CHAPTER 1

Introduction

1.1 Science Education : The Present Scenario

Education is never in rest since the content of what is taught is changing continuously. This is particularly true in the field of science education where developments are proceeding at an ever-increasing pace. The events of the past four decades provide examples of planned innovation in science education on a scale rarely witnessed previously. The reasons for this are quite obvious and in developed countries there has been a growing concern for scientific man power to meet increased industrial and military demands. Gradually the developing countries, realising the fact that the overall national development would depend primarily on the advancement of science and technology and utilisation of natural and human resources, have laid considerable emphasis on strengthening the science education and restructuring their system of education. Against this background, science education becomes increasingly acknowledged as essential contributors to industrialisation, modernisation, self-reliance and quality of life, that would combinedly lead to national development.

Vaidya (1997) has conceptualised science education as an integrated concept linking science with education using psychology. The field of science education is coterminous with life and one has then to proceed confidently on a continuum of scientific knowledge, scientific literacy, social action, productivity/prosperity for the society and quality of life (p. 354).

In India, various national commissions on education have laid considerable emphasis on strengthening the science education. The Education Commission (1964-66) recommended science education for all students of both
sexes upto the first ten years of schooling. Accordingly, science was made a compulsory subject upto first ten years of school and the previous discipline based curricula were replaced by environmental studies at the lower primary stage (Class I to V) and integrated approach of teaching science at the higher primary stage (Class VI - VIII) and secondary stage (Class IX - X). Most of these developments of science education are an outcome of the significant efforts made by National Council of Educational Research and Training (NCERT), SCERTs and State Institutes of Education (SIE). The global programmes of science education such as Physical Science Study Committee (PSSC), Chemical Educational Material Study (CHEM), Chemical Bond Approach Project (CBA), Biological Sciences Curriculum Study (BSCS), Harvard Physics Project, Science Curriculum Improvement Study Project and Novak's Concept Mapping for Meaningful Science Learning in America and Nuffield Science Teaching Project in UK, had some impact on the curricular developments and teaching strategies in science education in India. The National Policy of Education (1986) has laid great emphasis on science education in the school education system and made the following observations:

"Science Education will be strengthened so as to develop in the child well defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to question and an aesthetic sensibility. Science education programmes will be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. (p.23)"

Accordingly, learner-centred, activity-oriented and competence-based inquiry approach has been emphasised in science education that aims at providing scientific literacy and fulfilling the dimensions of scientific literacy such as:
• Understanding the nature of science
• Ability to use processes of science.
• Ability to properly apply appropriate science concepts
• Ability to understand values that underlie science
• Ability to understand and appreciate the joint enterprise of science, technology and society
• Ability to develop rich and more satisfied view of the universe to continue science education throughout life
• Development of certain manipulative skills which are required in day-to-day life situations.

The objectives of teaching science at secondary stage have been mentioned in NCERT document as fellows:

• consolidate and strengthen the knowledge, competencies and skills acquired at upper primary level.
• acquire understanding of scientific concepts, principles and laws.
• develop instrumental, communicational and problem-solving skills.
• develop a scientific temper, scientific approach and scientific attitude such as open-mindedness, intellectual honesty, courage to question and respect for human dignity and decision making.
• cultivate social, ethical, moral and aesthetic values which exalt and refine the life of the individual and society.
• appreciate the contribution of scientists and develop sensitivity to possible uses of science and concern for clear environment and preservation of the ecosystem.
• create an awareness of the need to guard the possible misuse of science. (NCERT, 1988, pp.194-195)
In India, National Council of Educational Research and Training has been entrusted the task of preparing science curricula. The SCERTs adopt the NCERT curricula and also develop their own curricula.

The new approach in science education at the secondary level is to teach science as general science. So far as the co-curricular programmes are concerned, the consolidation of classroom science education is done mainly through the activities organized by science clubs in various schools. In most of the states, the schools are encouraged to participate in district or state-level science fairs. The NCERT organizes national, state and a few district-level science fairs at various centres. These provide the forum for the bright and creative students to present their models, innovations and projects of various kinds.

The curricula, textbooks, instructional materials, teaching aids and science kits are produced at the NCERT and handed over to the various SCERTs for translating into state languages for their use in the school systems. A number of University Departments of Physics, Chemistry, Biology and some other institutions like Tata Institute of Fundamental Research, also produce similar materials.

The NCERT syllabus in science for the secondary stage contains ten units, viz.; (i) Matter- Nature and Behaviour (ii) Motion, Force and Energy (iii) Ways of living (iv) Human Beings (v) World of work (vi) Energy (vii) Food and Health (viii) Environment (ix) Natural Resources (x) The Universe. In respect of each unit, concepts, sub-concepts, learning experiences/situations and skills/competencies have been clearly delineated by the NCERT.

As regards the curriculum transaction, there are normally two teachers in every school who handle the science curriculum— One teacher for
'physical sciences' (Physics and Chemistry) and one for 'biological sciences' (Biology). In some of the schools, there are even three teachers—teaching portions related to biology, physics and chemistry separately. As such, in classroom transaction the teachers are following both the disciplinary and the integrated approaches.

1.2 Science Teacher Education

There are two major aspects on which the education of science teachers might be concentrated: (a) Pre-service, and (b) In-service. The science graduates are usually given pre-service teacher training through one year B.Ed. programme which specialises them in the methodology of teaching science at secondary level. An alternative pre-service science teacher education programme is the four year integrated B.Sc.Ed./B.Sc.B.Ed. course launched in the Regional Institutes of Education (RIEs) at Mysore, Bhubaneswar, Ajmer and Bhopal under the NCERT, where graduate level science content and methods of science are taught in an integrated manner. Thus, pre-service science teacher education is equal to either 3 year B.Sc. programme plus 1 year B.Ed. programme or 4 year integrated B.Sc.Ed./B.Sc.B.Ed. programme. After successful completion of either of the programmes, the trained graduates enter into the teaching profession. There are also untrained graduates in schools who join one year B.Ed.. While in service, they are also expected to keep themselves up-to-date on the developments in the content of science as well as the methods of teaching science. Various agencies undertake in-service education programmes for science teachers to help them in their professional development.

The following sections present briefly certain issues on science teacher education in respect of both pre-service and in-service components.
1.2.1 Pre-Service

Pre-service teacher education is considered as an initiation process. Some basic principles and considerations for developing teacher education curriculum designs are as follows:

1. Pre-service teacher education programme is meant for professional preparation of teachers. These provide a comprehensive coverage of professional knowledge, values and skills and have a strong functional orientation.

2. Pre-service teacher education is an open ended design, fostering initiative for further growth.

3. The programme is flexible to accommodate local and regional needs.

4. The programme design is having built-in provision for vertical and horizontal mobility of professionals from stage to stage.

5. The curriculum emphasizes integration of theoretical understanding with their practical applications.

6. The programme provides for comprehensive and continuous evaluation.

7. The programme fosters research outlook and the desire to experiment and innovate. (NCTE, 1989, p. 5)

For organizational convenience, the whole programme is divided into four major components:

(a) Foundation courses: The foundation courses have been designed as core courses that would fulfil two functions:
(i) To provide the trainee with necessary theoretical insights into and understanding of the meaning and aims of education and its role in national development.

(ii) To develop knowledge and understanding of the process of human development and learning.

(b) Stage Relevant Specialization: The stage relevant specialization component has got two parts. The first part highlights the special objectives, features historical background and the scope of education at secondary stage. The second part deals with subject specific learnings concerning different methods, techniques and strategies of teaching different school subjects. These have been hitherto organized as content-cum-methodology course.

(c) Additional Specialization: In addition, provision is made for additional specialization in areas like health education, physical education, etc.

(d) Practicum / Fieldwork: This component is of crucial importance in the entire design of teacher education curriculum as it is concerned with the fulfilment of the central objective of development of professional competencies with respect to the different functions of a teacher. Some of the important activities covered under this component are: Observation and critical analysis of lesson and unit planning; Preparation of instructional material, Using educational technology and media resources; Construction and administration of evaluation tools; etc.

A structured outline of pre-service teacher education programme design for secondary stage suggested by NCTE is presented in Table 1.
Table 1

Pre-service Teacher Education Design for Secondary Stage*

<table>
<thead>
<tr>
<th>Curriculum components</th>
<th>Weightage in terms of time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Foundation courses</strong></td>
<td>20%</td>
</tr>
<tr>
<td>(i) Education in Emerging India</td>
<td>10%</td>
</tr>
<tr>
<td>(ii) Educational Psychology</td>
<td>10%</td>
</tr>
<tr>
<td><strong>B. Stage Relevant Specialization</strong></td>
<td>30%</td>
</tr>
<tr>
<td>(iii) Secondary Education &amp; Teacher Functions</td>
<td>10%</td>
</tr>
<tr>
<td>(iv) Content-cum-Methodology of Teaching General Science</td>
<td>10%</td>
</tr>
<tr>
<td>(v) Content-cum-Methodology of Teaching Biological Science / Physical Science / Mathematics</td>
<td>10%</td>
</tr>
<tr>
<td><strong>C. Additional Specialization</strong></td>
<td>10%</td>
</tr>
<tr>
<td>(vi) An elective from areas like Adult Education, Secondary Education, Population Education, Distance Education, Educational Technology, Computer Education, etc.</td>
<td>10%</td>
</tr>
<tr>
<td><strong>D. Practicum / Field Work</strong></td>
<td>40%</td>
</tr>
<tr>
<td>(vii) Internship in teaching including field assignments</td>
<td>20%</td>
</tr>
<tr>
<td>(viii) Practical work: Working with community, social service, work experience</td>
<td>20%</td>
</tr>
</tbody>
</table>

In addition to the aforesaid one year teacher education programme, there exists an alternative four year integrated teacher education programme. The basic assumption underlying the integrated programme of teacher preparation is that it would break the isolation between content and pedagogy. The student would make a conscious decision to join the teaching profession at a young age and thus would get more time to develop and stabilize positive attitudes towards the profession. The curriculum includes Physical / Biological Science (1800 marks), Applied Science (200 marks) & Education (900 marks) for four academic sessions.

Objectives of the Teaching of Science Course

The objectives of the teaching of science course at the secondary level are to develop such competencies and skills in the student teacher so that he / she is able to:

1. Develop an understanding of the nature of science;
2. State instructional objectives in terms of specific behavioural outcomes;
3. Analyse contents in terms of concepts, sub-concepts and the relation between them;
4. Construct suitable tools of evaluation and understand continuous and comprehensive evaluation and employ it for feedback and remediation;
5. Establish the ecology of science classroom to generate a healthy learning environment;
6. Use appropriate educational technology and develop low-cost teaching material;
7. Undertake comparative study of science curricula developed by curriculum groups in India and abroad and to familiarize with global concerns in curriculum development;

8. Analyse and evaluate science syllabi and science textbooks;

9. Develop skills of organising out-of-school or extended curricular activities such as science clubs, science fairs, science exhibitions and field studies. (NCERT, 1991, p.58)

Curriculum Transaction and Teacher’s Role

Science is taught as a procedure of inquiry. So it is more than a body of facts, a collection of principles, and a set of machines for measurement. Among the techniques of instruction which play an important role in the type of effective curriculum transaction involving activity-based approach, the student teacher has to be apt at planning of activities, preparing the students for activities, conducting group discussion, and designing activities for evaluating learning outcomes.

