Chapter 7: Findings and Conclusions

*It requires a very unusual mind to undertake the analysis of the obvious.*

**A. N. Whitehead** (1861 - 1947)
- From *Science and the Modern World*

This chapter presents and discusses the objective wise summary of the findings based upon the analysis of data done in chapters 5 and 6. The findings have been reflected upon objective wise first, under the heading ‘Discussions’. Relevant conclusions from the research finding in the light of the research questions have also emerged and presented. Next sub-section includes some important implications for the science learners, science teachers, school administrators and school level policy planners, teacher educators, teacher education policy planners, technocrats and educational software developers that have come into view in the light of the research findings and conclusions. This discussion is followed by suggestions for further research in the area that can be undertaken.

7.1 Summary of Findings

Following is the objective wise summary of findings that emerged from the analysis of data in chapters 5 and 6.

7.1.1 To explore teaching learning contexts in science classrooms with respect to

a) Teachers' natural dispositions towards formation of and addressing the Alternative Frameworks

From the self assessment of the responding teachers, following are the areas in which teachers face challenges

- locating Alternative Frameworks amongst learners
- being tolerant to individual interpretations by the learners
- addressing the Alternative Frameworks amongst learners

Discussion: Thus, the teachers face the greatest challenges in locating Alternative Frameworks among learners, being tolerant to individual interpretations and finally
addressing these. Since the teachers have problems in even locating the Alternative Frameworks, addressing them becomes a very difficult task for teachers.

b) Possible sites of formation of alternative frameworks among learners in science

- The possible sites identified were found to be similar to those seen in the earlier research studies.
- Impact of the socio-cultural environment did not emerge in the possible sites of formation of Alternative Frameworks amongst learners except for one example by a teacher that formation of rainbow is due to Indra Devta.

Discussion: In contemporary understanding of teaching learning process, it is generally considered that the most significant impact on learning is their socio-cultural environment. However, in the present study the sites located did not seem to have connection to the socio-cultural environment of the learners. This, perhaps, requires a detailed profiling of the Alternative Frameworks to be undertaken.

7.1.2 Understanding science teachers’ perception about Alternative Frameworks

Teachers’ views about Alternative Frameworks have been understood to include the following features.

- known fixed knowledge about science that can be modified or changed when something new with evidences come up
- views held by the learners which don't really coincide with scientific views
- concepts in which learners may be unable to understand the whole process clearly and construct their own ideas about the possibility of process
- preconceived notion or conceptual misunderstanding when something that a person knows and believes does not match with what is known to be scientifically correct
- an unfounded belief that does not embody the agreement of fear, good luck, faith, or supernatural intervention, frequently the intuitive understanding of the world around them that does not agree with the scientific explanation
views children hold, that differ from conventional scientific explanation or classification

• some complex topics that are defined in some small series and some step is missed

• preconceived notions, conceptual misunderstandings and non-scientific beliefs that a person holds, he/she is never aware of the fact that his or her ideas and beliefs are incorrect

• myths which are constructed by people not using logical and critical thinking

• children's belief about things that they expect and something which enables them to predict future events

• inferences about any phenomena of nature, that are not actually true

Science teachers reported the following reasons for the formation of Alternative Frameworks:

• everyday talk or everyday use of language

• people using simple language to explain concepts

• everyday experiences

• socio-cultural context

• subjectivity of the learner’s interpretations

• inappropriate guidance by the teacher

• content not presented or taught in the class in proper sequence

• children’s own experiences combining with logic and non-scientific understanding

• wrong interpretation of different concepts

• previous misbelieve or misconception about any topic

• just having theoretical knowledge of topic (no practical orientation)

• handed down from one person to the another

• theory put by scientists are wrongly interpreted, the scientist tend to forget that common people do not understand scientific language

• the effect of religious beliefs

The following is the nature of Alternative Frameworks as has been described by many
teachers:
- linked to everyday use of language
- may be personal or shared with others
- similar to our earlier scientific models like Earth being flat
- inconsistent with science being taught
- resistant to change

Teachers think that the Alternative Frameworks can be addressed by
- identifying the Alternative Frameworks by paying attention to the learners’ ideas properly and questioning those
- identifying learners’ existing ideas by diagnostic assessment
- being well read and well aware

Some examples given by the teachers related to the Alternative Frameworks are as follows:
- a nucleus in a blood cell is used to store food
- in eye, images are formed on the cornea
- in chemistry-organic means natural
- heat rather than hot air is thought to rise
- magnetism is involved in chemical bonds
- when things dissolve, they disappear
- formation of rainbow is due to Indra Devta

Discussion: A lot of diversity is seen to emerge in the perceptions of teacher’s related to Alternative framework. In the light of the outcomes from objective two, it is important to note that while some teachers think that socio-cultural factors may influence formation of Alternative Frameworks, this has not emerged in the findings of the present study. Thus there is a contrast in the perception of teachers and what actually emerged form their own classrooms.

