CHAPTER ONE
CONCEPTUAL FRAMEWORK OF THE STUDY

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CHAPTER ONE
CONCEPTUAL FRAMEWORK OF THE STUDY

Science is a system of knowledge, a process of acquiring and refining knowledge through the processes of observation and experimentation. Science education research shows that teaching science and its issues enables students to identify problem, analyze data, make rational choices among alternatives, and take appropriate actions and is necessary for citizens to be considered scientifically literate (Aikenhead, 1980; Zoller, 1987). In the present times, the rapid advancement of science and technology, and increasing need for scientists and technologists have made it all the more important to provide science-based education in schools. It is beyond any doubt that science education is core area of our education system and science is an essential and fundamental subject in our curriculum. Science education provides us an opportunity to think critically and unify the concepts of man’s natural environment and utilize it for the benefit of mankind.

The Secondary Education Commission (1953) as well as the Kothari Commission (1964-66), both have recommended that every secondary school student should study general science as a compulsory subject, so that he gains a basic quantum of scientific knowledge as a part of his general education.

Emphasizing the importance of science teaching in schools UNESCO in its report of the International Commission on the Development of Education, ‘Learning to be’ (1972) recommended as under:

“Science and technology must become essential components in any educational enterprise; they must be incorporated into all educational activities intended for
children, young people and adults, in order to help the individual to control social energies as well as natural and productive ones, thereby, achieving mastery over himself, his choices and actions, and finally, they must help man to acquire a scientific turn of mind so that he becomes able to promote science without being enslaved by it.”

As a consequence of the recommendations of various commissions because of the multifarious value of science to the individual as well as society, science has become a compulsory subject in the school curriculum in India through the efforts of National Council of Educational Research and Training (NCERT).

According to Amitabha Mukherjee, (2001) Director, Centre for Science Education and Communication, University of Delhi, “… Science should emerge as something alive, fallible, and therefore, exciting. Such a model will meet the wider aims of science education, and at the same time is more likely to encourage potential scientists to want to study science”.

1.1 Present Scenario in Science Teaching: Problems and Need for Systems Approach

The bitter truth is that present science teaching in schools is based on the reductionist approach to science curricula, hence, students are learning science in a fragmentary way. Science students see it as a collection of disconnected facts and ideas. They are often unable to see where all the information about a particular area of science fits into science as a whole. They lack the integrated understanding of science content (Gulyaev et al., 2002). Therefore, reductionist approach to teaching is considered responsible for leaving the learners with shallow learning.
The learning theories, especially cognitive theories, provide evidence that for meaningful learning, knowledge is constructed by linking and knitting together different pieces of information (Ausubel, 1978b; Novak, 1984). Apart from this, there are also evidences available supporting the view that mind is a pattern making system and non-linear connections are hard to build (De Bono, 1986).

Due to reductionist approach students generally compartmentalize knowledge which results in incoherent knowledge and leads to shallow learning (Kalie et al., 2003). It appears that systems approach to teaching science can enhance students understanding of science by helping them to construct coherent and meaningful knowledge by making the underlying connections, between different components, explicit rather than just imparting the knowledge as fragmentary (Assaraf & Orion, 2005; Kalie, et al., 2003; Ossimitiz, 2000b). For this purpose, it is desirable to develop a teaching learning unit in systems paradigm to enhance students’ ability to see the links, interconnections and existing patterns in scientific concepts for better understanding of them.

Figure 1.1 Problems of present science teaching
1.2 Concept of Systems Approach

The need for applying systems approach to science teaching has been discussed in section 1.1. In this section, an attempt has been made to throw light on the concept of systems and systems approach. In general systems theory, system is defined as “any arrangement or combination, of interacting parts or elements, in a whole” (Bertalanffy, 1968). Being universal in nature systems appear everywhere, all around us, from the microscopic particles to gigantic objects such as stars, planets, etc.; from our most simple daily activities to complicated situations. Thus, it can be said that whatever we do, wherever we go, we cannot escape systems. Our solar system is a system consisting of sub-systems such as stars, planets, and other objects in space while itself it is a part of a larger system i.e. the universe. The human skeletal system is a system that is comprised of sub-systems such as the foot and hand while itself is part of a larger system which is the human body (Gerstein, 2011).

Systems are characterized not only by their parts, but, by the relationships between these parts as well as their relationship to other systems in the environment. The complexity of a system can not be discussed without relating to its sub-systems and supra-systems. Similarly, considering the field of education as an educational system, its problems can not be dealt successfully, without acquiring a systemic perspective taking into account students, teachers, society, values, knowledge, resources, constraints, etc.

According to Donella Meadow (2008) author of the book, Thinking in Systems, the contribution of systems approach is the way in which it hones people’s abilities to understand parts, see inter-connections, and ultimately, to envision new possibilities for re-designing the world. When we think in terms of systems, we are not just analyzing by
breaking system into its parts and studying them, but, we also try to see interconnectedness, patterns, relationships, etc. before reaching any conclusion.