The principal role of the teacher would essentially be teaching and guidance of the pupils through classroom instruction, tutorials, personal contact and other ways of building the character of the students. Besides, the teacher has to undertake upon himself / herself the role of a researcher to undertake small case studies of his / her students and to design appropriate strategies. The teacher has also the role to promote research, experimentation, extension and social service; and to participate in management of a variety of service and activities organised by the institutions.

Formulation of Science Method Course

In the 1990s, most of the teacher education institutions in India have adopted the course outline suggested by the NCERT (1991). The time allocation
for the one-year programme for secondary teacher preparation is 120 hours for teaching of science and the course contents in science teaching are: (1) Nature of science, (2) Objective-based science teaching at secondary level, (3) Learner-centred and activity-based approach to teaching of science, (4) Science curriculum, (5) Transactional strategies, (6) Laboratory management and safety, (7) Extra-curricular activities in science, (8) Evaluation and (9) Project work, practicals and practice teaching.

Pre-service Science Teacher Education Institutions

There are 13 institutions in Orissa which offer one-year B.Ed. Programme out of which three are IASEs, 6 CTEs and 4 training colleges with intake capacity of 1384 trainees. Out of 1384 trainees, 761 trainees specialise in science method course (415 in physical science and 346 in Biological / Life science). Besides, Regional Institute Education, Bhubaneswar imparts four-year integrated B.Sc.B.Ed. course with an intake capacity of 100.

1.2.2 In-Service

In-service education and training (INSET) is essential for updating the knowledge and improving the professional competence of science teachers. The concept of initial (pre-service) teacher training is integrally linked to a continuing programme of in-service education. Since the pre-service teacher education programme is an initiation process, it is not aimed at turning out a finished teacher. Teacher education is now recognised as a continuous process beginning with pre-service preparation and continuing throughout the teacher's career. In such a system, pre-service education should be integrated with in-service education, fostering the concept of life-long learning.

The twentieth century, particularly its last few decades, have seen unprecedented technical developments in the education of science teachers.
Introduction of the 'Science for All' approach would require the orientation of in-service science teachers in the objectives, content, methods, materials, skills, competencies and strategies for implementation. The need of refresher courses for in-service science teachers has been emphasised so as to enable them to impart scientific knowledge, methodology, competencies and experimental techniques far more effectively. School heads got orientation on science education, under PMOST (Programme of Mass Orientation of School Teachers). Regular content based in-service programmes were organised by Centres for Continuing Education. Under the centrally-sponsored scheme of teacher education institutions were elevated to the status of IASEs and CTEs. These have been conducting in-service programmes. In-service programmes are also being conducted by School Boards.

Need

The in-service education and training (INSET) programmes in science are organised for: 

• meeting the subject-matter deficiencies of science teachers;

• developing science teaching skills;

• introducing active-learning approaches;

• helping the science teachers gain qualifications;

• implementing a new curriculum which requires additional skills related to methodology, classroom management and assessment;

• the professional advancement of science teachers.
Objectives

The objectives of in-service science teacher education for secondary level may include:

• development of competencies of acquiring proficiency in stating instructional objectives and the related learning outcomes;
• development of new curriculum materials based on real life situations, its tryout and improvements;
• organising content sequences based on inter-disciplinary approach linked to real life situations;
• identification of science concepts and relevant issues in the real life situations from the local environment and development of lessons and learning activities round them;
• development of units and lessons in modular form using process-oriented science teaching approach;
• training in development and implementation of new instructional materials;
• development of skill of using local and community resources;
• enrichment in science contents and science education aspects;
• remedial treatment in the desired aspects;
• bringing desirable attitudinal changes in the light of the aims and philosophy of new science programmes;
• evaluating the current trends in science and rejecting or accepting the changes;
• meeting professional colleagues and working as a part of the team.
Approach

Two models for in-service science teacher education are found in Europe: (1) Compulsory in-service training, and (2) Voluntary in-service training. The first approach enables science teachers to become acquainted with new developments in the subject-matter, in general pedagogical matters and in educational issues that are specific for the subject. It has the advantage of ensuring that all science teachers have the most recent insights into the state-of-the-art of their school subject and the academic discipline to which it refers. The second approach is left entirely to the interest of the individual teacher. It has the advantage that those who participate are intrinsically motivated and will be more inclined to use in practice what they have learned in the courses.

Howey and Joyce (1978) have provided a different typology from American context:

(a) Job embedded: It can be embedded in the job, with emphasis on actual performance in the classroom.

(b) Job related: It can be closely related to the job, but not take place while teaching is going on.

(c) General professional: It can consist of experiences to improve general competence, but not be tailored to specific needs as closely as the above experiences.

(d) Career / Credential: It can be organised to help one obtain a new credential or prepare for a new role.

(e) Personal: It can facilitate personal development which may or may not be job related (p.206).
Broadly two approaches of in-service education and training are quite familiar: (1) Off-campus (external) INSET and (2) School-Based In-service Teacher Education and Training (SBINSET). The off-campus external INSET is conventional type, relying only on the guidance of external agencies, and entailing the absence of teachers from their schools. On the other hand, the SBINSET seeks to emphasise the deeper involvement of the participant, as also to bring in-service work to every school. It envisages a self-reliant, self-motivated, self-sufficient and self-inspired programme of faculty development. It is on-the-job training to develop teacher talent for self-satisfaction, as well as to meet institutional requirements. It originates from the felt needs and real problems faced by teachers in their day-to-day school life. Through gearing and revitalising the modus operandi of various school activities, the structure of SBINSET attempts to bridge the gap between theory and practice. To create professional growth of science teachers, no one system can achieve this objective. Rather a multi-channelled and multi-tracked system of in-service teacher growth is needed. SBINSET has the exclusive advantage of meeting immediate day-to-day needs for effective professional functioning. It is supplementary as well as complementary to the pre-service teacher education programme. It may be described as 'a programme of growth of teachers, by teachers, for teachers' (NCERT, 1988, p.225)

Activities

The in-service science teacher education activities are broadly categorised as direct and indirect activities. The direct category covers specific programmes focused on teachers' growth. The indirect category includes all programmes dealing with student development, as also those concerning specific needs of the institution and its philosophy. Various in-service science teacher education activities are as follows:
1. Development of inquiry skills and problem solving ability through teaching
2. Improvisation of teaching aids (group activities)
3. Value oriented teaching
4. Institutional planning
5. Community participation for qualitative improvement teaching
6. Learner-centred approach in teaching
7. Use of mass media
8. Use of educational technology
9. Creation of environmental awareness
10. Clarification and discussion of content difficulties
11. Laboratory activities
12. Laboratory practicals suggested in the science text books (group activities)
13. Extension lectures, seminars, workshops, and action research projects
14. Field visits / field study (group activities)

Support systems

There has been a mutual support system for strengthening in-service science teacher education programmes qualitatively. This support system has evolved through the networking of a large number of institutions at national, state and district levels.
At the national level, institutions like MHRD, NCTE, NCERT, CIET, UGC, Central Universities NIEPA are helping to:

- lay down appropriate policies
- evolve programmes of action
- conduct research
- develop a national curriculum framework
- develop training modules / training materials
- organise the training of teacher educators and key resource persons
- monitor and guide innovative projects
- establish norms for the teacher training Institutes and provide accreditation

At the state level, State Departments of Education, SCERTs, and State Universities, and State Boards of Education conduct research, revise the curriculum, develop training materials, train teachers and teacher educators, guide and monitor the in-service programmes.

At the district level, various colleges of education take care of the needs of their respective districts / catchment areas. All India Radio and Doordarshan also extend some support to the in-service programmes.

Professional support services to inservice science teacher education programme represent the form of team support with teams comprising content specialists, psychologists, science teacher educators, practical teachers, community agency personnel and educational technologists. At the state level, the following model (Figure 1) for the inservice training of science teachers is used.
Figure 1. Professional support services to in-service science teacher education.

Materials required to support for in-service science teacher education includes professional journals, curriculum and evaluative materials, applicable research monographs, equipments, inservice education package/modules etc.

Organisational support for in-service teacher education includes teacher resource centres, field study centres and experimental schools. In-service science teacher education is greatly facilitated by the availability of institutional mechanisms for attachments of teachers individually and in groups to resource centres, field study centres and curriculum development centres and by actively employing science teachers in research projects.

On networking of technical support structures for teacher education, the NCERT (2000) document has recently discussed as follows:
“Different institutions and modalities for teacher education can co-exit, but will be necessary for some institutions to take up the responsibility of planning and co-ordination. A national agency supported by the state level counterparts, may continuously identity the needs of in-service education, and recommend suitable modalities in designing teacher education programme.”

“The SCERT/SIE or any other institutions may be the nodal institution of a state. It may be assisted by the district level agencies. It should involve teacher training institutions, university departments, general colleges, high school teachers and supervising staff of the departments of education.”

“Strategies planned by agencies at the national, state or even district levels should meet the requirements of reorientation of teachers that arise out of changes in curricula. Such strategies cannot meet all the needs arising out of school situation, or a small group of individual teachers. These needs, however, cannot be underestimated. There should, therefore, be provision for less formalised, school-based inservice education of teachers as well.”

“Agencies associated with teacher education in the areas of their concern, would develop as national and regional curriculum development centres. In order that curriculum development work carried out at different institutions could be coordinated and utilised for mutual advantage at different levels, it would be imperative to establish some coordinating mechanism for dissemination of curriculum and teacher development strategies by the different centres. This exercise will ultimately produce a network of institutions to provide professional support not only to curriculum development but also to teacher development.” (pp. 104-105)

The point of discussion shows pertinence to the inservice science teacher education – the problem under study.
Programmes

In-service science teacher education is imparted through a wide variety of programmes such as orientation, refresher, workshops, seminars and conferences.

Orientation courses are meant for training of the newly recruited teachers as well as experienced teachers facing a new curricular programme. Such courses are organised for the teachers, administrators and key persons whenever a new policy, a new curricular change or a new text book is adopted and implemented. In U.K. and USA, such course is also recognised as an induction programme. Since the initial professional certification in the pre-service education is likely to remain inadequate in the new educational contexts, it needs to be supported by orientation courses. The Programme of Mass Orientation of School Teachers (PMOST) was a programme of in-service teacher education in this direction. One of the objectives of this programme was to increase teacher motivation and to get the teachers involved in the implementation of the National Policy on Education. The NCERT was designated as the agency for designing and implementing this programme at the national level, and it has been doing so through the SCERTs. The orientation of 500,000 school teachers was decided to be undertaken every year. The programme was run during 1986-90 and about 17.6 lakh teachers were trained. The statistics for the implementation of the PMOST in Orissa were as follows:

Secondary Teachers in Orissa Having Undergone the PMOST (1986-89)

<table>
<thead>
<tr>
<th>Total No. of teachers</th>
<th>1986</th>
<th>1987</th>
<th>1988</th>
<th>1989</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>38,452</td>
<td>7,256</td>
<td>453</td>
<td>4,550</td>
<td>800</td>
<td>13,059</td>
<td>34</td>
</tr>
</tbody>
</table>
It was reported that 192 subject-oriented in-service education programmes of one month duration had to be organised in the six CTEs and three IASEs of the state during each academic year.

