the fundamental assumption underlying the concept of "emerging pedagogical model" is that with the introduction of the computer into the teaching and learning process, the roles played by the teacher and the learner should and need to change.

Thus, the study of pedagogical practices should not focus on the functional characteristics of the computer used but rather the roles played by

the three actors, the teacher, the learners and the technology used, as well as the interactions between them. As depicted in Figure 1.1, the actual implemented curriculum will be affected by the idiosyncratic factors associated with each of the three actors present in any specific situation, for example the schools, professional and technological background and the pedagogical orientation of the teacher, the school and technical competence of the learners as well as the technological infrastructure and technical support available.

The focus in this study is on the teaching of chemistry with the use of computer-based activities that are integrated into organized teaching and learning situations in schools as a part of the formal school curriculum. This study is conducted within a broad curriculum framework, where the teaching activity is illustrated as synonymous to the "implemented curriculum" within an extended framework. This framework distinguishes three dimensions of curriculum description, the intended, the implemented and the achieved curriculum (Robitaille, 1996). The intended curriculum refers to the curriculum described in terms of achievement targets, and educational processes defined at the national school system level. At the classroom level, the intended curriculum refers to the learning goals or objectives of a lesson. Implemented curriculum refers to the educational processes happening at the school and classroom levels, and it is described in terms of learning opportunities for students. Finally, the attained curriculum refers to the students' learning outcomes which can be achieved from the learning experiences at school or classroom levels. A summary of the conceptual framework is depicted in Figure1.1.

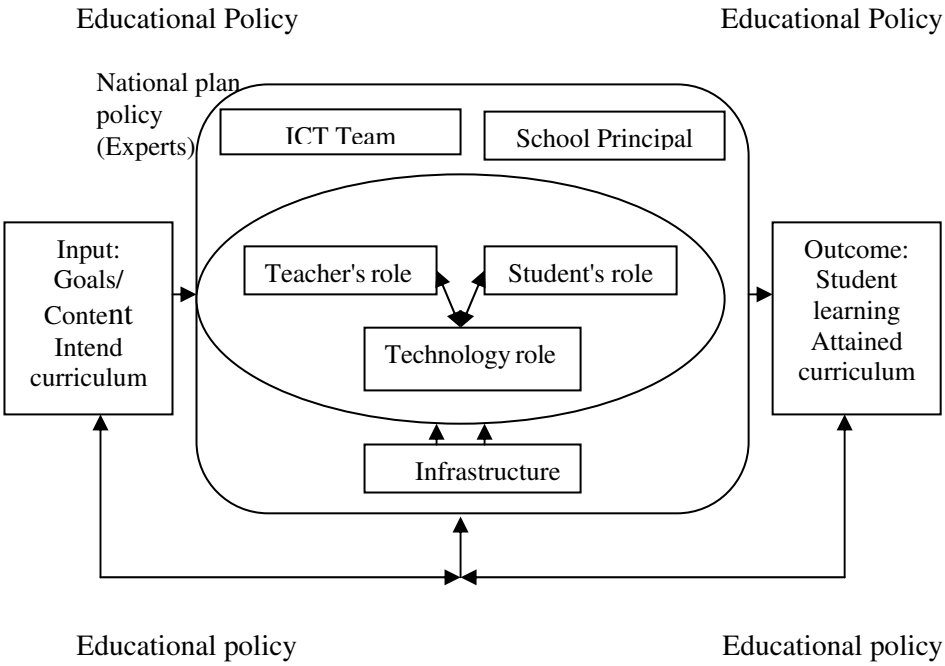

Figure 1.1. Hypothesized model representation of the framework for conceptualizing and analyzing pedagogical practices in school settings.

The success of any pedagogical practice is essentially accompanied with the relationship between the teacher and the learners. Such practices occur in the school context, which are also influenced by external factors at district/regional/national levels. Thus, the entire curriculum context for studying ICT practices has to be studied within the three concentric contexts: 1) micro level (classroom), 2) meso level (school), and 3) macro level (community). These levels are mutually interacting and the boundaries between them are not distinct (Kozma, 1999). Therefore, the conceptual framework is adapted (Robitaille, 1996). However, the analysis includes the same three aspects: micro level (classroom), meso level (school), and macro level (community) as depicted in Figure 1. 2.