Kershaw and Mckean (1959) defining systems approach in the field of education write “Systems approach is one of the techniques which aims to find the most efficient and economically intelligent methods for solving the problems of education scientifically”. Therefore, systems approach to curriculum development attempts to maximize educational effectiveness by clarifying educational objectives with great precision and then by re-designing the entire educative process in order to ensure students’ achievement.

An instructional system which is, “an empirically developed set of learning experiences”, is designed to achieve with a given degree of reliability a given outcome for a given class of learners (Razik, 1972).

As a system, science education comprises of inputs in the form of teachers, students, content, pedagogy, learning-teaching strategies, infrastructure etc. which pass through the teaching-learning process to give the output in the form of improved knowledge of students and teachers.
In order to improve the system of science education there is a need to bring about improvements in its inputs and teaching-learning process. Out of all the other inputs content and pedagogy or learning-teaching strategies can be easily manipulated compared to the other variables, hence, enrichment of content and pedagogy by the application of systems approach can lead to the betterment of science education.

The systems approach to course and curriculum design attempts to use a process of logical development and ongoing monitoring and evaluation in order to allow continuous evaluation of the course or curriculum to take place.

The practice of applying systems theory to education is not new. Educational Technologists Finn (1956), Hoban (1956), Heinrich (1970), among others have convinced us that we need to take “systems approach” to education. The concept like ‘systems’ and ‘systems approach’ have been frequently discussed in context with education by Bern (1967), Corrigan and Kaufman (1966), Bason and Heinich (1966); Kaufman, Corrigan, Corrgan, Goodwin (1967), Manch (1962), Silvern (1963), Hayman (1974), Mithell (1975), Mitchell (1976), Banghart (1969), Lehman (1963), Shoemaker (1972) and Dedrick and Sturage (1975) (as cited in Sharma, 1978). On the basis of the discussed points (related to systems approach), the researcher felt the importance of systems approach and decided to apply it to science teaching.

1.3 Emergence of the Problem

Unfortunately, despite of the growing importance of science as a valuable part of the educational repertoire of students, the standard of teaching it has been steadily declining.
The present dismal condition of science education in our country is a matter of serious concern, since, this has severely limited the potential of our capable youth power.

It is widely accepted that science education in schools not only in India but across the world is facing a crisis. “Too few students choose to continue with science into higher education and career. Science teaching in schools is often criticized for being too prescribed, impersonal, lacking in opportunity for personal judgments and creativity” (Sixth Survey of Educational Research 1993-2000, NCERT).

Even the Ministry of Human Resource Development admitted in its background note (2006) the ‘poor quality’ of science teaching saying that “Science education at school level onwards suffers from lack of reasonable experimental facilities, absence of quality teachers with dedication, inadequacies in curricula and lack of flexible subject and course combinations.”

NCERT, in its National Curriculum Framework document of 2005, has acknowledged the “product” obsession of school science and has stressed the need for a “curriculum that is less laden with facts, weakening disciplinary boundaries and linking school knowledge with outside knowledge”. This clearly indicates towards the need for applying systems approach to science teaching.

According to R. C. Sharma (2006), “The review of the present curriculum shows that it suffers from the following defects:

(i) It is subject centered and defective
(ii) It is not in conformity with the aims and objectives of teaching of science
(iii) It is cut off from real life outside
(iv) The depth of subject is sacrificed at the expense of vastness of range of topics.”

According to Secondary Education Commission Report (1953), the present curriculum is:

(i) Narrow in conception
(ii) Bookish and theoretical
(iii) Leads to lop-sided development of child’s personality
(iv) Cut off from the life around.

For the improvement of curriculum Kothari Commission (1964-66) has suggested that “Schools should be given the freedom to devise and experiment with new curricula suited to their needs”.

Furthermore, science education being an important component of the education system, should contribute to the development of desirable attitudes, values, skills, abilities, along with the knowledge and understanding of various facts and principles. It should enable not just physical well being of people but also lead to psychic delight, cultural harmony and spiritual elevation of thought (Ramasamy, 2006). Swami Vivekanand expressed the need for an educational system ‘by which character is formed, strength of mind is increased, intellect is expanded ad by which one can stand on his own feet’. Unfortunately, our present education system does not give due importance to the development of affective domain, which is a dire need today.
In fact, as long back as in 1966, Indian Education Commission has also stated that “If science has to be pursued with full vigour and zest, and is to become a mighty force in Indian renascence, it must derive its ‘nourishment’ from our cultural and spiritual heritage”. It has also emphasized inculcation of spiritual values among the four national objectives set to be achieved. In NCERT National Curriculum Framework for Secondary Education 2000, one of the objectives was to provide “Broad based general education to all learners up to the end of the secondary stage to help them become life long learners and acquire basic skills and high standard of intelligence, emotional and spiritual quotients”.