A series of print material on the following aspects had been developed to facilitate the PMOST:

- In-service Teacher Education Package with 30 Modules
- Policy Issue/Thrust-Oriented Material
- Pedagogy-Oriented Material
- Attitude/Value-Oriented Material
- Subject-Oriented Material

A variety of programmes aimed at exposing teachers to new concepts such as micro-teaching, community participation, skill for use of local resources, low cost teaching aids, approaches to promoting child-centred and activity-based learning, information pertaining to ecology and environment, were provided. Telecast support was also included as an integral component of the In-service Teacher Education Package. The endeavour was to integrate the print and the telecast programmes so as to reinforce certain pertinent aspects of the in-service teacher education curriculum.

Refresher courses are meant for upgrading previously acquired knowledge and skill. Such courses may be organised either through face-to-face contact during vacations, week ends, evening hours, etc. or through distance mode. Refresher courses include a wide variety of activities such as lectures, discussions, observations, visits, film shows etc. NCERT in collaboration with Board of Secondary Education organise refresher courses through centres of continuing education located at training colleges and general colleges.
NCERT organised summer institutes in science subjects during sixties and early seventies for secondary school science teachers. This was a collaborative effort between the UGC, the NCERT and the United States Agency for International Development (USAID). These programmes were organised at the science departments of general colleges and also at RCEs for a period of 30 days. Programmes developed in the USA such as BSCS, PSSC, CHEM Study, CBA etc. were discussed in these summer institutes. The USAID organized mobile science show to popularize science as an inquiry all over the country.

Workshop, seminar and conference provide a platform where teachers can have their in-service training. NCERT, SCERT, BSE, IASE, CTEs and Regional Science Centre have been organising a large number of workshops or seminars for in-service science teachers in Orissa. Teachers' associations such as the All India Science Teachers Association, Delhi; Indian Science Congress, Calcutta, etc. have been organising seminars, workshops and conferences at periodic intervals on topics of scientific interest. Such organisations are also publishing journals and the reports of the science seminars/conferences for wider dissemination among the science teachers.

1.3 Education of Science Teacher Educator

The intentions for improving science teacher education certainly depends upon the improved quality of science teacher educators. In an Asian Regional Workshop of the Commonwealth Secretariat held at the NCERT, New Delhi (Aug. 28- Sept. 2, 1995), a few monographs were developed which could guide science teacher educators in their attempt to prepare science teachers for secondary science education. Science graduate programmes in the universities have long been organised in terms of separate subjects namely physics, chemistry, botany, zoology etc. Consequently the scope of general
science knowledge of most science teacher educators is limited, since they are familiar with one or two science subjects. However, science education usually involves inter-subject teaching. This requires teacher educators to have a broad base of science knowledge.

1.3.1 Needs, Responsibilities and Competencies

In order to improve the quality of science teacher education, the science teacher educators must meet the academic and professional needs. Their academic needs include updating on knowledge of subject matter and content, whereas their professional needs include an understanding of and confidence in the use of subject-specific pedagogical skills, together with an understanding of appropriate methods for science education research. The academic and professional needs interact with one another as well as with the wider context that includes gender issues, ethical and humanistic issues in science, cultural awareness and communication skills, as shown in Figure 2.

![Figure 2. The interactive nature of academic and professional needs of science teacher educators.](image-url)
The science teacher educators usually have the following responsibilities:

"Teaching: To organise, implement and critically evaluate the content of science curricula and appropriate teaching methods.

Practice teaching: To support science teacher trainees in teaching practice.

Research: To design, plan, conduct and publish research.

Evaluation: To carry out continuous review of existing programmes and the diagnostic and formative assessment of learners' academic attainment and progress.

Documentation: To keep accurate records of examination results, nominal roll, laboratory stock, workshop materials, etc.

Development: To contribute to curriculum development and other developmental programmes." (Commonwealth, 1996, p.4).

The science teacher educator needs to possess pedagogical knowledge, both of concepts and procedures, which could be passed on to science teacher trainees and in-service science teachers for improving their effectiveness in the classroom. They, therefore, need to develop competence in the areas such as pedagogical skills; supervisory, guidance and counselling technique; social and psychological considerations; curriculum development and research.

1.3.2 Strategies for Ongoing Professional Development

Science teacher educators need support to develop both academically and professionally throughout their teaching career. This can be
realised through in-service programmes organised by universities, colleges of education, subject associations and employing authorities (i.e. Department/ Directorate of Education); (ii) formal links, including visits and attachment, with industry; (iii) teaching at the school level and carrying out action research with science teachers; (iv) provision of resources by government, including improved salary conditions and career paths; (v) joining professional organisations; and corresponding with other professional science teacher educators.

Co-ordination within and between teacher education institutions will provide an avenue through which teacher educators can foster their own professional growth, promote some uniformity in the quality of experiences provided for science teacher trainees and develop cross-curricular links and inter-disciplinary approaches. These may be achieved through:

- Developing professional organisations for science teacher educators. These may relate to the two disciplines — education and science separately, or in any combinations as required by the specific circumstances of the country.

- Promoting regional co-ordination between such national professional organisations and associations of advancement of science.

- Mounting workshops, seminars or conferences for sharing ideas in teaching approaches and resource materials, and for engaging in discussion on current issues and trends in science education.

- Preparing position papers representing the consensus views of science teacher educators as a means of influencing policies and decision-making with respect to science teacher education.
• Making proposals for new directions in science teacher education in response to prevailing social, economic or cultural influences.

• Fostering collaborative approaches to teaching, such as team teaching and team planning.

• Developing theme and project approaches to science teacher education, as well as improving the delivery of the science teacher education curriculum. Such approaches will benefit science teacher trainees by providing them with models for cross curricular approaches in their own classrooms.

• Exchanging human and material resources within and between colleges. (Commonwealth Secretariat, 1996, p.71)

1.3.3 INSET Programmes for Science Teacher Educators

In-service Education and Training (INSET) is essential for updating the knowledge and improving the professional competence of science teacher educators. Since there are no regular INSET programmes specifically designed for science teacher educator in the country at present, Commonwealth Secretariat’s Asian Regional Workshop (1995) has suggested three types of INSET programmes, such as (i) Issue-based, (ii) Certification-based, and (iii) Institution based. The first type includes workshop and seminar, the second type includes sandwich courses (vacation courses), study courses, and distance learning; and the third type includes in-college activities and meetings, and conferences. Table 2 shows the organisers, lengths, activities and outcomes of these INSET programmes.
### Table 2

<table>
<thead>
<tr>
<th>Type</th>
<th>Organiser</th>
<th>Length</th>
<th>Activities</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Issue-based</strong></td>
<td></td>
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<tr>
<td>(i) Workshop</td>
<td>Professional association, educational agency, private organisation, Department/ Directorate of Education, college of education, polytechnic, university.</td>
<td>varies</td>
<td>Lectures, demonstrations, discussions, practicals</td>
<td>Improvement of professional and academic competence.</td>
</tr>
<tr>
<td>(ii) Seminar</td>
<td>As in workshop</td>
<td>1-3 days</td>
<td>Lectures, demonstrations, discussions</td>
<td></td>
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<tr>
<td><strong>2. Certification-based</strong></td>
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<tr>
<td>(i) Sandwich Courses (Vacation courses)</td>
<td>College of education, polytechnic, university</td>
<td>2-10 vacations of 10 wks each</td>
<td>Practical, lectures, demonstrations</td>
<td>Degree/diploma/Certificate</td>
</tr>
<tr>
<td>(ii) Study courses</td>
<td>College of education, polytechnic, university</td>
<td>1-2 academic years</td>
<td>Lectures, demonstrations, Practical</td>
<td></td>
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<tr>
<td>(iii) Distance learning</td>
<td>Open university</td>
<td>1-3 years</td>
<td>Self-instructional modules with follow-up contact for lectures, demonstrations, discussions.</td>
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<tr>
<td><strong>3. Institution-based</strong></td>
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<tr>
<td>(i) In-college activities and meetings</td>
<td>College of education</td>
<td>Usually not more than a day</td>
<td>Discussions Demonstrations</td>
<td>Exchange of ideas, update of professional &amp; academic knowledge.</td>
</tr>
<tr>
<td>(ii) Conferences</td>
<td>Professional association, educational agency, university.</td>
<td>1-5 days</td>
<td>Lectures, demonstrations, discussions, practicals</td>
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*Commonwealth, 1996, p.9.*
1.4 Rationale and Statement of the Problem

Science teacher education per se is universally in a state of terrible flux like all other aspects of teacher education just prior to the outset of the new millenium. The 1980s and 1990s have witnessed a process of continuous overhaul of the different aspects of the science teacher education— the pre-service and the in-service, due to the call of the Programme of Action (POA) of the National Policy on Education (NPE), 1986. Initiatives for qualitative improvement of science teacher education are linked with several factors, such as the quality of students choosing the teaching career, the relevance of the science teacher education curriculum to the avowed objectives of science teacher preparation, inputs into the professional preparation of science teacher educators, the infrastructure support to teacher education institutions and the maintenance of quality control in science teacher education. How is one to ensure the quality of student clientele for the teaching profession? In what way does a national curriculum contribute to it?

Experience has shown that designing a national curriculum and expecting it to cascade down to the institutions look sound theoretically, but its adoption and adaptation are beset with practical problems. This situation has been marked more prominently in the science teacher education programmes in Orissa.

One of the serious accusations is that teacher education institutions in Orissa do not themselves practise what they preach to science teacher trainees. A yawning gap is perceived between the training principles and practices that are made to be borrowed from the training institutions and what is feasible in the context of the school system in Orissa. How is one to minimise this gap? Can we think of developing indigenous methodologies that would suit to our local conditions?
It seems appropriate to look at the process of science teacher education from the prospective of the purpose of preparing science teachers from a continued and effective practice of science teaching. Science teacher is affected both by factors which derive from the particular context in which it takes place and by the theoretical tradition which influences the process overtly or covertly. In fact both aspects do not act separately, as context may be the reason for a theoretical tradition and conversely that tradition, through its influence on policy, may also be determinant of context. How is one, then, to appraise the programmes of the pre-service as well as the in-service education of secondary level science teachers in Orissa in terms of factors such as the policy, the agencies, the agents, the limiting and facilitating condition, the participants, the design of the course, the execution of the course, the effects on the agent, and the effects on the participants?

There has been a general criticism by parents of school going students and the general public of Orissa that the existing secondary science courses have put undue pressure in the mind of the student. A feeling has grown that current science education encourages disproportionate dependence of students on private coaching and emphasis on rote memory. What ails the science education at secondary level? What might be the reasons that eat into the very vitals of science education in Orissa? What goes wrong with the education of secondary level science teachers in Orissa? Does the fault lie with the pre-service component, the in-service component or the both?

In order to address the above-mentioned issues, the present investigator undertook the research project entitled:

'A STUDY OF EDUCATION OF SCIENCE TEACHERS OF THE SECONDARY SCHOOLS IN ORISSA'.
The Problem

The purpose of the study was to examine how the current pre-service and in-service education programmes in Orissa meet the needs of secondary science teachers by surveying opinions of prospective secondary science teachers, in-service science teachers and science teacher educators.