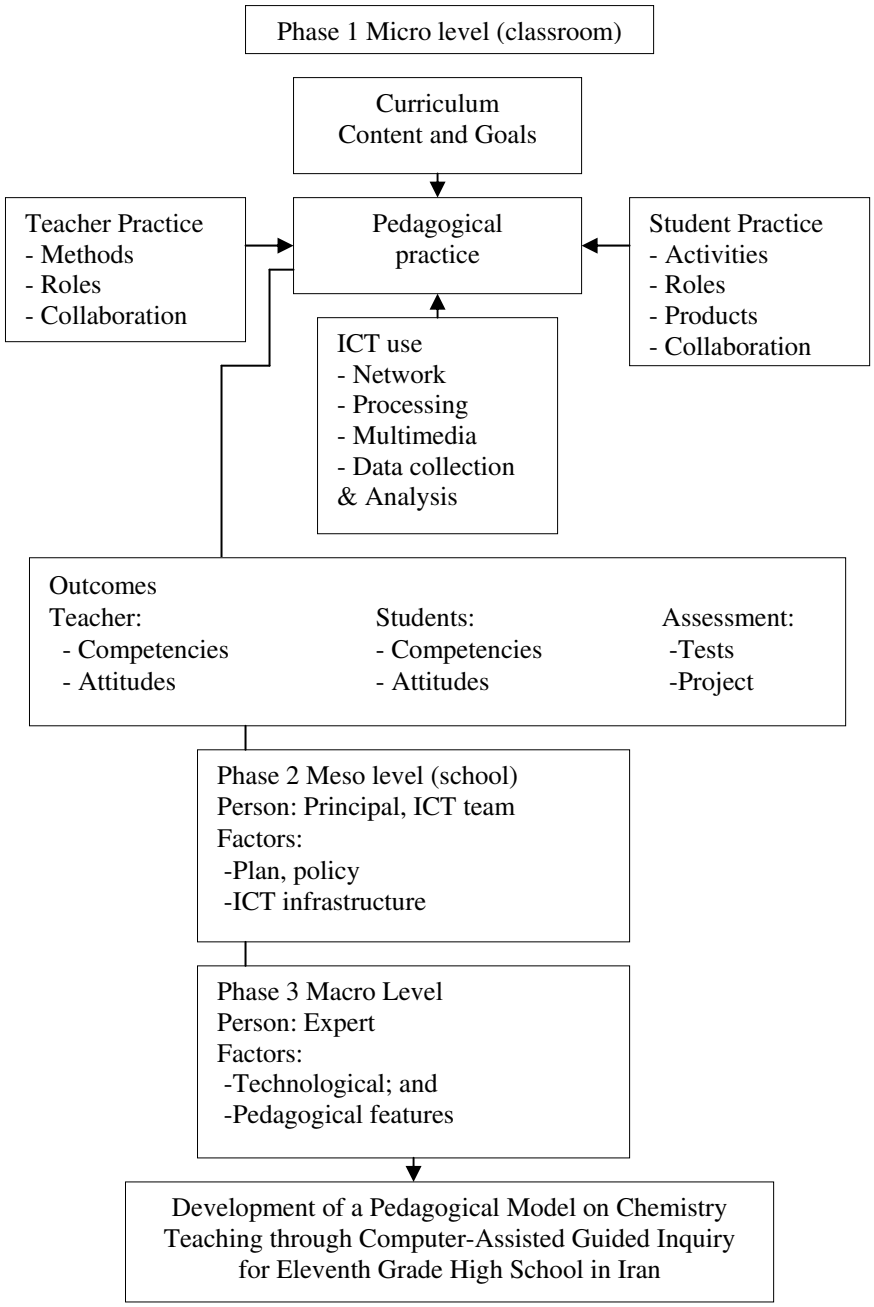

Figure 1 .2. Hypothesized model representation of the major component of the analysis and development phases.

Research Questions and Methodology

In the itinerary of the current research, it is planned to collect data from 10 schools over a period of time for a minimum of seven months. For the first step research questions were used to discuss the current pedagogical practices as common understandings at the classroom level and at the school level. The research element, teachers, students, principal, ICT team, and experts were observed and interviewed to seek future recommendations. Table 1.1 shows the indicators, research questions and methods for measuring the current pedagogical practice in learning environments.

Table 1.1

Research Questions and Methodology

Indicators	Research Questions	Methods of Measuring
Curriculum Teaching strategy Assessment	What is the status of the computer-aided teaching of chemistry subject in the 11th grade of the Iranian High schools?	Observation and interviews of students and teachers Observation of lesson Student logs of activity Tools
Plan and policy school ICTinfrastructure Teacher support	What are the contributing factors to the success of computer-based activities in classroom in teaching chemistry to the 11th grade students in the Iranian high schools?	Interviews of principal and ICT team Teacher support and preparation Plans and policies Fit equipment
Knowledge Experts	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?	Interviews of experts Technological and, Pedagogical features

Analysis of Factors Contributing the Success of Computer-Based Activities in Classroom

These factors are classified into three levels of observed roles as follows:

I) Roles within the classroom: this category includes the teacher, students, technology, and their interaction. These factors are measured on a scale referring to the extent of identification of teaching using computer-based activities, the type of student involvement (passive vs. active), and the level of interaction.