In simpler words, today there is also a need for symphonic fusion of science and spirituality by enriching science curriculum. Teachers need to inter-link scientific discoveries with esoteric truths to bring meaningfulness in them and enhance the relevance of science, making it interesting for the students. Students need to be taught that education does not aim only at worldly success and comforts in life, but, beyond these, it has a higher transcending aim of getting to understand the ‘Whole’ comprising of life, creation, consciousness, microcosm and macrocosm.

In view of the above discussion a need was felt to overcome the current reductionist approach to science teaching and to integrate it with the overall aim of holistic education. Therefore, it was decided to explore the problem and suggest alternatives along the lines of modern thinking such as systems approach.
1.4 Justification

The need for conducting the present study was strongly felt due to the following reasons:

i. *Decline in the number of students opting for science:*

The number of students opting for science stream is declining every year. J. V. Narlikar in his article entitled ‘No Fizz and Spark – Decline in Science Education’ published in Times of India (6 May 1999, p. 10) has stated that the present trend of a sharp decline in numbers and standards of students opting for science at the undergraduate level will have its impact in about ten years from now, as is being felt to some extent already; science personnel of high calibre and experience to man our projects will be in short supply.

ii. *Need for reforming science curriculum*

One of the significant causes of the decline in the number of students opting for science is the poor curriculum over-burdened with incoherent factual information with hardly any scope for activity-based learning. "It is unfortunate that the majority of schools across the country teach science in a boring and mechanical style allowing little room for original thinking and innovation. … Science is all about doing and learning even through mistakes. It's vital that interest in science is kindled and nurtured through the school years," says Dr. Arvind Kumar, the Mumbai-based director of the Homi Bhabha Centre for Science Education (HBSCE) (as cited in Yasmeen, 2004).
iii. Need for Enhancement of Spiritual and Emotional Intelligence through science:

Kothari Commission (1964-66) and NCERT’s National Curriculum Framework for secondary education (2000), as well as other concerned organizations have emphasized the need for developing spiritual and emotional intelligence (along with general intelligence quotient) of the learners. Moreover, the aim of science learning-teaching is not just acquisition of factual knowledge, but, holistic development of students’ personality. According to Jane (2006), Professor in Monash University, “When teachers of science acknowledge a spiritual dimension, science learning can be enhanced because spiritual knowledge helps promote students’ initiative and self-reflexive thought; emphasizes the connectedness of all things; can integrate heart, mind and soul to give meaning and purpose; enables ethical and compassionate decision making.”

Even researchers (Bracket, 2006; Parker, 2006; Goyal, 2006, and others) have shown that intelligence quotient is not a guarantee for success in life. Today one needs a high IQ plus a high spiritual and emotional quotient to ensure holistic development. Therefore, in view of the urgent need for developing the neglected emotional and spiritual dimension of students’ personality, a reformation of school curriculum needs to be carried out.

iv. Limited number of studies in the present area of science education

The earlier reviews of researches by Ganguly and Vashista in 1991 and Vaidya in 1997 reported that only a few studies were conducted in the field of science education (as cited in NCERT, 2007). Ganguly and Vashista (1991) listed a total of
101 studies during the period of the first four surveys in educational research. The first four surveys covered a period of 14 years from 1974 to 1988. This would suggest around 7 studies per year. Table 1.1 depicts that during the period from 1993 to 2000 only 23 studies were conducted in the category of science teaching. Though, it amounts to 19 percent of all the studies in science education it still remains one of the focused research area in science education (NCERT, 2007).

Table 1.1 A possible categorization of the various studies in Science education conducted from 1993-2000.

<table>
<thead>
<tr>
<th>Areas of Science Education</th>
<th>No. of Studies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive studies of science</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>Science teaching</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Teaching material</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Students’ attitudes towards science</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Achievement of students in science subjects</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Gender issues in science teaching</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Creativity</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>


v. Evaluating the effectiveness of systems approach to science teaching

Some of the studies conducted by different people, with reference to the development of systems thinking and enhancing students’ understanding, in varied disciplines in different parts of the world, maintain that systems approach plays an important role in improving the understanding of students in their particular subjects (Kalie et al., 2003; Assaraf & Orion, 2005; Ossimitiz, 2000a; Verhoeff, 2003; Knipples, 2002). The result of these studies showed that efforts to develop
systems thinking as well as to use systems approach as a teaching tool result in improved understanding level of students. These results indicate that systems approach is a cognitive tool for learners and instructional tool for teachers.