The Subproblems

The first subproblem was to examine how the current B.Ed. programme meets the needs of prospective secondary science teachers by surveying opinions of the B.Ed. trainees.

The second subproblem was to examine how the in-service science teacher education programmes meet the needs of the secondary science teachers by surveying opinions of participants and science teacher educators.

1.5 Review of Related Literature

Review of Indian studies in the area of teacher education has been attempted by Lulla and Singh (1974), Mehrotra (1979), Das and Jangira (1987), Singh and Malhotra (1991), and Joshi (1997). The most explored area in teacher education is pre-service education, having 248 studies, while 110 studies have been done in in-service education. There are 36 studies that have tried to probe both pre-service and in-service education (The Fourth Survey, 1991). Of the 129 research studies under review from 1988-92, it appears that only feeble attempts have been made to provide a research base for analysing the complex phenomena of teacher education— preservice and inservice. Evaluative surveys of teacher education as reported by Joshi (1997) in the Fifth Survey of Educational Research are those of Devi, Laxmi (1988) in Agra University; Somneuk, S. (1989) in Thailand; Nagpure, V.R. (1991) in Maharashtra; Reddy, C.P. (1991) in Andhra Pradesh; Patted, L.B. (1992) in Karnataka; and Walia, K.
31
(1992) in North India. Besides, Ganguli and Vashishtha (1991) have reviewed 50 studies relating to science teaching which can be broadly categorised into two types. One type, which can be termed as status studies, pertains to survey of the present state of teaching science subjects at different levels, while the other type is related to the effectiveness of different methods or strategies of teaching. In the present context, a selected number of studies conducted in India and abroad have been reviewed.

1.5.1 Researches in Pre-service Teacher Education

The study of pre-service component has been mostly undertaken through surveys, descriptive and qualitative analyses, programme evaluations, case studies and follow-up studies and only a few through experimental or meta-analytic methods. Out of the total number of researches reviewed in the following paragraphs, only 13 studies pertain to the field of science teacher education. Review of researches in pre-service teacher education has been presented under the following headings: (1) Status, (2) Effectiveness, (3) Training needs, (4) Models/Designs/Innovations and (5) Follow-up studies.

Status. Various studies on status of pre-service teacher education are as follows:

Newton and Watson (1968) sought to study the nature of science teacher education in 922 U.S. Colleges and Universities and reported about: (1) the diversity of programmes in science education in respect of methods courses, practice teaching arrangements, course requirements etc.; (2) the lack of basic, objective evidence on the effectiveness of teacher education programmes; (3) the isolation of science educators from their colleagues at other institutions which seemed to have serious implications for programmes for the preparation of science teachers. The chaos in the profession was
probably one consequence of the inability of science educators to confer about and agree upon the goals and structure of the teacher preparation programme in the sciences.

Meyer (1975) identified two general trends of science teacher education: (1) the end-on approach (pre-service training) and (2) the concurrent approach. It was reported that the concurrent approach was more advantageous as it provided the student with an early opportunity to develop a personal position and commitment on certain aspects of teaching and education, allowing for greater flexibility in course structure and for closer integration between academic and education areas. Marker (1975) conducted a survey of teacher education in the state of Maharashtra and found that: (i) the state level institutions set up for pre-service education were generally outdated and lacked sufficient accommodation; (ii) the B.Ed. syllabi were revised infrequently; (iii) students were dissatisfied with the teaching in B.Ed. and evaluation. Researches of similar nature have been conducted by Dubey (1981) for a comparative study of Madhya Pradesh and Maharashtra and by Sharma (1982) for Bihar. Tamir (1976) described the Science Teacher Education Project (STEP) in Britain, an example of model teacher education practices in the international arena. The British STEP was potentially the most effective approach available for the improvement of science teacher education. The key feature of this project was the formation of a community of tutors extending across many institutions who shared a common interest in improving their method courses by adapting them to the needs of prospective science teachers.

Mahmoud (1979) conducted a study on the teacher education programme in Bahrain and reported weaknesses in the programmes of teacher education and suggested measures such as: (i) Identification of teaching skills required of students; (ii) The development of a clinical experiences programme
which provide students with both simulated and real teaching situations; (iii) The provision of incentives in order to attract new students; (iv) The evaluation of graduates; (v) The continuation between pre-service and in-service education, etc. Pathak (1979) conducted a quantitative as well as qualitative analysis of teacher education in Eastern U.P. which revealed that the courses of study and co-curricular activities were traditional and superficial, the instructional programme being pursued in a slipshod manner; innovations were, by and large, unknown and unpractised. Singh (1980) reported that the main aspects helpful to the pre-service teachers in their teaching learning process were techniques of teaching, skills leading to effective teaching, skills of understanding the behaviour of students, developing confidence of teaching, better knowledge of motivational factors, knowledge of educational psychology and techniques of evaluation. Regarding the duration of the course, the pre-service programme was suggested for one academic year. The existing syllabus was acceptable to both the groups. So far as teaching methods were concerned, lecture followed by discussion was rated first, the multimedia approach was rated second and the lecture method was rated third.

Rai (1982) made a survey of the problems of teachers training colleges with regard to practising schools. The major findings of the investigation were: (i) The teacher-educators faced the problem of limited periods of practice teaching allowed by schools; (ii) The principals of training colleges felt that they were unsuccessful in realizing the objectives of student teaching because of lack of co-operation from the schools and inadequate time. Dash (1985) reported about the lack of uniformity in the B.Ed. curriculum of the three universities in Orissa, the predominance of the lecture method in teacher training programmes. Deo (1985) studied the role of practical work other than practice teaching in secondary teacher education programme of three teacher education institutes of Delhi. Most of the student teachers felt that lack of time, lack of
proper guidance, lack of sufficient opportunities, and lack of feedback from the teachers were the major factors in not being able to achieve the objectives of the practical programme, whereas the teacher educators opined that lack of sufficient opportunities and lack of time were the causes for own-fulfilment of the objectives of practical programme.

Arora (1986) conducted validation of the curriculum of teaching science in B.Ed. colleges of Haryana, Punjab and Chandigarh. The findings of the study were: (1) School teachers, teacher educators, and educational administrators fully agreed that the objective to understand the importance of teaching physics and chemistry—concerning knowledge and understanding was being fully realized. (2) According to teacher educators and educational administrators, the objective to understand the interrelation and interdependence of different branches of science and their relationship with other school subjects—concerning knowledge and understanding was being fully realized. (3) They were unanimous that the objectives to acquire knowledge about contribution made by eminent scientists and to acquire competence for understanding scientific literature—were not being realized. (4) According to the school teachers and educational administrators the objective concerning interrelation and interdependence of different branches of science and their relationship with other school subjects, was not fully realized while administrators agreed that it was being fully realized. (5) In case of the objectives concerning skills and abilities, the school teachers and educational administrators rated that these were being fully realized but teachers educators did not agree to this. (6) The school teachers and teacher educators rated the use of theory papers in science education as low. (7) The school teachers, teacher educators and educational administrators rated the use of the practical of the theory papers and practical work in skill of teaching as quite low. They thought it not at all useful for teaching in the class room. The study implied the need for change in
the practice teaching programme with longer duration, less workload of practice teaching for supervisors, and recruitment of teacher educators form among the senior secondary science teachers. Kargbo (1986) conducted a study of the training of secondary school teachers at Njala University College in Sierra Leone and on the basis of the views / perceptions of the graduating education students recommended the following for the purpose of programme improvement: more emphasis on developing specific teaching methods courses for all subject areas; extending teaching practice to two terms; training cooperating teachers; creating an audio-visual aids course, etc.

Brockway (1990) investigated the science background and teaching experience of staff, the various facets of the professional science education sequence, and the number of students prepared for secondary science teaching at the 25 private colleges and at the state universities in Iowa. The results of the study showed that few of the education staff who prepared science teachers at the private colleges had an undergraduate major in science, had any graduate work in science education, did not have teaching experience in the secondary schools. Just the opposite was true for the science education staff at the three state universities. Most science teacher preparation programmes at the private colleges did not offer a separate science methods course nor did they have with science education credentials involved with supervising student teachers or conducting seminars for the teaching majors. Again, opposite was true for the three state universities. Ducote (1990) reported that the strength of the teacher education programme remained in (1) faculty, especially those teachers in residence, (ii) clinical experiences occurring prior to student teaching (iii) good working relationship between university and local schools. Improvements were needed in (i) subject matter preparation courses, (ii) classroom management skill development, (iii) clinical work and (iv) classroom teaching
experience. Dongol (1990) developed the notion that the understanding of modern view of science, especially for developing ability to do classroom teaching according to the rationale for science teaching, was the first step for the foundation of modern science education and for the development of scientific understanding. A training programme was proposed that included teaching procedure, training course, and the classroom evaluation tool. The minimum requirements for science teaching were, knowledge and practical activities of text book contents, use of locally available resources and basic theoretical aspects of science education. The procedure of the training programme consisted of a general introduction, demonstration of teaching, discussions for group decision and actual training for practice teaching phases with a duration of one month totalling 150 hours.

Woods (1991) undertook qualitative examination of student teaching experience of three secondary science student teachers from Western Oregon State College in Monmouth. The data sources included (a) Audio-taped journals from the student teachers, (b) Transcribed audio tapes from seminars, (c) Video tape of teaching, (d) Rich descriptions from field notes made by the researchers, (e) A journal from one co-operating teacher and a journal kept by the researchers. The findings revealed: (i) complexity of student teaching experience, (ii) variation in the nature of critical point and the outcome of the experience, (iii) necessity of a support group or support individuals, (iv) stronger influence of the co-operating teachers than the college supervisors and (v) the unreliability of unpredication of student teaching:

Effectiveness. Various studies on effectiveness of pre-service teacher education are as follows:

Kanaga (1979) conducted evaluation of a teacher training programme. No significant differences were found in the extent of student
learning between classes aided by trained teaching assistants as opposed to those classes aided by untrained teaching assistants. However, while training programme was in progress, the teaching assistants who participated in it were perceived to be more closely associated with effective levels of classroom performance than teaching assistants who did not participate in the programme. Moreover, the trained teaching assistants continued to be more closely associated with effective leadership through the remainder of the term. The findings suggested that while the trained teaching assistants may have been perceived to be more effective in their classroom performances, their efforts did not result in more student learning. Mohan (1980) studied the effectiveness of the teacher training programmes in the colleges affiliated to Avadh University and pointed out the following weaknesses: (i) inadequate buildings or equipment, (ii) non-existence of girls' hostels, (iii) lack of adequate qualification among teacher educators to supervise teaching practice in certain subjects, (iv) nonavailability of extension services in the teacher training departments, (v) shortage of working days for the training course, (vi) discontentment in the system of examination for practical in teaching. Pande's (1980) observation of supervision practices almost corroborates that of Mohan (1980).

