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Good science curriculum should have Cognitive validity, Content validity, Process validity, Historical validity, Environmental validity, Ethical validity. At elementary level when the child is exposed to the formal experience of education for first time, the teaching should be connected with the surrounding environment of the child. For this purpose objectives of the science teaching should be related with nurturing their curiosity, engaging them in activity, developing technological quantitative comprehension skills and working in groups. Goals of science education are focused towards enabling student to learn science in composite world in which it is expected that science learned student should use science as an instrument of social change by applying it in minimizing diversity related to economy, gender, caste and religion. For this purpose method of science teaching should be changed from written learning to development of thinking, communication skills, stimulating investigating and creative ability. This reform needs and teacher empowerment by reshuffling the procedure of science teaching in the schools.

Science is knowledge and knowledge has much power within itself for development of new construction, for change as well as for destruction, however we especially in this century need it only for development and new construction.

6.1 Research in Science Education

When the researches in this area are reviewed, it is clearly understood that major focus of research is towards methods of teaching of science, media used in teaching and learning, tools of teaching, science and scientific attitude. Hence till 2004 content included in science text books was closely related to information required by scientists for their investigation, however it must be remembered that the students entering in the new society after completing secondary education are not scientists, technologists but they should become good scientifically literate persons, therefore in N. C. F. 2005, emphasis of science education shifted towards development of scientific literacy.

6.1.2 Scientific Literacy

In science education, we operate in an era in which achieving scientific literacy for all students is one of the main goals (NRC, 1996). The cultural roots of scientific literacy go back in history to the introduction of modern science into Western civilization in the 1500s. Over the past fifty years, the concept of scientific literacy was introduced to the science education community by Hurd (1958) and McCurdy (1958). Unfortunately, scientific literacy is a catchphrase having a wide variety of meanings depending on authors’ viewpoints (AAAS, 1989; NSTA, 1991; Miller, 1996; NRC, 1996; Bybee, 1997; DeBoer, 2000; Laugksch, 2000;
Norris & Philips, 2003; OECD, 2007; Bybee, et al., 2009; Holbrook & Rannikmäe, 2009; Acar et. al, 2010) The term 'scientific literacy' has been used in the literature for more than four decades (Gallagher & Harsch, 1997). Scientific literacy consists of the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

The National Science Education Standards define it as –

“Scientific Literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena.”

Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (National Research Council, 1996).

This definition suggests that students should be able to draw upon appropriate evidence-based knowledge and use skills in everyday life situations.

6.1.3 Development of Scientific Literacy – Theoretical Perspective

In order to assess any aspect of scientific literacy, some theoretical issues need to be addressed: the first is the understanding that being scientifically literate is not a ‘yes or no’ situation. There are various levels and expressions of scientific literacy. For example, Shen (1975), Pella (1976), Scribner (1986) and Shamos, (1995) all suggested similar levels. The lowest level is often called practical or functional literacy and refers to the ability of a person to function normally in their daily life, as a consumer of scientific and technological products. It deals with basic human needs such as food, health, and shelter. Higher levels of literacy, such as civic literacy (or literacy as power), refer to the ability of a person to participate wisely in a social debate concerning scientific and technologically related issues. Cultural or ideal literacy includes an appreciation of the scientific endeavor, and the perception of science as a major intellectual activity. Shamos (1989) also suggested a ‘passive to active’ scale, which differentiates recall of knowledge and memorizing from communicating and using scientific ideas.

Bybee (1997) and the BSCS (1993) suggested a comprehensive theoretical scale that is more suitable for the development of scientific literacy during science studies at school, since its hierarchy can be easily transferred to instructional purposes. This scale was used as one of the theoretical frameworks for the current study. The scale suggests the
following levels of scientific literacy:

Nominal scientific literacy: Students recognize a concept as related to science, but the level of understanding clearly indicates misconceptions.

Functional Scientific Literacy: Students can describe a concept correctly, but have a limited understanding of it.

Conceptual Scientific Literacy: Students develop some understanding of the major conceptual schemes of a discipline and relate those schemes to their general understanding of science. Procedural abilities and understanding of the processes of scientific inquiry and technological design are also included in this level of literacy.