7.1.3 Understanding science teachers’ perception about the use of Computer Assisted learning program in addressing Alternative Frameworks among learners in science.

Analysis of the science teachers’ responses about the understanding of computer-
Almost every teacher was of the view that in present day classrooms, a computer is a must and most of the teachers reported to being competent in using Computer Assisted Learning in their classrooms. There is a wide range of key terms used by the science teachers in order to explain computer-assisted learning. This shows a wide range of notions associated with computer-assisted learning. Also, these notions of the science teachers are in consonance with the review of related literature done in this area. To be specific, multimedia approach, models and simulations, interactivity, delivering coursework, assisting traditional teaching, concept construction and reconstruction etc have been represented in teachers’ responses. Interestingly, 50% of the responding teachers had never come across any Computer Assisted Learning material in their life. No teacher had experienced any Computer Assisted Learning material except ‘hot potatoes’ or certain power point presentations. Most teachers are confident about their learners’ competence in using computer-assisted learning material on their own. Those who are not, articulated that with some initial inputs their science learners will be competent in the same.

In the perceptions of teachers regarding Computer Assisted Learning in addressing Alternative Frameworks, the following themes emerged.

**Information resource**

Computer Assisted Learning can overcome the limitation of textbook as a source. The internet is a large and global network of computers. It provides access to an essentially unlimited source of information. Computer Assisted Learning can supplement the practical and experimental work also.

**Curiosity and interest**

Computer Assisted Learning can enable the learners to develop curiosity. Computer Assisted Learning can have more impact than normal teaching-aids like charts; Content delivery can be more effective, interesting, exciting and everlasting and traditional repeated boring method can be avoided.

**Drawing linkages**

By the use of Computer Assisted Learning material sequencing of all steps of complex areas of science in a logical order of simple to complex and concrete to abstract so that no step get missed by learner.
**Supporting imagination**

There are many concepts which are present in the real world but we can’t observe them directly such as atoms, earth’s movement in solar system etc. A computer simulation about these can prevent formation of alternative framework/misconception. Simulations and animations like ultrasound and sonar, electrical charges, electric current, magnetic field, transportation in animals and plants, erosion of soil, movement of blood in arteries, exchange of gases, Archimedes principle, buoyancy, work and energy and sound would have been possible. We can show activities which can’t be done in the classroom. Some videos of concepts like motion related to daily life and its analysis can be taken up.

**Thinking skills**

Computer Assisted Learning can be helpful in developing logical and divergent thinking among learners. Science is related to different phenomena, processes, experiments and experiences in which Computer Assisted Learning can provide opportunities of developing independent thinking of learners by developing their existing ideas, bringing existing ideas together, changing existing ideas, Identifying the areas of science pupils problems, considering evidence. This process will succeed when pupils feel safe enough to admit that they do not know or are unsure, accept the uncertainty of science and developed discussion skill.

**Learners’ style of learning**

Learning can be been highly individualized. Computer can provide authentic and reliable knowledge developed by experts. Computer Assisted Learning can help a learner in understanding on his/her own pace which leads to a better conceptual clarity. Attention deficit of the learners can be addressed. Classroom can thus become more learner-centred.

Discussion: Although the science teachers think that Computer Assisted Learning will be helpful in addressing Alternative Frameworks, in what way it will be helpful is a matter of opinions. All these opinions have important ideas to incorporate.