Dickerson (1981) examined the effects of a highly individualized personal growth programme for pre-service teachers and found that teacher training programmes could benefit students significantly by having every student in such programmes experience a personalized growth plan. Omar (1981) reported the effect of interactive practice-oriented instruction on the pre-service science teachers' stated preference for and actual classroom performance of the inquiry teaching behaviours—the level of questions, probing techniques, and use of inquiry encouraging behaviours. Ennis (1982) reported the effectiveness of the student-teaching practicum in achieving the student teachers' perceived educational goals, objectives and attitudes. Fakhruddin
(1982) analysed and evaluated the pre-service teacher education programmes at Dacca Teachers’ Training College in Dacca, Bangladesh and recommended changes in improvement of the secondary teacher education programmes. Gupta (1982) evaluated the effectiveness of the innovative methods in the direction of better learning and higher achievement in colleges of education. The results showed that the methods of discussion, symposium and supervised study were more effective than the lecture method.

Srivastava (1982) conducted a normative survey to find out the effectiveness of the teacher education programme of Avadh University and recommended changes in its curriculum, organisation of practice teaching, admission and evaluation procedures, establishment of independent colleges of education, teacher-educators’ orientation and research facilities. Wisedsook (1982) determined how the knowledge of inquiry teaching and the use of inquiry behaviours of science instructors were affected by such factors as educational background, number of seminars attended, teaching experience etc. Educational background was found to be only factor that affected the knowledge of inquiry teaching of science instructors. Science instructors who had a master’s degree understood the knowledge of inquiry teaching better than science instructors who had a bachelor’s degree.

Studying the relative effectiveness of three different training approaches, Syag (1984) recommended that (1) The micro-teaching approach should be made an integral part of the student teaching programme; (2) At least two continuous periods should be allotted for practising skills in a micro-teaching setting; (3) Teacher-training institutions may use either peer feedback and/or peer-cum-audio tape feedback during micro-teaching treatment; (4) Instructional materials on various teaching skills should be developed. Slinger (1985) documented concepts about teaching held by secondary science pre-
service teachers as they began a methods course in relation to five issues: (1) the nature of a teacher’s work, (2) the problem defined for course interpretation, (3) an idealized view of teaching based on dispositional type of knowledge about teaching, (4) a realistic view of teaching based on propositional and procedural types of knowledge, and (5) the determinants of a course curriculum. The implication showed that it was possible (1) to identify problematic conceptual patterns of pre-service teachers, and (2) to define a thought-based methodology for determining directional changes in a teacher’s development into a more effective teacher.

Daugherty (1986) evaluated the undergraduate teacher education programme of the University of Wyoming and recommended for modification and improvement of pedagogy courses and giving attention to selecting outstanding classroom teachers for conducting faculty searches.

Lopez-Tosado (1986) conducted a case study and evaluation of the pilot Bilingual teacher training programme in science education and found that trained teachers, compared to the non-trained: (1) were involved in higher ratio (83% to 56%) in the teaching of science; (2) spent more time (18 vs. 10 minutes/day) teaching science in their classrooms; and (3) used activity and inquiry-based science teaching materials in a higher ratio (23% vs 19%). Their attitudes changed positively, too. Krajcik (1987) evaluated the University of Iowa’s science teacher education programme, 1977-1984 in respect of course objectives, teaching strategies, equipment use, time allocation, and textbook use. This study provided evidence that a science teacher education programme with Iowa programme features, could have a very positive effect on the development of pre-service teachers into effective practising teachers.

Prothero-Smith (1990) evaluated the undergraduate teacher education programme at William Penn College based upon a survey of the
graduates' perceptions of the programme from 1983-1987. Graduates were found satisfied about the perceived achievement of programme objectives. Joubert (1991) reported on factors such as policy regulation in South Africa, effect of physical training environment, the merits of contact with actual school teaching practice, training for extra curricular school activities, training in curriculum research etc. as effective training milieu for student-teachers. Jones (1997) compared trained and untrained secondary school teacher in Barbados in respect of their classroom performance and found no significant difference between them. Such research finding contradicted what Evertson, Howley and Zlotnik (1985) had found in their study. Their study revealed a marked difference in educational quality through teacher education and, rather, found teacher training effective.

Training Needs. Various studies on pre-service teachers' training needs, opinions and perceptions are as follows:

Wijetunge (1980) surveyed the training and continuing education needs of Diploma-in-Education students at the Faculty of Education, University of Colombo, Sri Lanka, as perceived by two student groups and teacher educators at the Faculty of Education; and on the basis of these perceived needs, made suggestions for programme redesign such as: (1) skill training through professional laboratory experiences utilizing Teacher Education Centre as laboratory / resource centre and increased participatory analysis of teaching and focusing on skill areas; (2) setting up of a Teacher Education Centre to provide instructional support services.

Nealy (1981) conducted a survey of the opinions and perceptions of graduates and students towards the pre-service teacher education programme at Texas Southern University. Results of the survey indicated that the respondents felt prepared to: develop lesson plans, develop and utilize classroom materials effectively, relate effectively with parents, develop
motivating learning activities, and diagnose student interests. Respondents felt least prepared to: counsel students, diagnose student learning needs, utilize test scores appropriately for evaluating students, and handle discipline problems. Terhune (1981) explored the opinions of science graduate student and college science teachers to analyse programmes that train college level educators of science. The method of training college-level science teachers was perceived as being at least adequate. However, there was support for the idea that there were areas of training such as formal course work, individual professional development, and laboratory work that could benefit from some changes. Voltmer (1981) identified the teaching competencies needed for laboratory science teaching as viewed by science educators and pre-service science teachers. Fifty five of the 70 laboratory competencies were considered appropriate for inclusion in science teacher preparation programmes by both science educators and pre-service secondary science teachers.

Covington (1983) identified a set of competencies that would be of utmost importance to teacher training institutions. The seven competencies identified were: subject matter, classroom organization, and management, teacher's presentation, programme development, interpersonal relations, pupil performance, and personal professional growth.

Abuakar (1986) attempted a study to (1) identify the perceived instructional needs of Malaysian secondary science teachers, (2) identify these needs as perceived by Malaysian secondary science teacher educators, and (3) compare the perceptions of the two groups and recommended for the development of pre-service curricula that addressed the perceived needs of both samples, better communications and cooperation between the secondary science teachers and teacher educators, better communication and understanding between the two groups in terms of each other's needs.
Szpiczka (1990) examined how pre-service teachers understand their student teaching experience in order to gain an informed understanding of what it means to be a teacher and how they understand their role as student teacher. Understanding the student teaching experience as "self-display" underscores pre-service teachers’ intentions for behaving the way they do; rather it emphasizes the emotional aspects of becoming a teacher through the relationships they hope to develop with their pupils. Anand (1992) analysed the views of B.Ed. students of teacher training programmes conducted in Meerut region of U.P. and reported that (1) the existing lesson plans were rigid, (2) the courses of studies required systematic organisation, (3) both entrance tests and merit should count in selections, (4) the duration of the course was accepted as sufficient.

**Models / Designs / Innovations.** Various studies on pre-service training models / designs / innovations are as follows:

Zeitone (1979) designed a pre-service programme in biology for secondary school teachers in Jordan with a major emphasis on the selection and design of biological science curricula. Method courses in biology were suggested for the completion of the programme as a part of the professional education segment of the biology programme. One common and unifying theme in the programme was the emphasis on the scientific inquiry and laboratory activities.

Perrot and Padma (1981) reported a successful adaptation of a self-instructional teacher training course from a North American to a British context first, and then to India. However, in reporting this, the authors stressed that the concept of adaptation was crucial, because the teaching practical which were originally suggested could not be presumed to be culture free. Thus the transfer
design by which procedures are to be adapted, needs careful attention by the
teachers of the culture to which transfer is to be made. Stokan (1981) examined
the utilization of concept teaching strategies that have been presented to pre-
service teachers. The results of the study suggested that pre-service teachers
in secondary education could be taught to utilize generalized concept teaching
strategies. However, specific strategies such as concept attainment and concept
relationships had no direct effect in helping pre-service teachers teach concepts
in their secondary classrooms.

Sinha (1982) evaluated various innovative programmes in the field
of teacher education in Bihar and their impact on the quality of output. It was
reported that recent innovations in teacher education had not been incorporated
into the system. There was little attention paid to follow up programmes. The
evaluation process had remained traditional. Practice teaching in colleges of
education was being neglected by the method masters. Jitmoud (1983)
developed an effective plan for teacher education in Thailand. In the proposed
plan, the three major components in teacher education— general, specialized
and professional education— were programmed throughout all four years of
undergraduate work with opportunity for further study during the fifth year.
Through out the total five year programme, the time distribution of the three
major components was proportionately proposed as twenty eight percent, fifty
percent and twenty-two percent respectively.

Mian (1983) formulated the curricular content and methodology in
the areas of science and agriculture science for teacher’s training colleges of
Bangladesh. Practical-based activities ; methods such as conference method,
modified conference method, modified conference method, field experimentation
method, demonstration method, programmed learning method, project method
and laboratory method; and meaningful utilization of media such as film
projectors, CCTV, overhead projectors and film strips were recommended. On the basis of an analytical study of secondary teacher education curricula, Kakkad (1984) suggested a model of Secondary Teacher Education Programme (STEP) of two years duration with components such as (i) Pedagogical/Educational Theory (ii) School Experience Programme (SEP) with Block Practice Teaching Programme (BPTP) to be conducted in 1st year (from November to January) and Internship in Teaching (ITP) to be conducted in 2nd year (from July to October), (iii) Field Experience Programme (FEP) comprising of ‘working with the community’ and ‘living with the community’ for one week each year (iv) Sessional Work and Related Practical Work. Marking system was recommended for theoretical papers in the University Examination, while grading system was recommended for internal assessment of SEP, FEP, Sessional and Related Practical Work.

Maltese (1985) reported that through a co-operative effort, the current pre-service curriculum could be revised to include professionally structured, developmentally sequenced field experience practices especially designed for teaching in the multicultural, urban classroom. Rohe (1985) proposed a model which would help colleges or departments of education structure and focus the student teaching practicum. The proposed model was described as an interaction model; interaction between teacher and learner. The student teacher interacts as teacher with the students in the classroom and as learner with the co-operating teacher and university supervisor. The steps of the teaching process, i.e., assessing, planning, implementing, and evaluating, guide interactions toward accomplishing cognitive, affective, and psychomotor learning tasks. It was suggested that the implementation of the proposed model may be a way to improve the professional quality of the student teaching practicum experience.
Shukla (1985) studied the feasibility of transaction training in teacher-training programme and found that (1) the student-teachers trained through transaction training scored higher on 'teacher response positive', 'teacher question open', 'teacher direction', 'pupil response open', 'pupil response closed', 'pupil information', and 'pupil question' than at the pretest stage; (2) the trainees scored lower on 'teacher information', 'teacher does not direct', 'silence and disruption aspects' at the post-test stage than at the pretest stage, (3) the trainees trained through transaction training improved their verbal teaching behaviour in the classroom significantly compared to their previous behaviour at pre-treatment stage. Sweitzer (1985) reported that the training techniques involving questioning analysis, modelling strategy, and behaviour coding/strategy analysis produced large changes in teacher outcomes in pre service science-teacher education programmes. Mohanty (1987) reported about two innovations in the programmes of the training colleges in Orissa. These were micro teaching and team supervision of criticism lessons. The case study on micro teaching revealed the haphazard manner in which it was being carried out.