Multidimensional Scientific Literacy: This perspective of scientific literacy incorporates an understanding of science that extends beyond the concepts of scientific disciplines and procedures of scientific investigation. It includes philosophical, historical, and social dimensions of science and technology. Here students develop some understanding and appreciation of science and technology regarding its relationship to their daily lives. More specifically, they begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society.

It is also important to note, that Bybee (1997) is aware of the fact that achieving multidimensional scientific literacy in all scientific domains is probably impossible, or a lifetime task, and may not be attainable at all. One can attain a high level of literacy, referring to a very specific topic (even without becoming an expert in terms of career, for example: some people who build airplane models as a hobby may achieve a deep understanding of aviation Physics), but a lower level in other topics such as molecular genetics.

The taxonomy of scientific literacy levels does not suggest a teaching sequence, but rather a horizontal view as well as vertical development. Developing functional literacy, by enlarging students’ vocabulary, should be done in a way that will also increase students’ conceptual literacy by understanding the connections between concepts and the main ideas underlying the details. The challenge for developers of learning materials is to recognize and enhance all levels of literacy with respect to students’ personal development and interests.

6.1.4 Scientific Process Skills

In the early 1960s, there was a proliferation of new science programmes. This was a manifestation of a shift in emphasis of teaching from content to process skills. Scientists themselves questioned whether previous school science courses were truly representative of science (Hurd, 1969). This was the turning point from the content-led curriculum to a process-led curriculum for science teaching.
The science education movements in the world and their activities have had a significant impact on science teaching worldwide especially with curriculum development. Whether it is the current theme of "Science for all" or general science, integrated science, modular science, they all have their original roots in the West (Ogunniyi, 1993).

Several studies in the world have indicated that science teachers who are proficient in process skills use strategies that give children's opportunities to learn those skills (Tamir and Lunetta, 1979; Wellington, 1987; Harlen, 1985, 1990). Other studies have shown that knowledge of science processes is positively related to student's achievement (Roth and Raychoudhury, 1993).

If our society deserves scientifically literate as well as scientific process skilled students after completing a school education, the required pre-requisite is scientifically literate teachers and scientific process skilled teachers. This movement should be initiated from elementary education with this intention that study has been undertaken as follows:

6.2 Summary of the present study
Complete thesis is divided into six chapters and are summarized as below.

6.2.1 Chapter –I Introduction
This chapter affirms the statement of problems, objectives of study, need and significance, limitations and scope, the methodology in abstract.

The statement of the problem was as follows:

6.2.1.1 Statement of the Problem
Development of Teaching Strategies for Enhancing Scientific Literacy and Scientific Process Skills among Student Teachers.

6.2.1.2 Definitions of Technical Terms
2) Teaching Strategies
   Conceptual Definition
   Teaching strategy is a carefully prepared plan involving a sequence of steps designed to achieve a given goal.

   Operational Definition
   Teaching strategies prepared by the researcher, which are useful for enhancing scientific literacy and scientific process skills among student teachers.

2) Scientific Literacy
   Conceptual Definition
   For scientific literacy measurements following scientific literacy levels are taken into account:

   1. Nominal Scientific Literacy Level (NSLL)
2. Functional Scientific Literacy Level (FSLL)
3. Conceptual Scientific Literacy Level (CSLL)
4. Multidimensional Scientific Literacy Level (MSLL)

Bybee (1997)

**Operational Definition**

In present study the above conceptual definition will be used as operational definition.

3) **Scientific Process Skills**

**Conceptual Definition**

The science process skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientist’s. These skills are listed below.

1. Observation,
2. Inference
3. Measurement
4. Communicating,
5. Classification,
6. Predicting

(SAPA, 1980)

**Operational Definition**

In present study for acquisition of scientific literacy level above fundamental scientific process skills are taken into account:

4) **Student Teachers**

**Conceptual Definition**

A college student pursuing a degree in education who teaches in a classroom under the supervision of an experienced, certified teacher.

(The free Dictionary, 2013)

**Operational Definition**

For the present study students admitted in the D. Ed. colleges are considered as student teachers.