**7.1.4 Identifying the characteristics of desirable Computer Assisted Learning program as per the perceptions of science teachers.**

As per the perceptions of the science teachers, the following characteristics emerged for the desired Computer Assisted Learning program.
The content should be supplemented with instructions; include self-assessment, interactive questions and ample number of activities; demonstration of natural activities such as formation of rainbow; inclusion of drills and practices; validated and checked by experts in the field; liberty to the learner to arrange pace of learning as per their own needs; material designed as per the socio-cultural context of the learner; interactive; content areas arranged in increasing level of difficulty; practical work oriented instructions; carefully interwoven images, videos, audios, effects and text; easy to understand; is appropriate for the age and stage of the learner; motivating for the learner; gave immediate feedback to the learner; include interesting games; based on discovery approach, develop problem-solving skills and strategies; adaptable for distance learning environments; provide regular and timely interaction with the instructor; learner gets the liberty to repeat tutorials; makes the web based expeditions possible; adapts to the learners individual needs; acquire information about learner’s current knowledge of the subject, his or her learning goals and prepares a profile based on that; should have structure for eliciting evidence of learner’s cognition and performance; develop interest in science; supplement traditional methods and modes of the classroom learning; provide support for learner-learner and learner-teacher interaction; appealing animation effect; simple and comprehensive language; give support for constructing and testing hypothesis; learner can select the level of challenge with which they feel comfortable; learners able to get life like experiences; enables learners to gain hands on experiences and increase their skills; match the curriculum settings; generating curiosity in the learner.

Discussion: The perceptions of teachers reveal a lot of expectation from the Computer Assisted Learning program that may be used for addressing alternative frameworks. Form the characteristics emerged, it is evident that the teachers are not just concerned about their own preferences but have to some extent considered what is needed by the science learners and what will make the program effective and interesting from the science learners’ perspective.
7.1.5 Evaluating features of some of the computer-assisted learning programs in science on the basis of

a) Understanding that has been developed about the teaching learning context in science classrooms

These features are lacking in both the programs evaluated.

- Should be able to locate the Alternative Frameworks amongst learners
- Channelize individual interpretations by the learners
- Address the Alternative Frameworks amongst learners

b) Perceptions of science teachers

Two programs were evaluated based on the perceptions of teachers regarding the features required in a Computer Assisted Learning program.

The following evaluation is based upon the characteristics emerged as most significant.

Table 24 - Evaluation of Computer Assisted Learning program

<table>
<thead>
<tr>
<th>FEATURE EVALUATED</th>
<th>Prog. 1</th>
<th>Prog. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liberty to the learner to arrange pace of learning as per their own needs.</td>
<td>Absent</td>
<td>Good</td>
</tr>
<tr>
<td>Carefully interwoven images, videos, audios, effects and text.</td>
<td>Satisfactory</td>
<td>Good</td>
</tr>
<tr>
<td>Appealing animation effect.</td>
<td>Satisfactory</td>
<td>Good</td>
</tr>
<tr>
<td>Include self-assessment, interactive questions and ample number of activities.</td>
<td>Absent</td>
<td>Good</td>
</tr>
<tr>
<td>Inclusion of drills and practices.</td>
<td>Absent</td>
<td>Good</td>
</tr>
<tr>
<td>Motivating for the learner.</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Develop interest in science.</td>
<td>Satisfactory</td>
<td>Good</td>
</tr>
</tbody>
</table>

When evaluated on all the 35 characteristics that have emerged-
Program 1 featured good on the following- validated and checked by experts in the field; material designed as per the socio-cultural context of the learner; adaptable for distance learning environments; learner gets the liberty to repeat tutorials.

Program 2 featured good on the following- include self-assessment, interactive questions and ample number of activities; inclusion of drills and practices; liberty to the learner to arrange pace of learning as per their own needs; interactive; gave immediate feedback to the learner; include interesting games; based on discovery approach, develop problem-solving skills and strategies; give support for constructing and testing hypothesis; enables learners to gain hands on experiences and increase their skills; validated and checked by experts in the field; adaptable for distance learning environments; learner gets the liberty to repeat tutorials; demonstration of natural activities such as formation of rainbow; carefully interwoven images, videos, audios, effects and text; develop interest in science; supplement traditional methods and modes of the classroom learning; appealing animation effect; generating curiosity in the learner.

Discussions: It emerged in the evaluation that more interactive program featured better on the perception and expectation of the teachers. The research focus of increasing the interactive aspect of CAL program is supported by the teachers.