As mentioned earlier that systems thinking has been used in many fields, but, there is dearth of such studies in science education, especially in Indian scenario. Although, some studies on the development on systems thinking and enhancing understanding in science education have been conducted (c.f. Tables 1.2 and 1.3), however, very little has been reported with reference to systems approach to science teaching for enhancing spiritual and emotional intelligence along with academic achievement at the secondary school level. Therefore, the need for conducting the present study was felt to utilize the asset of systems approach for improving science learning-teaching process.
<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Theme</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. O’Shea Peter</td>
<td>2007</td>
<td>Promoting a systems theory / approach to instruction.</td>
<td>The author argues that the use of systems engineering concepts in education would be likely to reduce failure rates and improve quality. This is particularly so in large-scale complex learning systems. The paper also discusses some implications of trying to use systems engineering methodology in modern educational systems.</td>
</tr>
<tr>
<td>2. Shunin Yu.</td>
<td>2006</td>
<td>System approach to language teaching</td>
<td>The system approach to language acquisition allows implementing all the elements of the educational process most effectively, enabling to manage human resources, time resources and to attain the maximum efficient results in the process of students’ intellectualization.</td>
</tr>
<tr>
<td>3. Satsangee N. et al.</td>
<td>2005</td>
<td>Effectiveness of using systems approach for classroom instruction.</td>
<td>There was significant improvement in the academic achievement of students taught through the instructions based on systems approach.</td>
</tr>
<tr>
<td>4. Chandi S.</td>
<td>2000</td>
<td>Systems thinking as a tool for teaching and learning Biological complexity.</td>
<td>Systems thinking has been regarded as a high order skill which can be learnt and improved as it involves content, ability to connect the information and experience. It has been commented that systems thinking is not encouraged in formal education at school level. Moreover, it has been stated that to some extent biology teaching is reductionist and the importance of systems thinking in order to enhance students’ understanding has been realised.</td>
</tr>
<tr>
<td>5. Hamadani zadeh J.</td>
<td>1980</td>
<td>The systems approach to teaching calculus.</td>
<td>The author argues that the use of systems engineering concepts in education would be likely to reduce failure rates and improve quality. This is particularly so in large-scale complex learning systems. The paper also discusses some implications of trying to use systems engineering methodology in modern educational systems.</td>
</tr>
<tr>
<td>6. Stewart et al.</td>
<td>1963</td>
<td>A system approach for education</td>
<td>A system approach in education can help in developing advanced techniques for solving problems of education by providing a conceptual framework for planning, orderly consideration of functions and resources, and a phased and ordered sequence leading to the accomplishment of specified and operationally defined achievements.</td>
</tr>
</tbody>
</table>
Table 1.3 An overview of research literature related to science teaching

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Theme</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Akarsu et al.</td>
<td>2007</td>
<td>Students’ conceptual understanding of quantum physics in college level classroom environments.</td>
<td>In order to increase students’ conceptualization of Quantum Physics concepts, the faculty members who participated in this study suggested that: (1) more time on solving more abstract conceptual questions should be spent, (2) recitation hours for solving more numerical problems need to be dictated, and (3) revision of curriculum is necessary.</td>
</tr>
<tr>
<td>2. Young, K.S.</td>
<td>2007</td>
<td>Genetics instruction with history of science: Nature of science learning.</td>
<td>The result indicated that a greater percentage of the experimental group than the control group improved their understanding of the nature of science.</td>
</tr>
<tr>
<td>3. Kohl et al.</td>
<td>2007</td>
<td>Towards an understanding of how students use representations in physics problem solving.</td>
<td>(i) Representation was found to be a major factor in student performance, (ii) courses that are rich in representations can have significant impacts on student skills, (iii) meta-representational skills in solving physics problems were found poorly developed in the introductory students.</td>
</tr>
<tr>
<td>4. Ruth et al.</td>
<td>2007</td>
<td>Impacts of reform-based science in middle school classrooms.</td>
<td>The level of inquiry-based instruction was not found to be a primary predictor of student learning gains, but was found to be associated with teachers who implemented the curriculum and associated pedagogical techniques.</td>
</tr>
<tr>
<td>5. Mukherjee et al.</td>
<td>2007</td>
<td>Science education in India.</td>
<td>It is acknowledged that the prevalent model of science education has failed, both from the wider perspective of education and its aims, and from the narrow one of producing scientists. It is imperative to move to a new model of school science education, in which science is not alien, but organically linked to children’s experiences. The processes of science have to be given due importance, and children have to be given opportunities to do things “hands-on.”</td>
</tr>
<tr>
<td>6. Yasmeen S. et al.</td>
<td>2004</td>
<td>Science education on a slippery path.</td>
<td>Though the programmes initiated by organisations such as the HBSCE and the Indian National Science Academy to promote the scientific temper are valuable, they are not only under-promoted but also too few. The major thrust to frontier science education and research has to come from the nation’s 317 universities and 14,000 plus colleges. Quite obviously this national drive requires the participation and cooperation of the corporate sector and industry also.</td>
</tr>
<tr>
<td>7. Mukherjee A. et al.</td>
<td>2001</td>
<td>Science education in schools.</td>
<td>Students should go through the processes of science. They should observe the world around them, go on field trips, do laboratory experimentation, investigation, analyze, discuss, argue, make mistakes – in short do all that “scientists” do. Clearly the curriculum needs to be reformed to connect more with the real lives of people.</td>
</tr>
</tbody>
</table>
1.5 Statement of the Problem