5) **Development**

**Conceptual Definition**

The act or the process of developing where develop means to evolve to a higher or more useful stage.

(New Webster's Dictionary, 2000)
Operational Definition

For the purpose of this study development means preparation of teaching strategies based on basic concepts in general science textbooks of 6th, 7th and 8th standards used in the Marathi medium school and trying out its effectiveness.

6.2.1.3 Objectives of the study

1. To finalize the components of scientific literacy with respect to levels of scientific literacy essential for acquisition of science at upper elementary level.
2. To finalize the components of scientific process skills essential for acquisition of science at upper elementary level.
3. To analyze science content at upper elementary level in the context of scientific process skills and scientific literacy.
4. To develop the teaching strategies for the pre-service student teachers at the elementary level to enhance their scientific literacy.
5. To develop the teaching strategies for the pre-service student teachers at the elementary level to enhance the performance level of process skills.
6. To implement the sets of teaching strategies on the pre-service student teachers through training.
7. To evaluate the effectiveness of teaching strategies employed to enhance scientific literacy level.
8. To evaluate the effectiveness of teaching strategies employed to enhance the performance level of process skills.
9. To examine relation between gender and effectiveness of the teaching strategies for the scientific literacy and scientific process skills.
10. To examine relation between faculty of student teachers and effectiveness of the teaching strategies for the scientific literacy and scientific process skills.

6.2.1.4 Assumptions

1. Scientific literacy is one of the objectives of the science education.
2. Scientific literacy and scientific process skills are essential for acquisition of information in science.
3. It is possible to develop the scientific literacy and scientific process skills among student teachers.
4. Scientific literacy and scientific process skills are necessary to acquire for teaching science at the upper elementary level.
5 Student teachers are familiar with basic scientific terms and basic processing skills.

6.2.1.5 Research Hypothesis of the Study

1. RH₁ – The developed teaching strategies are effective for enhancing the scientific literacy level in physics among student teachers.
2. RH₂ – The developed teaching strategies are effective for enhancing the scientific literacy level in chemistry among student teachers.
3. RH₃ – The developed teaching strategies are effective for enhancing the scientific literacy level in biology among student teachers.
4. RH₄ – The developed teaching strategies are effective for enhancing the multidimensional scientific literacy level in biology among student teachers.
5. RH₅ – The developed teaching strategies are effective for enhancing the scientific process skills in physics among student teachers.
6. RH₆ – The developed teaching strategies will be effective for enhancing the scientific process skills in chemistry among student teachers.
7. RH₇ – The developed teaching strategies are effective for enhancing the scientific process skills in biology among student teachers

6.2.1.6 Limitations, Delimitations and Scope of the Study

6.2.1.6.1 Delimitations of the Study

Delimitations of the Study

1. The study is limited to two D. T. Ed. colleges, which is from Kolhapur district.
2. The study is limited to those 2nd year D. T. Ed student teacher admitted in academic year 2012-1013.
3. The study is limited to Marathi medium D. T. Ed. Colleges.
4. The study is limited to Science content of upper elementary level for the academic year 2011-12.
5. Research is limited to the contents, which are based on science textbooks published by ‘BALBHARATHI’ at upper elementary level.
6. Research is limited to the student teachers of Marathi medium teacher education institution.
7. Research is limited to only upper primary level.
8. Research is limited to the Kolhapur district.
9. The development of teaching strategies includes designing, developing and evaluating stages. The evaluating stage includes large scale try-out of the system. However, the study is confined to experimental try-out on only two Colleges of education. The results of the evaluation of developed teaching strategies will be limited to these colleges only.

6.2.1.6.2 Limitations of the Study

1. The number of students from science faculty in control group and experimental group were 13 and 19 respectively. Due to centralized admission process in D. T. Ed. Which may be affected the sampling error, this was removed statistically by applying co-variance.

2. The admission of D. T. Ed. Course in Maharashtra is conducted according to merit list based on 12\textsuperscript{th} standard marks. The first slot of merit list in allotted to DIET and remaining students are allotted for other D. T. Ed. Colleges.