II) Roles within the school: this category includes the principal, and the ICT team. These factors are measured on a scale referring to the extent of identification of computer, the type of involvement (passive vs. active) and the level of involvement.

III) Roles outside the school: These categories include experts (writers of curricula, teachers, researchers, and academic faculties), position holders in the Ministry of Education (supervisors, ICT advisors) and municipal position holders (director of the Chemistry Department, regional coordinator). These factors are measured according to the domains of involvement (pedagogical and technological features). A summary of research design is depicted in Figure 1.3.

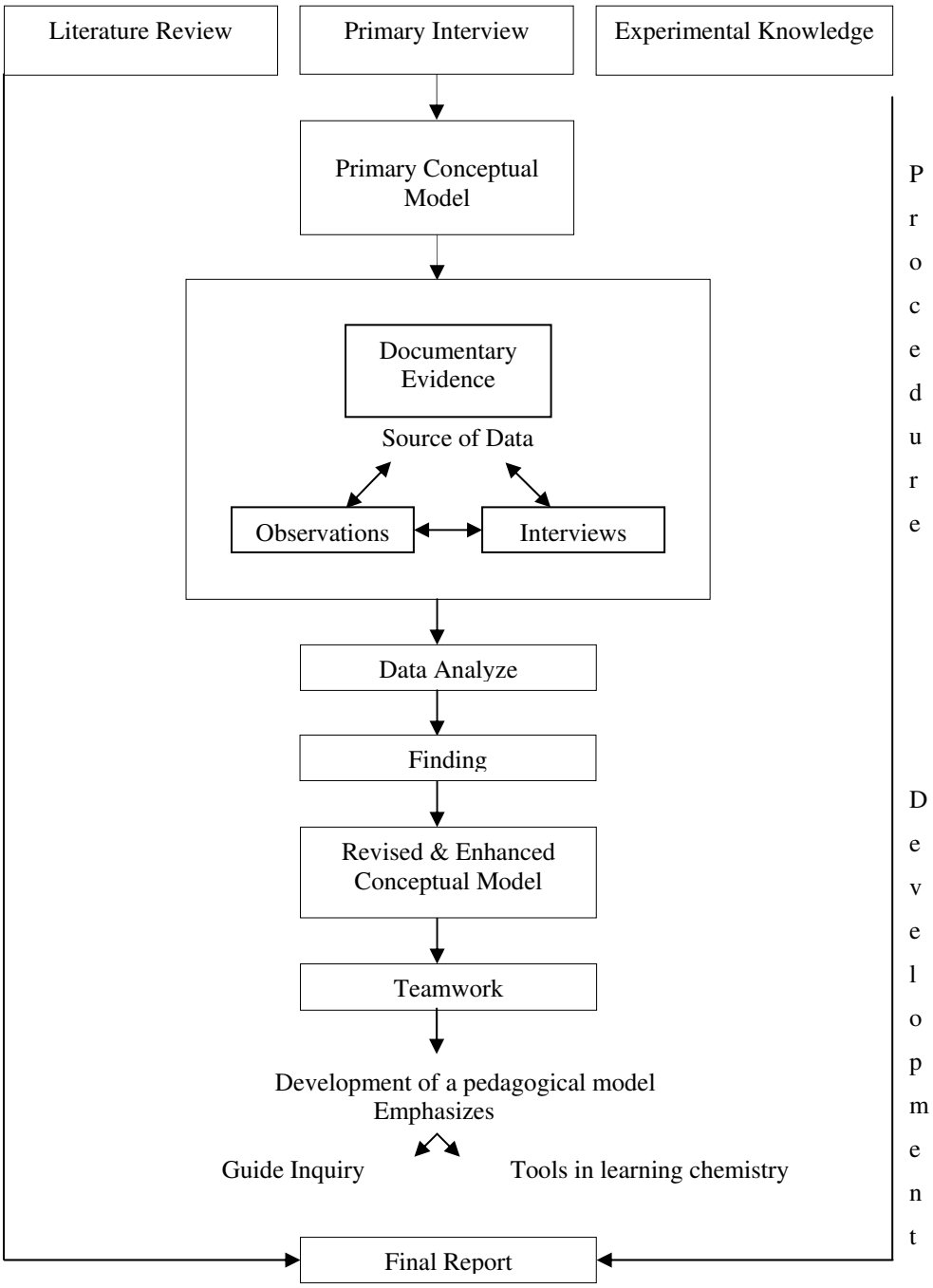

Figure 1.3 Research design.