In the light of the discussion in the previous sections, the problem of the study can be stated as – Application of systems approach to science teaching by using systems approach based resource material and learning-teaching strategies.

1.6 Definition of the Terms

The terms used in the statement of the problem have been defined in this section.

(i) Systems Approach

Ludwig von Bertalanffy (1968) describes systems approach as an “analytical, integrative problem solving strategy” in which “a certain objective is given; to find ways and means for its realization requires the systems specialist to consider alternative solutions and to choose those promising optimizations at a maximum efficiency and minimal cost in a tremendously complex network of interactions.”

Cyrs and Lowenthal (1970) define systems approach (when applied to education) as a “…rational problem solving method of analyzing the educational process taken as a whole, incorporating all of its parts and aspects, including the students and teachers, the curriculum content, the instructional material, the instructional strategy, the physical environment and the evaluation of instructional objectives”.

Operational Definition

In the present study systems approach is defined as a rational problem solving method of analyzing the process of science teaching taken as a whole, incorporating all its aspects: students and teachers, curriculum content, instructional material, instructional strategy, physical environment and evaluation of instructional objectives leading to the
goal of holistic learning for integrated development of all domains of students personality viz., cognitive, affective and psychomotor.

(ii) Resource Material

The term resource material as used in this study implies the study material or the enrichment material developed by the researcher using the steps of systems approach. For this the researcher analyzed the needs of science students and teachers, explored related books of science, searched relevant matter on internet and journals, consulted experts and then arranged the content both systematically and systemically to produce the resource material. In short the resource material thus developed consists of the following:

   a) List of objectives to be achieved.
   b) Content organized to encourage holistic and coherent understanding of scientific facts.
   c) Illustrations, pictures, charts, flow-charts, concept maps, graphic organizers, etc.
   d) Various types of questions for revision and self evaluation.

(iii) Learning-Teaching Strategy

The Oxford Dictionary (2000) defines strategy as ‘a plan that you use in order to achieve something’, therefore, learning-teaching strategies can be considered as chronological arrangement of methods and materials chosen to attain certain educational objectives. These can be considered as the ways in which the teachers and the students employ the available resources and fight against the constraints and turn them into advantages. These may include lesson plans, outlines and flowcharts of activities related to various dimensions of learning-teaching, mind mapping, role play, concept mapping, brain storming, etc. for improving the quality of learning-teaching substantially (Ministry of Education, Ontario, 2002).
(iv) Science Teaching

According to Good’s Dictionary of education (1959), science is “An organized body of principles supported by factual evidence, together with those methods applied in the search for and the organization of scientific facts and principles” (p 360).

As stated in Academic American Encyclopedia (1997), “In the 19th century the term science, which hitherto was applied to any body of systematic knowledge, came to denote an organized inquiry into the natural and physical universe (Academic American Encyclopedia, pp 142-143).

Robert Gagne (1965) has defined the term teaching as “Arranging conditions of learning that are external to the learner. These conditions need to be constructed in a stage by stage manner, each stage is the just acquired capabilities of the learner, the requirement for retention for these capabilities”.

*Operational Definition of Science Teaching:*

In the present study, science teaching implies imparting knowledge of scientific facts, principles, theories, etc. using appropriate learning-teaching strategies “…so as to develop in the child well defined abilities and values such as the spirit of enquiry, creativity, objectivity, the courage to question, and an aesthetic sensibility” (National Policy on Education -1986) leading to the goal of acquiring “high standard of intelligence quotient, emotional quotient and spiritual quotient” (National Curriculum Framework for Secondary Education- 2000, NCERT). Science teaching is taken to include both the content (resource material) as well as the learning-teaching strategies.
1.7 Objectives of the Study

The general and broad aim of this study was to use systems approach for developing resource material and learning-teaching strategies to facilitate coherent understanding of science leading to improved and holistic academic achievement. The specific objectives leading towards the broad aim are delineated in this section.

Primary Objectives:

1. To explore and analyze the available resources and needs of science students related to science learning - teaching.

2. To explore and analyze the academic difficulties faced by the science teachers in science learning - teaching and their suggestions for improving it.

3. To design and develop resource material and learning-teaching strategies based on systems approach for science learning-teaching with a focus on holistic and coherent learning.