3. The number of girl students admitted in D. T. Ed. Course was more than boys.

4. Scores earned at 12\textsuperscript{th} standard by girls is more than boys from science faculty.

6.2.1.6.3 Scope of the Study

The results of this study may be generalized to all pre-service teacher education at elementary level.

6.2.1.7 Significance of the Study

No research of with objectives stated in this study have been undertaken in India as far as the knowledge of the researcher goes and there is need to conduct such research to enhance the scientific literacy level of pre-service student teachers.

The study will enhance the scientific literacy level of pre-service student teachers. The set of teaching strategies developed through this research can be used during pre-service teacher training courses with the help of D. Ed./B. Ed./M. Ed. colleges to enhance the scientific literacy level and scientific process skills. The set of teaching strategies developed through this research can be used during in-service teacher training programmes with the help of teacher education institutions.

6.2.2 Chapter –II Review of Related Literature and Researches

This chapter deals with review of books, research papers and articles published worldwide in the area of teaching strategies, scientific literacy, and scientific process skills. This chapter splits in two sections first is review of literature and other is review of research related papers. These sections further divide in to Indian and foreign contexts. There were eleven articles and books related with teaching strategy reviewed from abroad and six from India. Twenty books and articles were reviewed in the
area of scientific literacy published in abroad and five from India. Nine books and articles were reviewed in the area of scientific process skills from abroad and two from India.

There were six research papers reviewed in the area of teaching strategy form abroad and nine from India. Twenty research papers were reviewed in the area of scientific literacy from abroad and three from India. Twenty eight research papers were reviewed in the area of scientific process skills from abroad and five from India.

6.2.3 Chapter –III Plan and Procedure

This chapter explains plan and procedure with methodology of research design, selected sampling technique used, tools and techniques used for data collection and research procedure for implementing developed teaching strategies.

Researcher has selected pre test and post test non-equivalent group, sample has been selected by incidental and also by randomization. Tools and techniques developed and used as per the objectives.

6.2.3.1 Methodology of Research

6.2.3.1.1 Method

Experimental method was used in this study. In this experimental method pre test – post test non-equivalent group design.

6.2.3.1.2 Sampling

There were two colleges had been selected among thirty colleges from Kolhapur district and eighty student teachers were selected from them.

6.2.3.1.3 Tools of Data Collection

For the purpose of data collection following standard test and tests developed by researcher were used.

1. Scientific Ability Test for College Students.(Dr. Sinha, A, Dr. Sinha, L)
2. Researcher developed scientific literacy test
3. Researcher developed scientific process skill test

6.2.3.1.4 Statistical Techniques

For the present study, t-test was employed for data analysis.

6.2.3.1.5 Procedure of Research

Research procedure involves 2 major phases, which are shown follows:

Phase – I : Development Teaching Strategy

Analysis carried out of science textual content at upper elementary level with respect to scientific literacy and scientific process skills. Researcher enriched the science textual content by adding extra
information and hands on activities, developed pre and post tests to assess levels of scientific literacy and scientific process skills and developed teaching strategies for student teachers to enhance scientific literacy and scientific process skills.

**Phase– II: Implementation and Assessment Of Scientific Literacy and Scientific Process Skills**

Developed teaching strategies were implemented on student teachers and tested its effectiveness in the areas of scientific literacy and scientific process skills.

**6.2.4 Chapter – IV : Development of Teaching Strategies for Enhancing Scientific Literacy and Scientific Process Skills.**

This chapter elaborates concepts of teaching strategies specially used at school level. Chapter explains procedure of development, as specific teaching strategies for enhancing scientific literacy and scientific process skills.

**6.2.5 Chapter – V : Plan and Procedure**

This chapter includes thorough analysis of collected data. The data was analyzed using t-test and with graphical presentation. Detail list of findings of the study are tabulated and given in this chapter.

**6.2.6 Chapter – VI : Summary, Conclusion and Recommendations**

This chapter elaborates summary and conclusion of the research work.

**6.3  Conclusions (In relation with Objectives of the study)**

**Objective No. 1 - To finalize the components of scientific literacy with respect to levels of scientific literacy essential for acquisition of science at upper elementary level.**

The levels stated by Bybee (1997) found to be useful for the present research because research was carried out on student teachers who are going to teach elementary level.