Tillema, de Jong and MathijsSEN (1990) reported the use of protocol materials for the conceptualisation of demonstrations as an alternative for science teacher trainees. The same alternative was also recommended by Cruickshank and Haefele (1987).

Cornfield (1991) reported that micro-teaching was considered to be an useful technique in USA. It was more useful for in-service programmes than for pre-service programmes. Mohanty (1991) reported about innovations in B.Ed. programmes of Chembur Comprehensive College of Education, Bombay. The innovations reported were — (a) restricting number of students per method master, (b) communication skills workshop, (c) involvement of ex-students in
training, (d) full period observation of lessons during practice teaching, (e) video recording of good lessons, etc. Pallante (1991) suggested that systematic and deliberate instruction in critical pedagogy could transform preservice teachers. Mohanty (1993) reported about innovations in St. Ann's College of Education, Mangalore. A few of these innovations were: (a) school adoption, (b) counselling seminars, (c) educational tour, (d) printed format for observation of lessons etc.

Passi (1997) reported about the initiation of an innovative teacher education programme called Zero Lecture Programme (ZLP) at the Department of Education, Devi Ahilya University, Indore under his leadership. The programme was later introduced as an innovation for a few students of the DIET, Daryaganj, Delhi. The programme aims at developing teaching skills through self study; self designed plans and programmes. It provides certain amount of freedom with respect to field of study and modes of learning. Mohanty (1998) reported about innovations in teacher education in colleges of education in Orissa. A few of these innovations were: (1) Morning prayer assembly, (2) Training in Individual skills of teaching, (3) Distribution of plans for demonstration lessons to the trainees prior to delivery of demonstration lessons, (4) Utilisation of non-lecturers in dealing certain curricular areas, (5) practice teaching lessons as per school's scheme of work.

Follow-up studies. Various follow-up studies on pre-service teacher education are as follows:

Akins (1980) developed an evaluation system which would provide the education development at Baker University, the data to enable to make informed decisions regarding the need for changes and improvements in the competency based teacher education programme. It was found that Baker University had achieved a rather good balance of emphasis on the forty-eight
teaching competencies across the five years the programme had been in existence. Sidhu (1983) conducted a follow-up study of secondary teachers trained through different approaches. Micro-teaching approach was found superior to conventional training approach in terms of development of general teaching competence in the teachers.

Mohanty (1990) reported a follow-up study on education of school teachers in Orissa. A majority of the respondents found their practical training useful. The delivery of only one demonstration lesson per subject was felt to be inadequate. They suggested that demonstration by school teachers could improve the situation. The respondents found their training in audio-visual aids unsatisfactory. They favoured provision of regular period(s) for audio-visual training. In case of science subjects, the respondents reported non-suitability of project, problem solving and observation methods. Wiseman (1990) conducted follow-up study of the alternate secondary education programme at Eastern Illinois University for the years 1981-82, 1984-85, 1986-87 and 1987-88. A clinically oriented competency based secondary teacher education programme was developed consisting of 27 required modules.

Al-Houli (1991) reported some drawbacks in the Islamic teacher preparation programme in the areas of: (i) admission policy, (ii) counselling for the students, (iii) specialisation facilities (iv) teaching of Arabic language, (v) method of teaching the student teachers, (vi) evaluation of student teachers, (vii) practical teaching skills, (viii) communication and management skill, (ix) personal interaction of faculty members.

1.5.2 Researches in In-service Teacher Education

Two sets of researches in in-service teacher education are quite prominent in the Indian context: The first, on critical examination of in-service programmes in terms of their impact, or effectiveness (Srivastava, 1966; Chilana,

**Status.** Various studies reflecting the status and problems of in-service teacher education are as follows:

Buch and Singh (1978) conducted an All India Educational Survey that revealed that 28.76 percent of secondary school teachers had participated in some kind of in-service training programme during the two years preceding
the survey. This national survey was also accompanied by surveys of in-service teacher education at the state level, viz. Lakdawala (1977) for Greater Bombay, Gupta (1978) for U.P., Muddu (1978) for Nalgonda District, Desai (1986) for Karnatak, and Butala (1987) for Gujarat. In all cases, lack of adequate facilities have emerged as disincentives in in-service education of teachers. Nonte (1979) studied in service-education practices in selected small school corporation in U.S.A. The study reported (i) necessity of in-service education, (ii) needs assessment of the participants preceding programme planning, (iii) involvement of teachers in planning of in-service programme, (iv) necessity of examining variety of contexts for in-service education of teachers such as job-embedded, job-related, credential-oriented, professional organization-centred and self-directed, (v) utilization of expert teachers as resource persons, (vi) incentive for teachers such as released time, salary increment or college credit.

Rosas (1981) conducted a study on the status and problems of in-service teacher education relating to the four interlocking dimensions such as (1) substance, (2) mode, (3) delivery, and (4) governance. The substance or focus of in-service programmes in relation to curriculum development thrusts reflected teachers' concern for current socio-economic issues in conjunction with the country's development goals. Teachers had experienced different in-service modes at least once a year. The mode most engaged in was personal development-oriented, and most appealing was job-related. The most preferred instructors for job-embedded, job-related, general competence-oriented and credential-related modes were school administrators. For personal development mode, the most preferred were college/university professors. Time options preferred for in-service training, in addition to official time, were summer, weekends, and holidays, with extra pay. There was strong commitment to the idea of governance of in-service education through collaboration of different constituencies having vested interests in teacher education.
Al-Ghamdi (1983) examined some issues and practices surrounding the professional development of in-service teachers in Saudi Arabia. Out of seven major categories of teaching skills and competencies—(1) developing pupil self-concept, (2) handling classroom problems, (3) planning instruction, (4) developing personal self, (5) individualized instruction, (6) managing classroom instruction, and (7) evaluating and assessing achievements—all respondents identified competencies related to pupil self-concepts as the greatest priority of needs, and skills associated with individualized instructions as the least. Harris (1983) surveyed the status of in-service education in public school districts in the state of Wisconsin as reported by teachers and persons responsible for district in-service programmes, and recommended for the inclusion of (a) in-service activities that focus on solving school and district identified problems (b) evaluation of in-service programmes, (c) activities that meet a variety of learning styles and (d) the use of needs assessment activities that allow time for the clarification of needs.

Desai (1986) investigated the aspects of science teaching covering the sufficiency of science teachers' qualifications, understanding of the course content, effect of teachers' workload, practical work competence, methods and aids of teaching, evaluation procedures, co-curricular activities, sufficiency of laboratory and library facilities, in-service training, effects of handbook, problems of syllabus implementation, etc. and suggested for improving science teaching through the practice of writing lesson plans, organisation of science clubs, laboratory experiments and attractive science text books. Suleiman (1986) identified the areas in which science supervisors need assistance in order to improve in-service education for secondary school science teachers in Jordan. Twenty needs were identified as of critical importance in the areas of professional growth, teaching techniques, supervisors' practices, student assessment, and
policies of educational administration. A proposed strategy for in-service education and a proposed in-service education programme for science supervisor were suggested. Butala (1987) reported that the main modes employed in the in-service programme conducted by secondary teacher training colleges of Gujarat state were lectures, seminars and workshops without use of any audio-visual aids. The teachers were in favour of in-service training programmes being organised on working days only, the second preference being summer vacations. The training colleges did not have adequate facilities for conducting the programmes. Teacher-participants considered an attendance certificate to be a proper incentive for participating in in-service programmes, which should be considered a necessary qualifications for the purpose of promotion. The in-service programmes were not evaluated systematically. The quality of in-service programmes was rated fairly high by the participants, which were felt useful in terms of their professional growth.

Marcin (1991) evaluated teacher induction programme in the state of Pennsylvania, U.S.A. The process was not beneficial in the development of teaching skills in subject area(s), instructional delivery, classroom time-on-task, use of the direct instruction model, building relationships with students’ families and developing an understanding of the cultural influences of the community. However the process was beneficial in the areas of teacher expectation, classroom management, orientation to policies and procedures and developing relationships with colleagues. Richwine (1991) reported that majority of college or university supervisors did not feel the necessity of orientation or preparing them to supervise student-teachers whereas co-operating teachers felt such a necessity.

Rugh, Malik and Farooq's (1991) investigation on effective teaching practices in Pakistan led them to conclude that teacher training needs to avoid
its excessive theoretical focus and concentrate more on specific methods of teaching which have proven to be effective in that country. Such methods were detected through the analysis of classroom observations of a sample of teachers considered effective on the basis of examination results of their students and ratings of supervisors.

Wolfe (1991) conducted a study on effective practices in in-service education under Head-Start Programme of U.S.A. and found effective in-service education programme based on assessed needs with support from agency staff, variety of engaging training techniques and follow-up activities that promoted problem solving and feedback.

Needs. Various studies reflecting the perceptions of in-service training needs are as follows:

Gordon (1979) surveyed the views and needs of rural public school educators on the topic of staff development and in-service education. The conclusions of this study were presented in the form of a design and a set of guidelines for the implementation of a teacher centre in a rural school district. The design included facilities that involved several formats working in concert with each other such as central location with a staff and resource materials, a travelling van that brought teacher centre staff and facilities to a particular school on a specific schedule, and utilizing the television translator system.

Pisetsky (1980) determined the extent to which teachers and principals differed in their perceptions of in-service education needs of teachers in an urban school system. Out of seven categories of training needs, there were significant differences in teachers' and principals' perceptions on four categories: planning instruction, communicating and interacting, developing personal skills, and developing pupil self. Principals perceived the in-service needs more intensely than did teachers and differed from teachers in the rank
order of categories. Roy (1980) studied the teachers' perceived needs in elementary science in-service training for subject matter competency and the correlates of these needs in order to predict appropriate science in-service training in local settings without formal needs assessment. In a local setting where teachers had similar backgrounds and teaching environments it was found possible to predict teacher needs and to design programmes to meet these needs.

Angello (1981) identified the interests of Washington teachers in in-service training courses and workshops related to classroom instruction in science and other subjects which focused on: instructional materials, methods, curricula, management strategies, assessment, and parent involvement in each of the areas. About three-fourths of the respondents indicated probable or definite interests in in-service courses or workshops focused on materials and methods for use in science and other subjects. Sutjipto (1981) identified the perceived in-service training needs of teachers in public junior secondary school in West Sumatra, Indonesia. Teachers, principals and administrators were found preferring (a) use of released time, and (b) the clustering of schools in a local area to conduct their own in-service training programmes.

Hashem (1982) conducted an analytical survey of in-service training needs of secondary level biology teachers in Kuwait and found that the population of the study lacked in academic background preparation, both in terms of quality and quantity of biology and teaching methods courses. A majority of the respondents reported that they had not received high quality in-service training since they had commenced their teaching careers. The most desirable in-service topics reported by the population were Curriculum Development and Methods and Techniques of Instruction. McClaron (1982) reported that the degree of teacher involvement in the planning processes of in-service education
at the school level had a direct relationship to the extent to which certificated school personnel perceived in-service education to be meaningful and effective. Teachers expressed a definite need to be involved in certain areas of the planning process at the school level.