Limitations and Delimitations of this Study

There are a number of limitations and delimitations conceived for the present research. The use of multiple methodologies and multiple data sources, which focus only on information provided by the teachers, the students, the principals and the ICT teams, is among the limitations of the current research.

Furthermore, the number of participating elements (informants) in each category is limited. The method of data collection is largely confined to observations and interviews, most of which only involved the actively participating individuals. In terms of methodology, it is important to realize that this report just reflects one person's (the researcher's) encounter with a complex case, namely the complicated process of digesting technology in a traditional setting of education. The researcher admits that there are many aspects, issues, and dimensions that she has missed or has failed to discover in adequate depth and wide breadth.

There also might be some misinterpretations or erroneous assertions of the themes and issues derived from the case. Due to these limitations the findings of this study are about chemistry classes in the high schools of Iran, hence any generalization to other types of schools in other countries will not be advisable.

After further research is undertaken on the pedagogical model for teaching chemistry, it may be plausible to generalize the findings to similar educational contexts such as middle schools within Iran, as well as to other countries where such a pedagogical model is the norm.

Definition of Terms

Inquiry. Scientific inquiry refers to the ways in which scientists study the natural world and propose explanations based on evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council, 1996, p. 23).

Guided Inquiry. It refer to promoting a positive learning environment in which students collaborate in small groups to solve problems. These groups are composed of three members: a manager, a recorder, and a reporter. With interaction and participation in their own learning, students can find the solution to problems, and reflect upon their learning process (Hanson & Walfskill, 2000).

The Student-Centered activities. These refer to the interaction between students, where students discuss and share their thoughts with each other (Lemke, 1990).

Computer-Assisted Guided Inquiry. This refers to conducting student inquiry in an Information and Communications Technology (ICT) environment. ICT is used as an aid in collecting information and data from various sources, for example from phenomena through the Internet, and database learning environments. In this study, small groups of students, in particular, conduct investigations, for example collect data and information.

It is believed that employing "computer-based tools facilitate generative process of information by learners" and "facilitates critical thinking and higher-order learning" (Jonassen, 1992).

Information and Communications Technology in Chemistry. Information and Communications Technology (ICT) will play an increasing role in chemistry education in Iran (Arshadi, 2004), and worldwide (Kozma, 2003, pp. 1-14). ICT has been an inherent component of every modern chemistry research laboratory since the 1950s (Lagowski, 1998, pp. 425-436). ICT provides opportunities, for example to understand chemical phenomena more deeply, to guide and to monitor chemical reactions, to design new molecules with specific programs and/or using databases, to visualize molecules and chemical reactions (Arshadi, 2004), to conduct small scale experiments in accordance with green chemistry principles, and to communicate easily and quickly with researchers around the world through collaborative technology. The Internet can also be an important source for data, data analysis, and data exchange (Songer, 1998, pp. 333-348).

Use of technology can support inquiry in the classroom (Edelson, Gordon & Pea, 1999, pp. 391- 450). Moreover, technology can be used for collecting and sharing data, analysis of data through modeling and visualization, evidence gathering and evaluation; communication and collaboration through technology facilitate the adoption of attitudes, techniques, and social interactions that characterize the scientific community (Edelson, 1998, pp. 317-331). Students who learn to use technological tools will be better prepared for the workplace and for

opportunities to update and expand their scientific ideas (Linn, 1998, pp. 265-295).

Practices. The goals of this study were to study examples of current pedagogical practices in using computers in teaching and learning with the aim of developing a pedagogical model. A most challenging question facing the researcher was how to identify the pedagogical model and what criteria should be used to identify it. The researcher decided against setting up any conceptual criteria for selection. Instead the researcher just solicited widely through various knowledgeable contacts such as ICT Department M.E working in the area of ICT in education, and members of various education organizations for nominations of schools or teachers they know to be actively integrating the use of computers in teaching chemistry and may act as good role models for others. This simple and theoretical criteria is chosen because at the time of the study (2005), Tehran schools has only just begun to introduce the use of computers across the curriculum, following the release of the 7-year ICT in education strategy plan in 1999. Given such a short history of this innovation, the researcher decided that the best way to develop a pedagogical model is to do a naturalistic study of the teacher's role and student's role with computers and what schools implement change, in addition to whether those practices exhibit features of the "emergent" or the "traditionally important" model.

Pedagogical model. This refers to the procedures adopted for delivery of content of the various subjects in the school curriculum. The term is also used interchangeably with teaching techniques, methods of teaching, and instructional strategies.