Synopsis

The Objective

The purpose of the present study was to demonstrate the significance of computer-learner interaction in developing computer assisted instructional systems for elucidating concepts in chemistry. The objective was achieved by developing prototype software for various concepts based on the "Integrated Learner-Centered and Concept-Dependent" approach to interactivity that we have proposed. The validation of the said approach was done by the educational evaluation of these software packages in terms of their ability to promote various learning and cognitive skills. The general aims of the thesis can be summarized as follows:

1. To find out types of difficulties and misconceptions that students have in learning chemical concepts at various levels through literature survey.
2. To sort out a suitable complexity level and representational mode of interaction for developing prototype software for four major misconceptions and difficulties in chemistry.
3. To develop prototype software packages for the same using the analyzed level and mode of interactivity.
4. To evaluate each prototype software in terms of its utility for better elucidation of concepts in chemistry by testing them with appropriate student samples.
5. To interpret the results of evaluation in terms of the cognitive skills students acquire while learning concepts using these software.
6. To validate the proposed approach to interactivity through these results.

Organization of the Thesis

This thesis has eight chapters. Chapter 1 is an introduction to the educational software development. It includes a brief description of the aims and objectives of the educational software, and its significance in providing a learner with the opportunity to acquire basic learning skills as well as to elucidate the basic concepts. It also presents a brief overview of the learning paradigms associated with the development of educational software, role and significance of computer-learner interactivity in the educational software. Chapter I ends with the general observations and questions regarding the development of educational software for chemistry. Finally the research problem is proposed and its rationalization presented.

The second Chapter, which is devoted to review of literature in the related areas has two sections. First one describes the work done on the difficulties and misconceptions about learning chemistry. The second section which deals with computers in chemical education has two sub-sections. Sub-section I, presents a description of the educational software that have been developed till 1995 in chemistry. The articles reviewed in this section do not present any statistical evaluation in terms of the educational utility of these software, rather the authors have presented their experiences in using them in their respective classrooms. Second sub-section deals with the chemical education computing research. Our literature survey reveals that the work done in this area, is much less as compared to the work done in related areas in other subjects of mathematics and science.

In chapter three we introduce the proposed "integrated learner-centered concept-oriented" computer-learner interaction for the design of the educational software systems. Here we first present the limitations of the domain oriented approach, and then describe the theoretical framework of our approach, which is based on the nature of the concept, learning demands, and pedagogical demands. We then describe the structure of our user interface model encompassing our computer-learner interactivity design. We have also

discussed how the above mentioned, two important approaches to educational software development can be successfully integrated for the development of a more appropriate design in line with theories of learning.

Chapters four through seven describe four cases of development and educational evaluation of the prototype software packages using the proposed approach to computer - learner interactivity. In chapter four we have discussed the use of interactive modeling for teaching concepts at the macro level. The concept chosen is electronic configuration, and we have studied the impact of interactive modeling on the conceptual change amongst learners. The complexity level involved in the design of this software is functional interactivity and at the representational mode it is the modeling interactivity. The overall conceptual change is measured in terms of the change in their concept knowledge, concept reasoning ability and problem solving skills.

Chapter five deals with the second aspect of chemistry learning; understanding of concepts at the particulate level i.e. the atomic and molecular interactions.The concept chosen is kinetic theory of gases and its application to understand gas laws. The complexity level of interactivity involved here also is functional but the mode is simulation interactivity . The software developed has been used to study the impact on the development of a dynamic mental model about the said concept amongst learners. The overall effectiveness has been measured in terms of change in concept knowledge, concept reasoning, graph and experimental data interpretation abilities

In chapter six we have discussed the role of interactive linguistic modeling in remedying learning barriers related to the representational aspect of chemistry. The interactivity level involved is adaptive type and the mode is modeling interactivity. Chemical equations have been described as the language of chemistry by several authors. In the software Chem_Eqn, developed for teaching chemical equation, we have treated atomic symbols as alphabets, molecular formulae as words, and provided the learner with the opportunity to learn construction of `chemical' words(molecular formulae) using 'chemical

alphabets' (atomic symbols) in the correct syntax. The software is aimed at sensitizing the students to the information conveyed by the chemical equations by way of learning the symbols, formulae, the significance of the other symbols used in the chemical equation, the difference between atoms and molecules as also the rules governing the formation of compounds from its constituent elements, etc.

Chapter seven deals with the last aspect of problems in learning chemistry, i.e. numerical perception. As an example we have taken the periodicity in various properties of elements. Although the students generally possess knowledge of the trends in periodic properties, they seldom have an idea of the magnitude by which these properties change. The software Per_Tab, which has been developed, for teaching periodic properties, incorporates the navigational level and the mode of representation is hyperlinked interactivity. The overall effectiveness of the prototype software has been measured in terms of the students understanding of the magnitude by which certain property varies along a period or a group, the magnitude of variation of one property when a second property is varied and the relation between any two properties.

The last chapter, describes the overall effectiveness of the new approach to interactivity, that we have proposed, in the development of the interactive instructional software systems. We conclude by summarizing the results of our study. All the prototype software packages that were developed and evaluated have shown to assist learning of chemical concepts. Besides they have also been helpful in developing higher order cognitive skills such as promoting positive conceptual change, retention of information, development of a dynamic mental model, etc. These results support the viability of our proposed model of computer-learner interaction for the design of educational software systems. Lastly we conclude by pointing out the limitations of the study and suggesting directions for further research in the area of computer-learner interactions for the design and development of better chemistry educational software systems for better elucidation of chemical concepts.