Secondary Objective

1. To evaluate the effectiveness of the developed systems approach based resource material of science and learning-teaching strategies on the following:
   i. Spiritual Intelligence of secondary school science students.
   ii. Emotional Intelligence of secondary school science students.
   iii. Academic Achievement of secondary school science students.
1.8 Hypotheses of the Study

Keeping in mind the secondary objective of the study, the four hypotheses which were framed are outlined in this section.

H1: There is no statistically significant difference between the means of the scores obtained on Spiritual Intelligence Assessment Scale by the secondary school science students of the experimental group (taught using systems approach based resource material and learning-teaching strategies) and the control group (taught by conventional method).

H2: There is no statistically significant difference between the means of the scores obtained on Emotional Intelligence Scale by the secondary school science students of the experimental group (taught using systems approach based resource material and learning-teaching strategies) and the control group (taught by conventional method).

H3: There is no statistically significant difference between the means of the scores obtained on Physics Academic Achievement Test by the secondary school science students of the experimental group (taught using systems approach based resource material and learning-teaching strategies) and the control group (taught by conventional method).

H4: There is no statistically significant difference between the means of the scores obtained on Systems Thinking Skills Test by the secondary school science students of the experimental group (taught using systems approach based resource material and learning-teaching strategies) and the control group (taught by conventional method).
1.9 Variables of the Study

The variables related to the evaluative (experimental) phase (concerned with the secondary objective) of the study have been outlined in this section.

*Independent variable:* In the present study independent variable included systems approach based resource material (SARM) and learning-teaching strategies (SLTS).

*Dependent variables:* The variables on which the effectiveness of the systems approach based resource material and learning-teaching strategies were studied were:

i. Spiritual intelligence

ii. Emotional intelligence

iii. Academic achievement in physics

iv. Systems thinking skills

*Intervening variables:* The intervening variables which were controlled through the research design during the evaluative phase were academic achievement, age, sex, teaching environment, teacher, medium of instruction, school, teaching subject and the topics taught.

1.10 Delimitation of the Study

The explorative sub-phase of the developmental phase of the study was delimited to the subject of physics, science stream students (classes XI and XII) and teachers of secondary level schools affiliated to Uttar Pradesh board of secondary education.

During the cyclic research sub-phase of the developmental phase of the study the resource material and learning-teaching strategies were designed on the basis of selected
topics from prescribed physics syllabus and text book of the Uttar Pradesh board of secondary education for the science stream students of classes X and XII.

The evaluative (experimental) phase of the study was limited to a sample of ninety male students of class X of a Government aided boys school (affiliated to Uttar Pradesh board of secondary education) of Agra.

1.11 Methodology of the Study

The present study utilized a combination of developmental research and experimental approach. The research approach applied to accomplish the primary objectives of the present study can be characterized as the ‘Developmental Research’ which follows the method of ‘Descriptive research’ that is concerned with ‘what is, describing, recording, analyzing and interpreting conditions that exist’ (Best, 1977).

For fulfilling the secondary objective of the study to investigate the effectiveness of the developed systems approach based resource material and learning-teaching strategies (independent variable) on spiritual intelligence, emotional intelligence, academic achievement and systems thinking skills (dependent variables) of the secondary level science stream students ‘Experimental Method’ (pre-post test experimental design involving a control and an experimental group) which is “the description and analysis of what will be or what will occur under controlled conditions” (Best, 1977) was involved.

1.12 Procedural Design of the Study

This section describes the procedure of how the present study was carried out step by step.
1.12.1 Phase I: Developmental Phase

The developmental research process carried out in the present study for efficiently developing the systems approach based resource material and learning-teaching strategies for science teaching can be broadly classified into two major phases: Developmental and Evaluative. This phase comprised of two sub-phases: Explorative and Cyclic research. Various steps of this phase have been discussed in this section. The explorative sub-phase was concerned with theoretical and practical orientation for guiding the whole research. It was sub-divided into the following two major steps.

(a) Comprehensive review of related literature
(b) Needs analysis, which was based on survey method, was done to get an insight into the available resources for learning-teaching physics and needs of the secondary level science stream students and teachers.

The explorative sub-phase of the study led to the cyclic research sub-phase for the development of the systems approach based resource material and learning-teaching strategies for teaching the selected topics of secondary level physics (U.P. Board of secondary education). This sub-phase was also sub-divided into five steps which ultimately resulted in the development of the resource material and learning teaching strategies as shown in Figure 1.3.

![Diagram showing steps of the cyclic research sub-phase](image-url)
In the cyclic research sub-phase of the study, the first step was to develop a preliminary draft of systems approach based resource material (based on the findings of the explorative phase of the study) following the modified form of the Dick and Carey Systems Approach Model (1996) for designing instructions as shown in Fig. 1.4. The topics on which SARM was to be developed were selected on the grounds of needs analysis and demand of students and the concerned teacher of the institute where second field test was to be carried.