7.1.6 Drawing implications for Science Education.

- There is a need to develop a Computer Assisted Learning Program for addressing Alternative Frameworks among learners in science.
- Computer Assisted Learning programs need to assist the science teacher in the three least addressed challenges viz. locating the Alternative Frameworks amongst learners, channelizing individual interpretations by the learners and addressing the Alternative Frameworks among learners.
- Some already studied/developed Computer Assisted Learning programs can be used for the above purpose.
- Issues of availability, awareness and experience of Computer Assisted Learning program/s among science teachers need to be taken up.
- CAL program need to be more interactive and give learner space to get feedback, reflect and rethink.
• Science learners might need initial assistance in developing competence for self sufficiency in using Computer Assisted Learning material on their own.
• For developing a Computer Assisted Learning for addressing Alternative Frameworks among learners in science, the identified characteristics of desirable computer-assisted learning program (as per the perceptions of science teachers) can be used.

7.2 Conclusions from the Findings

Objective-wise findings have been discussed in the previous section, which sheds light on the questions that had emerged while undertaking this study from the classroom situation where a 10th grade student of researcher's class was found to be very enthusiastic and confident about her views regarding the level of water in a reservoir having fishes and other aquatic animals. The questions that have emerged from this fountainhead were related to the context in which alternative frameworks are being formed and addressed. While trying to explore the possibility of using Computer Assisted Learning in addressing Alternative Frameworks among learners in science, science teachers’ perceptions related to Alternative Frameworks and computer-assisted learning, as part of the teaching-learning process had emerged as an important focal point in the research questions. These perceptions of the teachers were provided from their own classroom settings. The inputs related to possible sites of formation of Alternative Frameworks from their science classrooms had built an understanding about the characteristics of Computer-Assisted Learning program in science for addressing them. An exploration in the form of evaluative inquiry on some available computer assisted learning programs has the potential of giving us some directions to understand ‘how’ and ‘how much’ can we move forward.

Research findings summarised in the previous section indicate that teachers’ perception about Alternative Framework and their formation relate to a range of notions that connect with the notions of misconceptions, naive conceptions, children's science, preconceived notions, non-scientific beliefs etc. These notions of teachers are similar to the notions that have emerged in the literature as terms similar to Alternative Frameworks. In teachers perception, the reasons for formation of Alternative Frameworks among learners in science has been located to be as diverse as has been depicted in the literature and researches available. However, it is
important to note that these notions are not a part of a single teacher’s understanding of Alternative Frameworks but is spread throughout teachers. An important conclusion for teachers and teacher educators in science is to focus on an appropriate understanding that assists them in reflecting on their own comprehension of ‘alternative framework and their formation’ in a more positive, considerate and accepting perspective. Although teachers’ perceptions depict that they have an understanding about how to address alternative frameworks, but they do find it difficult to identify, locate and address them. The understanding developed from the findings related to the possible sites, where science learners may develop Alternative Frameworks, brings forward an important point that there might be a role of socio-cultural environment in science learning, but in the formation and addressing of the alternative frameworks this might not hold true. The reasons that have been reported by science teachers for the formation of Alternative Frameworks include issues of pedagogy and content specific to learning science, and an interrelationship between them. An emphasis on how a particular science concept is transacted in a classroom has also emerged, which hints at the importance of pedagogical content knowledge framework (Travers & Shulman, 1973) in addressing these alternative frameworks.

Taking assistance from computer to support learning, especially in addressing these Alternative Frameworks, needs to be explored. This exploration, based upon the understanding about science teachers’ perception in relation with the use of computer-assisted learning program had been found to be supported by the teachers. While some teachers think that computer can assist in learning by being an information resource some others have supported the idea of computer assisting in learning science by preventing the formation of alternative frameworks. A range of characteristics that had been identified as per the perceptions of science teachers, indicate a high level of expectation from the computer-assisted learning program in science. These expectations are not centric to their own needs but include science learners’ perspectives also. This high level of expectation from the computer-assisted learning program has been reflected in the evaluation of the features of the available computer-assisted learning programs. This evaluation reveals that these computer-assisted learning programs are not able to cater to the needs of the teaching learning
contexts in science classrooms. Another revelation indicated that more interactive program is featuring better on the perception and expectations of the teachers.

7.3 Implications in Larger Perspective

This subsection reflects on the implications in the extended and broader perspective.

7.3.1 Implications for the Science Learners

Learners being the centre around which the whole teaching-learning process revolves, some implications can be extended to them also. Addressing Alternative Frameworks is not possible without an inclination from the learners’ side to understand the concept and not just recall and write it in the paper and pencil test. An open-minded attitude by the learner that include a willingness to explore, modify and change their understanding when something new with evidences come up can be helpful in this regard. Taking assistance from computer programs will need some skills in handling the software and hardware components of the computer also. Thus, motivated effort to learn the software and hardware components can bring about a positive change in the whole teaching-learning process in science.