Melnick (1982) studied teachers' perceptions of in-service education programmes in Tennessee Public School and recommended that (1) Programmes should be differentiated to meet the real and immediate needs and interests of the staff involved; (2) Organisational structure should ensure staff involvement; (3) There must be congruencies between what teachers perceive as actual and desirable in-service education practices. Spears (1982) studied perceptions of Indiana public school teachers regarding existing in-service programme practices, and effective practices for in-service programmes and recommended for: (1) Organisation of in-service programmes by school corporations, (2) Basing in-service programmes upon the needs of teachers, (3) Planning in-service programmes by both teachers and administrators, (4) Determining the duration of each session as per the needs of the programme, (5) Conducting an in-service programme during the normal school day with released time for those attending, (6) Appointing only qualified experts to conduct the in-service programme, (7) Grouping teachers by grade on subject interest or a combination of both, (8) Including workshop-type session for teacher improvement and participation, (9) Evaluating each session of the programme and, (10) Establishing a "follow-up" programme to determine if in-service objectives were implemented in the classroom.

Sudni (1983) analysed the perceptions of participants, administrators, and college faculty members about the In-Service Teacher Education (ISTE) programme at Phra Nakhon Si Ayutthya Teachers' College, Thailand. The strengths of the ISTE programme were its usefulness in helping
teachers to improve their job performance and providing the opportunity for instructors and teachers to share their ideas. The major weaknesses of the ISTE programme were that deficiency in programme planning and somewhat irrelevant to the needs of teachers and schools. Advanced degree, instructional improvement, and increasing of knowledge and subject matter content were the major reasons for enrolling as indicated by participants. Zurub (1983) made an assessment of need among secondary level Jordanian science teachers through the Science Teacher Inventory of Need (STIN). The study's implication extended to pre-service and in-service science teacher training in Jordan. Davis (1984) determined the perceptions of principals and teachers regarding teachers' in-service needs. Results of the study indicated that principals and teachers had differing perceptions about teachers' in-service needs, and suggested the need for teacher to be involved in selecting, planning, implementing, and evaluating professional renewal activities.

Matar (1986) studied the professional needs of science teachers in secondary schools in Bahrain. The results of the study indicated that the teachers perceived greatest need in the areas of scientific knowledge, laboratory skills, and science instructional materials. Less need was perceived in the areas of teaching strategies, planning, evaluation, and delivering and managing science education. The teachers attached greater importance to the areas of scientific knowledge, laboratory skills, and some aspects of delivering science instruction. Less importance was assigned to the areas of planning, instructional strategies, evaluation, managing science instruction and science teacher self-improvement. Adi (1987) studied the perceived in-service training needs of science teachers in public senior secondary schools in Bandung Municipality, Indonesia. This study found significant differences in perceived needs of nine competencies among teachers, administrators, and teacher-educators and eleven competencies among biology, physics, and chemistry teachers. While
teachers and teacher-educators perceived "mastery of subject area content" as most important, administrators perceived "use and management of the laboratory for teaching-learning process", as the most important for in-service programmes.

**Impact.** Various studies reflecting the impact of in-service teacher education practices in India and abroad are follows:

Bieber (1979) conducted a study of decision-making for in-service teacher education in Washington state and formulated criteria for successful conduct of in-service education, such as (1) Flexibility in design, (2) Teacher involvement, (3) Co-operative effort, (4) Co-ordination and planning, (5) Operation by objectives, (6) Relevance to the participant, (7) Time for conduct. Griffin (1979) evaluated a school-based in-service workshop and found that (i) locally based in-service experience was better than university-based training; (ii) attitude towards in-service training had strong correlation with attitude towards teaching and had no correlation with personality types of the teachers.

Mama (1980) conducted a study of the impact of in-service education on teachers in the state of Maharashtra, the main findings of which were: (i) Of the fifty-one teacher education colleges in the state, twenty-six ran extension centres; (ii) The colleges of education conducted a variety of programmes, most of which dealt with subject matter, planning of tests, evaluation and audio-visual aids; (iii) No effort was made to involve teachers in the planning, evaluation and follow-up of in-service programmes; (iv) Little importance was attached to in-service education; (v) The concept of in-service education was not clear to the teachers. SCERT, Andhra Pradesh (1980) conducted evaluation of in-service training of secondary school teachers in science teaching centres attached to the colleges of education. The findings of the study were: (1) The proportion of participants who understood the concepts, principles and facts was 50 percent
in physics, 64 percent in chemistry and 45 percent in biology teaching. (2) Participants indicated that many of the concepts were dealt with in an impressive manner in physics and biology. (3) The demonstrations were conducted in different units satisfactorily. (4) The explanatory aids were not used satisfactorily in the classroom in biology teaching. (5) Many of the participants felt that the laboratory techniques employed during the training programme were useful to improve professional competency. (6) The course was useful in teaching in the classroom and many simple techniques were given to make improvised apparatus for teaching science. (7) The duration of the course was felt to be quite short and time devoted to practicals was not satisfactory. (8) The syllabus prescribed for teaching in the schools was very heavy and some of the topics prescribed in the syllabus in biology were not relevant to the age group of the students. (9) Several activities and projects undertaken during the training programme made many participants enthusiastic to undertake such projects in their schools also.

Doyle (1982) conducted a study to ascertain the degree to which teacher in-service training would affect teachers' knowledge of the lecture, discussion and demonstration methods. It was found that significant increase in teachers' knowledge of the basic characteristics of the lecture, guided discussion, and demonstration could be possible more through a multimedia presentation of slides and cassettes rather than through printed material or cassettes alone at the time of in-service training.

Macdonald (1982) compared the teaching styles of a trial group of junior secondary science teachers trained to use and using new materials, and a control group of teachers using traditional materials. The new materials consisted of portable science kits, demonstration apparatus, teachers' guides, and pupil worksheets; and the in-service training consisted of a five-day
orientation course and three-day content course. It was found that lessons were characterized by teacher statements and directives, but trial teachers only spoke 71% of the time compared with 99% in the control group. Trial teachers asked a wider range of questions, but used fewer recall-type questions. Pupil activity in trial classes took the form of working in groups, using the kits and worksheets, but no pupil activity was recorded in control classes.

SCERT, Andhra Pradesh (1982) also conducted an evaluation study of in-service training of secondary school science teachers in improvisation techniques in science teaching courses of the colleges of education. The participants expressed that most of the teaching activities being practised during the in-service training programmes were not usually applicable in the classroom situation. Improvisation of the science apparatus was a good activity but it was not fully relevant to the environmental setup of the schools in which they worked. The improvisation of science apparatus was not possible as much of the time was used in covering the prescribed syllabus. The improvisation of science apparatus as taught in the course was mostly for the cheaper items, whereas for costlier items improvisation was rarely used.

Wade (1984) used meta-analysis to draw generalizations regarding the efficacy of various in-service practices. Specific findings of the study were: (1) The number of participants in an in-service training programme, the number of treatment hours, and the length of the treatment period did not significantly influence effect size results; (2) Outside originated programmes were generally more effective than in-school originated ones; (3) Enhanced status and college credit were the incentives most likely to increase effect size results, (4) Training programmes using observation, micro teaching, video/audio feedback, or practice showed greater effects than those programme not using these methods. Programmes which included discussion, lecture, games/simulations, and guided
fields trip were significantly less effective than those using other instructional methods. Coaching, modeling, mutual assistance, printed material, production of instructional material, and film as used were not associated with significant effects.

MacBride (1985) investigated the changes in knowledge, attitudes and behaviours of experienced classroom teachers which were related to their participation in an in-service education programme designed to provide training in effective teaching called Instructional Skills for Effective Teaching (ISET). It was found that the ISET programme had a significant positive effect on the knowledge level of the participants, but little or no overall effect on the attitudes measured. Thus, whereas attitudes changed very slowly, knowledge was acquired with comparative ease due to the impact of ISET.

Hashweh (1986) found that science teachers' subject matter knowledge and pedagogical knowledge influenced the transformation of a written curriculum into an enacted one during pre-active teaching through modifications in textbook subject matter content and organization and through the use of explanatory representations. These effects were also apparent during simulated interactive teaching through the teachers' evaluative structures and responses to critical incidents. Vance (1989) evaluated the effectiveness of a short-term math/science in-service based upon the participants' perceived changes in attitude and behaviour relevant to the prescribed goals and objectives. It was found that the in-service was totally effective in changing the teachers' attitude, relevant to the goals, but it failed to make a positive impact upon the teachers' perceptions of their actual practice in the classroom. Carroll (1990) determined the short-term and long-term changes in content knowledge of physics teachers who participated in a five-day in-service workshop and marked the following general trends: (1) There was a significant short-term increase in mean content
knowledge score, but there was no significant long-term increase. (2) Materials
development and teaching did not increase short term or long-term content
knowledge score significantly. (3) The level of academic preparation in physics
was a factor in initial performance, but there was no significant retention over a
3 month period for the participants. (4) Years of experience in teaching physics
was a factor in initial performance with the more experienced teachers generally
scoring higher than the less experienced teachers.

Strickland (1990) found how staff development training components
such as small group discussion, films and video tapes lectures by visiting
consultant, and attendance at state/regional meetings with required follow-up
could promote transfer of learning to the classroom level. Sundararajan and
Karuppathevan (1990) studied the effectiveness of in-service training
programmes organized by the SCERT, Tamil Nadu for the middle school science
teachers and found that women teachers, private school teachers, graduate
teachers and inexperienced teachers had better perceptions of the effectiveness
of such programmes than men teachers, government school teachers, non-
graduate teachers and experienced teachers respectively. Only a very small
percentage of the teachers were found to have a poor opinion of the
effectiveness of the in-service programmes.

Das (1991) studied the impact of programme of mass orientation for
school teachers (PMOST) in the districts of Birbhum and Bankura of West
Bengal. It was found that the PMOST was effective in orienting the teachers as
per the opinion of the course directors and resource persons. According to the
teacher participants, the programme was effective in orienting them to some
extent. So far as teachers' perceptions regarding learner-centred approach,
continuous comprehensive evaluation and use of educational technology in
classroom situations are concerned, 53%, 62% and 17% of the participants
were in favour of these modalities respectively.
Sawanakunanont (1991) studied the impact of in-service science workshop upon elementary science teaching strategies and found that no significant relationships between the teachers who had an in-service programme and who did not have.

Kaur and Kaur (1999) examined and compared the professional growth of the teachers of government, central and public schools. The results of the study indicated that central schools took more care of the professional growth of teachers as compared to government and public schools. Only 30 percent central school teachers used more teaching aids after increasing their additional qualification. No refresher courses were found to be offered to public school teachers.