![Fig 1.4 Steps for developing resource material and learning-teaching strategies](image)

The preliminary draft of the systems approach based resource material of science and learning-teaching strategies were developed following the modified form of the Dick and Carey Systems Approach Model (1996) for designing instructions, incorporating the following steps:

1. **Needs Analysis:**

   Before developing the resource material on science and learning-teaching strategies, “it is necessary to determine the need for that instruction (resource material) in terms of what problem within the organization (Science teaching
system) will be solved through the use of new skills, or what opportunity can be seized because of new skills in the organization. This step is critically important to the success of the design process” (Kaufman, 1972; Rossett, 1999). In the present study, this step was devoted to exploring and analyzing the resources available and the difficulties faced by science students and teachers in science learning-teaching.

This step also enabled the investigator to discover the hard spots in physics and also the shortcomings of the present science curriculum which need to be worked upon. It also provided an overview of the resources available and the constraints faced by the target groups. For this, the views of various concerned groups viz., students and science teachers were taken through questionnaires and interviews. As discussed before, this step was conducted during the explorative sub-phase of the study.

The following steps were conducted under cyclic research sub-phase of the study.

2. Specification of objectives

Based on the needs analysis, the instructional objectives of the resource material (related to affective, psychomotor and cognitive domain of personality) on selected topics of physics and learning-teaching strategies for science stream students of class X and XII were formulated in specific terms.

3. Defining the mechanism for the evaluation of the achievement of goals

Techniques were planned for evaluating the progress of the students with respect to their academic excellence in physics and inculcation of desired values.
4. **Selection and organization of content (subject matter)**

On the basis of the objectives, sample content was selected. Thereafter, the content was organized and sequenced appropriately, keeping in view the aspects of systems approach. For this the prescribed text-books of science (physics) for class X and XII of various authors were analyzed.

5. **Selection / development of appropriate learning-teaching strategies**

Learning-teaching strategies were decided based on the nature and objectives of content, students’ interests and other practical considerations such as available resources, facilities, equipment, time etc. Due emphasis was given to student-centred methods such as inquiry based teaching learning, problem solving method, brain storming, discussion and debates etc. along with systems approach based learning-teaching strategies.

6. **Developing resource material and learning-teaching strategies**

The selected content and learning-teaching strategies were designed in the form of topic-wise integrated resource material for teaching and learning of physics.

7. **Validation through the experts’ opinion**

Experts’ opinions were taken for validating the prepared resource material and learning-teaching strategies. Modifications were made on the basis of their suggestions to develop the initial preliminary draft of the systems approach based resource material (PSARM) and learning-teaching strategies.

8. **Field testing of the developed preliminary draft of Systems Approach based Resource Material (PSARM) and learning-teaching strategies:**

The PSARM and learning-teaching strategies were field tested twice on a small sample of students of classes X and XII. Modifications were carried out based on
the feedback of the concerned group of students received during the two field
tests to evolve the final draft.

1.12.2 Phase II: Evaluative Phase

In this a pre-and-post test with control group type of research design was used employing
the following sub-phases.

1. **Pre-test (One week)**

   The school which was chosen for the evaluative phase had two sections of class X. Since, through the discussion with the class teachers and authorities it was found that the reason for having two sections was simply to randomly divide a large group (102 students) into smaller groups for facilitating convenient accommodation of students in class-rooms and ease the management of learning-teaching, therefore, the two sections A and B were assumed to be equivalent in terms of academic achievement, age, socio-economic status, etc. Furthermore, the analysis of total of the scores (out of a maximum of fifty marks) obtained by the students of the two sections in three previous unit tests of physics held in class, confirmed that the two sections were equivalent in terms of academic achievement. Hence, considering the two sections to be equivalent, section A was chosen to be the control group, whereas, B as the experimental group, through the lottery method. After this pre-tests for assessing spiritual and emotional intelligence, and systems thinking skills were conducted on both the groups.
2. **Experimental intervention (Eight weeks)**

   The experimental group was taught physics with the help of the resource material and learning-teaching strategies developed on the lines of systems approach, and the control group was taught physics through conventional method for a period of eight weeks by the investigator.

3. **Post-Test (One week)**

   Academic achievement in physics, spiritual and emotional intelligence, systems thinking skills of the experimental and control groups were re-tested after 20 days to evaluate the effectiveness of systems approach to learning-teaching of physics.

4. **Analysis and Interpretation of pre and post-test data**

   The pre-test and post-test data were compared and analyzed using relevant descriptive and statistical techniques to make interpretations and draw conclusions.