7.3.2 Implications for Science Teachers

Teachers need to assist the science learners in developing an open-minded attitude for exploring, modifying and changing their understanding when something new with evidences come up. An extra effort for identifying and addressing the Alternative Frameworks amongst learners in science is also needed. Assisting the learners in developing the set of skills required for interacting with the software and hardware components of the computer is required. Teachers’ open-mindedness to accept the presence of multiple interpretations by the learners has to be developed.

7.3.3 Implications for School Administrators

School administrators need to provide infrastructural and other supports required for the science learners and teachers. This support is to be based upon an acceptance of teacher as a responsible partner in the teaching-learning process. In order that computer-assisted learning program is incorporated in science education, the science classrooms need to be equipped and computer labs with suitable programmes are required. Time Table that is developed in schools need to incorporate the requirements of science learners needing time for working with the computers.
The administrator needs an understanding that these computer-assisted learning program will be more effective if they are interactive in nature and the science learner is able interact with the program in person. Cloud computing has been found to be cost cutting in the related studies.

7.3.4 Implications for School Level Policy Planners

Infrastructural and other supports required in the school settings for the science learners and teachers can come only when the policy planning is done in synchronisation with the needs of science learning. For placing an effective computer-assisted learning program in the school settings is to be well supported through financial provisions also.

7.3.5 Implications for Teacher Educators and Teacher Education Policy Planners

As the teacher's perceptions about Alternative Frameworks and their formation relate to a range of notions that include notion of misconception, teacher educators need to challenge those notions so that more acceptable and positive notion of these frameworks can be developed in science teachers. For this teacher educators need to give metacognitive opportunities to teachers, for reflection on their comprehension of formation and addressing of alternative frameworks. Teacher educators need to mentor and prepare the science teachers in identifying, locating and addressing the alternative frameworks. Pedagogical content knowledge about specific concepts in science can become a point of reference in this regard. Teacher educators need to prepare the science teachers for handling software and hardware components of the science teachers in the areas of their difficulty. Teacher education policy planners will thus need to design the curriculum of teacher education in such a way that these opportunities are provided to the teacher educator. In the teacher education policy, computer-assisted learning in addressing Alternative Frameworks needs to be placed in teacher education settings. This would mean structural, financial, curricular and academic support to the teacher.

7.3.6 Implications for Technocrats and Educational Software Developers

Education as a field is not similar to the market forces that drive Computer applications in other fields. High demand and high return has driven the development of computer applications. This had not been true in case of education. The type of applications that needs to be developed for addressing Alternative Frameworks is also
different from the instructional materials that are usually developed. Technocrats and educational software developers need to identify those needs from the required program so that effective interactive learning programs may be developed. These interactive learning programs will need self-assessment, directive questions, activities, demonstrations, carefully interwoven images videos and audios giving feedback to both the learner and the teacher. A program that does not limit the learner to only the information provided as part of the program but can be connected to the web, making different expeditions possible is needed. This program is to be supported by appealing animation effects, simple and comprehensive language and the level of challenge in which the learners are comfortable. This challenge is not an easy one for the technocrats and educational software developers and need a range of support. Different experts from the fields related to education, science content experts, and computer software development experts, educational planning and administration related personnel have to join hands together for the benefit of science learners and learning of science. This will support development of science education in terms of culture of science as a practice and further expend support to technology and Society.

7.4 Suggestions for Further Research:

There is a very obvious suggestion that naturally emerges out of this work is that we need to compile already developed computer assisted programs from different parts of the world and test their adequacy in addressing Alternative Frameworks among learners in science. We also need to develop Computer Assisted Learning material on specific areas/topics from science, based on the identified Alternative Frameworks amongst learners in science. Then test the efficiency of these programs in the science classrooms, in natural school settings, on individual learners. We also need to understand the economic viability of the application of Computer Assisted Learning for being used in these specific contexts. How to involve parents in the process of science learning, how community participation is ensured, and its resources used etc are the issues that need to be understood. A long standing issue of paying individual attention to the science learners can be slightly addressed in this way, but only to the extent that it is related to Alternative Frameworks. A larger issue remains about how we engage every learner in science learning practices. Further research can also be taken up to address the issue of large classrooms. How to strengthen the role of teacher and empower them is also need a deeper understanding and may be undertaken.