Approach / Model. Various studies pertaining to innovative approaches to or models for in-service teacher education are as follows:

Clark (1980) found open education approach as an effective alternative of in-service education at the secondary level, which has practical and realistic value. Yogendra Kumar and Ratan Lal (1980) found the use of micro-teaching to be effective in improving general teaching competence of in-service teachers and in teaching skills of probing questions, reinforcement, stimulus variation, illustrating with examples, illustrations with aids, increasing pupils' participation after undergoing training through micro-teaching. Micro-teaching helped the teacher in self-assessment of his capabilities, gains, sense of self acceptance and self-achievement. Myers (1981) investigated from the point of view of both conceptualization and implementation a co-operative in-service teacher training venture. Through the development of a pilot study, the Mini Course in-service programme and a follow-up to this programme, it was possible to have in-service education meet the far reaching needs of a diverse educator population. O'Neal (1981) conducted a case study of the Professional
Development Centre for Multicultural Education (PDC-M) model for in-service teachers and found that PDC-M training resulted in teachers' application of new skills, attitudes and knowledge in their respective classrooms. Risma-Cordura (1981) developed modules for in-service education of science teachers such as (I) Planning: instruction, instructional material and media; (II) Instructional strategies for teaching science in the affective domain. The modules included a rationale, the competencies to be developed, the enabling objectives, a pre-test, enabling activities and a post-test. Modules I and II were evaluated by science supervisors, a science teacher doing in-service education and a university science educator. After their evaluations the appropriate revisions were incorporated.

Ahmadin-Baghbaderani (1982) developed a system and a model of faculty instructional improvement programme for the teachers of post secondary education. The model contained a pre-operational and five operational phases as follows: (1) information on institutional goals and characteristics, student needs and characteristics and educational experiences of values of the faculty; (2) identification of instructional goals and objectives of the programme; (3) identification and selection of relevant learning activities; (4) evaluative measures and (5) instructional principles such as participation-oriented decision-making, continuation training, participation, personalization, skills orientation, consistency of the training programme, collaboration orientation, practical orientation and motivation orientation. The model could be practically applied in three training periods of 15 hours each for 80 faculty participants. Each session consisted of four phases: (i) introduction, (ii) objectives, (iii) activities and (iv) evaluation. Kearns (1982) designed the operational model for science teachers incorporating a building-based approach and a grade level-team approach to in-service education and professional growth. A case study was used to evaluate the impact of the model on teacher practices in elementary
science. Implementation of the operational in-service model led to changes in teacher behaviour during the school year. Results of the case study indicated positive changes in teacher attitudes and motivations towards elementary science. Hartenbach (1982) developed a synthesized model for in-service programmes consisting of the five stages: diagnosis, design, development, diffusion and evaluation, which served as a guide to practitioners in the development and refinement of in-service programmes.

Tulloch (1982) conducted a factor analytic study of science teacher competencies and identified eleven factors: (i) Promoting scientific literacy, (ii) Showing enthusiasm and spontaneity when working with pupils, (iii) Demonstrating efficient and responsible classroom management, (iv) Professional maturity, (v) Expertise in physical science, (vi) Attending to the mechanics of the teacher centred instruction, (vii) Maintaining classroom control, (viii) Fulfilling school expectations, (ix) Seeking instructional assistance and support, (x) Showing sensitivity to pupils' feeling and values, (xi) Planning the instructional programme and their implications for in-service science teacher training and continuing professional development.

Bolak (1983) conducted a follow-up study of a group of teachers who had participated in the experimental graduate programme from September, 1977 through June, 1981. Teachers were exposed to three distinct in-service training models: the Individualized In-service Training Model, the Team Consultant In-service Training Model and the Required In-service Training Model. Teachers perceived the Team consultant In-service Training Model to be the most effective method of in-service training.

Nash (1985) developed a graphic model of a teacher centre that served middle and high school science teachers. The graphic model had as a central focus, whatever they might be, the teacher related concerns of science
teachers. Surrounding this central concern were the concerns of professional educators: education for scientific literacy, education of hard to teach, how to teach, selections of concepts, how to individualise instruction, teaching processes and the nature of science, increasing effectiveness of instruction, how to evaluate, and educating the gifted. On the outer area of the model were the concerns of local, national and world communities; survival of planet earth, interaction with space, use of nuclear energy, conservation of natural resources, environmental control, future energy sources, world agricultural needs, minority group concerns, control of pollution, and race for technological survival or supremacy.

Carter (1989) reported that peer coaching had a significant effect on the transfer of in-service education into the classroom teacher’s repertoire. The collaborative process of peer coaching may enable greater implementation of effective content and instructional strategies into the classroom. Shaeffer (1990) reported about ‘participatory teacher training’ approach that is ideally suited to in-service teacher training based on the analysis of previous experience of trainees, experience of teaching, and knowledge of the schools, the system and local context. Participatory teacher training is advocated from within the heuristic/interactive perspectives and characterized by the following features: (1) The teacher becomes an active agent rather than an object of change; (2) As a result of participation, training becomes self-directed and the teacher is self taught; (3) The teacher’s needs, problems, status, roles, etc., are defined, examined, and analysed by the teachers themselves, not by outside observers or experts; (4) Teacher reflection/introspection is based on the actual, concrete classroom experiences; (5) Teachers collectively examine and analyse their experiences, assisted by trainers and so co-operate in solving problems and learning from each other.
Jensen (1991) reported that in-service teachers recommended teaching instructional media competencies as a part of the method courses. Petersen (1991) reported that the major requirements for mentor teachers in state-mandated programmes were: self application, 2-5 years experience, relation of subject area to that of the inductees, use of research-related information in preparation of teacher induction programme and use of teacher-related programme. Lemberger (1992) conducted a study on mentoring practices in U.S.A. and reported necessity of bringing out structural changes in the system providing specific time and authority to interact with teachers.

Mata-Analysis. Two studies employing meta-analysis of the research in in-service teacher education are as follows:

Joslin (1981) used a meta-analysis technique to measure the overall effectiveness of in-service teacher education programmes. In-service programmes were found effective in changing teacher achievement, skills and attitudes. In-service programmes shown to be moderately effective included:

1. Programmes planned to achieve concrete objectives related to subject matter content;
2. Programmes planned around highly structured formats such as training programmes, minicourses, laboratory experiments, and institutes;
3. Programmes in which the participant engages in self-instruction;
4. In-service experiences planned to take place within the local district either during the working day or after hours;
5. Programmes planned around a treatment that has been field-tested or used extensively. Sweitzer (1985) conducted a meta-analysis on in-service science teacher education practices between 1965 and 1980. Overall, in-service science teacher education practices that existed were marked to be effective in producing their intended outcomes.

1.5.3 Implications of the Review

The present review indicates that in many countries the adequacy of pre-service teacher training has not been accepted fully. With same training
and same resources, teachers differ in their effectiveness. While some studies have found pre-service teaching effective (Everton, Howley & Zlotnik, 1985), others have revealed no significant difference between pedagogically trained and untrained teachers (Jones, 1997). Such studies point out necessity of more researches in pre-service teacher education to improve the prevailing condition.

Many researchers have confined their studies to assessing the functioning of single institutions with respect to the achievement of a small group of teacher trainees. It is, thus, urgently necessary that the gaps between functionality and set targets should be pointed out. This would help in planning pre-service teacher education programmes for the desired role of the teacher trainees in the new social order. Now that the National Policy on Education (1986) has laid special emphasis on education of teachers, it has become obligatory on the part of researchers to provide empirical evidence of how far existing pre-service teacher education is helpful in promoting such ideals.

Besides a few, there is no sufficient number of studies on the evaluation of pre-service science teacher education as a whole in terms of its effectiveness reflected in science teachers in the institutions where they secure teaching positions after the completion of their training. More particularly, there is no single study available in Orissa context.

So far as in-service science teacher education is concerned, the related studies have painted a dismal picture. Out of sixty studies, thirteen foreign studies and six Indian studies pertain to in-service science teacher education. Least coverage of in-service component of science teacher education might be due to the fact that in-service courses are adhoc in nature and researchers might have hesitated to undertake studies pertaining to such short lived and discontinuous courses. With introduction of the 'Science for All', orientation and refresher courses for in-service science teachers in the
objectives, content, methods, materials, skills, competencies and strategies for implementation have been emphasised during the recent past only. Programme evaluation and follow up studies on in-service science teacher education are rarely undertaken in the Orissa context.

None of the studies have reflected both pre-service and in-service components of science teacher education together. The present researcher feels that qualitative analyses of the programme of pre-service as well as in-service science teacher education particularly in Orissa have yet to emerge. Moreover, comprehensive programme evaluations of pre-service and in-service science teacher education need to be supplemented by surveys and case studies.

1.6 Statement of the Objectives

The objectives of the present study were as follows:

1. To study the provisions of the pre-service science teacher education—the B.Ed. programmes in colleges of education of Orissa in respect of

(i) Science method course and instruction,
(ii) Pre-practice teaching preparation,
(iii) Supervised practice-teaching,
(iv) Evaluation of practical teaching / skills.

2. To conduct a case study of the pre-service science teacher education programme.

3. To evaluate the pre-service science teacher education programmes conducted in colleges of education in Orissa in respect of
(i) Agencies/agents,
(ii) Limiting and facilitating conditions,
(iii) Participants,
(iv) Design of the course,
(v) Execution of the course.

4. To suggest a model of pre-service science teacher education programme for colleges of education in Orissa.

5. To study the in-service science teacher education programmes in respect of

   (i) The objectives,
   (ii) The needs,
   (iii) Activities and Modalities,
   (iv) Time/duration/venue,
   (v) Resource Persons,
   (vi) Incentives.

6. To conduct a case study of in-service science teacher education programme.

7. To evaluate the in-service science teacher education programmes in Orissa in respect of

   (i) Agencies/agents,
   (ii) Limiting and facilitating conditions,
   (iii) Participants,
   (iv) Design of the course,
   (v) Execution of the course.

8. To suggest a model of in-service science teacher education programme for secondary science teachers of Orissa.
1.7 The Delimitations

So far as the first subproblem is concerned, the study was delimited to the prospective secondary science teachers who enrolled in the B.Ed. programme conducted in various teachers' training colleges in the state of Orissa.

So far as the second subproblem is concerned, the study was delimited to the science teachers serving in various secondary schools of Orissa who participated in the in-service science teacher education programmes.

1.8 The Definition of Terms

Evaluation

Evaluation in the present study implied programme evaluation of science teacher education. Stufflebeam's definition for the term evaluation would be applicable in the research context. Stufflebeam et al. (1971) stated that "evaluation is the process of delineating, obtaining, and providing useful information for judging decision alternatives". (p.xxv)

Pre-Service Education

International Dictionary of Education defines pre-service training or education as “the education and training provided at a university or college of education to prepare a student for a career in teaching”. (Page, Thomas, & Marshall, 1977, p. 271)

In the present study, the above definition would be accepted. More specifically, the pre-service teacher education was considered an initiation process for teaching profession through the B.Ed. programme.
In-Service Education

    International Dictionary of Education defines in-service training or education as “training undertaken during the break in professional service or in conjunction with it as distinct from initial training”. (Page, Thomas, & Marshall, 1977, p. 175)

    Bolam's definition for the term inservice education and training (INSET) of teachers has been cited in the International Encyclopedia of Teaching and Teacher Education. It is defined as “those education and training activities engaged in by primary and secondary school teachers and principals, following their initial professional certification, and intended mainly or exclusively to improve their professional knowledge, skills, and attitudes in order that they can educate children more effectively”. (Bolam, 1980, p.3.)

    In the present context, the in-service education was used to mean the planned programme of learning opportunities afforded by secondary school science teachers for purposes of improving the quality of science education.