1.13 **Sample for the Study**

   For the present study purposive sampling (convenience sampling) technique was used for the major phases of the study. However, efforts were made to select a representative sample. Bloomers and Lindquist (1960) have defined purposive sampling (judgmental sampling) as the one “in which the sample elements are arbitrarily selected by the sampler because in his judgment the elements, thus, chosen will most effectively represent the population”.
1.13.1 Sample for the Phase I (Developmental Phase) of the Study

Following samples were required for the first phase of the study.

(A) Sample for resources and needs analysis

(i) Secondary school science stream students (400 in number)

(ii) Science teachers (20 in number)

The subjects for the above groups were drawn from government aided schools affiliated to U.P. board of secondary education.

(B) Sample for the development of the resource material and learning-teaching strategies: Total fifty six science stream students, of class X class XII were purposively selected for this purpose.

1.13.2 Sample for the Phase II (Evaluative phase) of the Study

In this evaluative phase, experimental as well as the control group, both consisted of a sample comprising of 45-45 male students of class X of a government aided boys school of Agra (affiliated to Uttar Pradesh board of secondary education) selected purposively. (Total sample consisted of 90 students).

1.14 Tools used in the Study

The following research tools were used for different phases of the research:

1.14.1 Tools for the Phase I (Developmental Phase) of the Study

(A) Tools for Explorative Sub-phase (Self-made)

- Needs Analysis in Physics Teaching: Difficulties and Resources-NAPT
- Interview Schedule for Science Teachers-ISST
(B) Tools for Cyclic Research Sub-phase (Self-made)

- Achievement tests on related topics
- Interview
- Observation
- Class assignments

1.14.2 Tools for the Phase II (Evaluative Phase) of the Study

- Spiritual Intelligence Assessment Scale-SIA (Self made)
- Emotional Intelligence Scale-EIS (Developed by Pethe and Hyde, 2002).
- Physics Academic Achievement Test-PAAT (Self-made)
- Systems Thinking Skills Test- STSA (Self-made)

1.15 Statistical Techniques

Various descriptive (percentage, skewness, kurtosis, mean, standard deviation, etc.) and inferential (critical ratio test for equivalent groups, ) statistical techniques were used for the analysis of data obtained through qualitative and quantitative measurement during the two major phases of the study.

1.16 Conclusion

The present chapter has thrown light on the importance of science education and its present scenario, which needs to be improved for the physical, intellectual, emotional and spiritual betterment of not just the learners and society, but, for the entire humanity. The concepts of systems and systems approach have also been discussed along with their desired incorporation in the field of education. With reference to above points, emergence
of the problem of the study and the justification for conducting it have also been pointed out.

To enable the readers to get an overview of the study, a brief report of the entire procedure adopted for the successful completion of the study, including the objectives, hypotheses, methodology, various phases, sub-phases and steps, samples selected, tools and statistical techniques employed, has also been discussed in this chapter. Furthermore, a synoptic view of the entire study has been presented in Table 1.4.

The next chapter, which is the review of related research literature highlights the studies which developed in the researcher the required insight and proper perspective related to systems, systems approach and allied terms, and spiritual and emotional intelligence.
<table>
<thead>
<tr>
<th>Phase &amp; Sub-Phase</th>
<th>Research Method / Procedure</th>
<th>Objective</th>
<th>Steps Performed for the Completion of the Study</th>
<th>Sample (Purposively Selected)</th>
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<th>Statistical Technique</th>
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<td>i. Selected Studies</td>
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<td>Obj 2</td>
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<td>i. Secondary school level</td>
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<td>science students: 400</td>
<td>Quantitative: Assignments, Achievement tests (Self made)</td>
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<td>2. Cyclic Research Sub-phase</td>
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<td>II. Evaluative Phase</td>
<td>Experimental Research Approach</td>
<td>Secondary</td>
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<td>1. Pretest Sub-phase (One week)</td>
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<td>2. Treatment Sub-phase (Eight weeks)</td>
<td>Experimental</td>
<td>Teaching through conventional and systems approach based (with SARM &amp; SLTS) learning teaching</td>
<td>SARM &amp; SLTS</td>
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<td>3. Post Test (One week)</td>
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<td>Conducted after a gap of 20 days after treatment</td>
<td>i. SIA (Self made)</td>
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<td>4. Analysis</td>
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<td>i. EIS (Hyde et al., 2002)</td>
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<td>i. PAAT (Self made)</td>
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<td>i. STSA (Self made)</td>
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**Abbreviations used**  
(P/F) SARM: (Preliminary / Final) Systems Approach Based Resource Material; SLTS: Systems Approach Based Learning-Teaching Strategies; NAPT: Needs Analysis in Physics Teaching; ISST: Interview schedule for Science Teachers; SIA: Spiritual Intelligence Assessment; EIS: Emotional Intelligence Scale; PAAT: Physics Academic Achievement Test; STSA: Systems Thinking Skills Assessment