Bybee (1997) put frothed an excellent of framework of levels in scientific literacy. These levels are applicable individually and depended on given situation, age, experience and capabilities.

These levels are 1) Nominal 2) Functional 3) Conceptual 4) Multidimensional. These levels are interrelated and progressive. These levels were developed referring to school’s science programs and teaching.

Researcher found same levels have been implemented by Murcia (2009), Holbrook and Rannikmae (2007), PISA(2007) and Dani, D. (2009).
Objective No. 2 - To finalize the components of scientific process skills essential for acquisition of science at upper elementary level.

Science process skills in science are very important to develop scientific knowledge and to make learners independent thinkers. Basic scientific process skills are important for elementary level and useful for enhancing scientific literacy.

The scientific process skills were finalized as 1) Basic 2) Integrated.

The basic scientific process skills are 1) Observation 2) Classification 3) Inference 4) Communication 5) Measuring 6) Using Numbers 7) Predicting.

Integrated scientific process skills are 1) defining operationally 2) Interpreting data 3) Controlling variables 4) Experimenting 5) Formulating models 6) Formulating hypothesis.

Above scientific process skills have put frothed by Padilla, Michael J. (1990). For this research only basic process skills are used.


Objective No. 3 - To analyze science content at upper elementary level in the context of scientific literacy and scientific process skills.

For present study following content was selected.

<table>
<thead>
<tr>
<th>Physics</th>
<th>Chemistry</th>
<th>Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Classification of matter</td>
<td>Living organisms-characteristics and classification, parts of plants</td>
</tr>
<tr>
<td>Force</td>
<td>Atomic structure</td>
<td>Organics system-Digestive system, Nervous system Circulation system</td>
</tr>
<tr>
<td>Motion and types of motion</td>
<td>Chemical reaction and types of chemical reaction</td>
<td>Food and food safety</td>
</tr>
<tr>
<td>Simple machine</td>
<td>Metals and nonmetals</td>
<td>Dieses</td>
</tr>
<tr>
<td></td>
<td>Acids and bases</td>
<td></td>
</tr>
</tbody>
</table>

Objective No. 4 – To develop the teaching strategies for the pre-service student teachers at the elementary level to enhance their scientific literacy.

The teaching strategies consisting of - 1) Questioning 2) Interactive Lectures 3) Group Discussion 4) Audio-Video presentation 5) Model presentations 6) Expert lecture 7) Discussion on contemporary issues with respect to content.


Objective No. 5 – To develop the teaching strategies for the pre-service student teachers at the elementary level to enhance the performance level of scientific process skills.

The teaching strategies for enhancing scientific process skills 1) Questioning 2) Hands on activity 3) Audio visual presentation 4) Improving learning climate.


Objectives No. 6 – To implement the sets of teaching strategies on the pre-service student teachers through training.

To implement set of teaching strategies researcher used quasi-experimental design i.e. pre test and post test non equivalent group design.


Objectives No. 7 – To evaluate the effectiveness of teaching strategies employed to enhance scientific literacy level.

1. The teaching strategies significantly enhanced nominal scientific literacy level in Physics, Chemistry and Biology among student teachers in experimental group than that of the control group.

2. The teaching strategies significantly enhanced functional scientific literacy level in Physics, Chemistry and Biology among student teachers in experimental group.

3. The teaching strategies significantly enhanced conceptual scientific literacy level in Physics, Chemistry and Biology among student teachers.
4. The teaching strategies significantly enhanced multidimensional scientific literacy level among student teachers


Objectives No. 8 – To evaluate the effectiveness of teaching strategies employed to enhance the performance level of scientific process skills.

Conclusions:

The teaching strategies significantly enhance the performance level of scientific process skills in Physics, Chemistry and Biology among student teachers.


Objectives No. 9 – To examine relation between gender and effectiveness of the teaching strategies for the scientific literacy and scientific process skills.

1. The teaching strategies for enhancing scientific literacy were found to be equally effective on boys and girls in D. T. Ed. Course.

2. The teaching strategies found to be more effective for enhancing scientific process skills related to Physics and Chemistry among boys and girls.

3. The teaching strategies were found to be more effective for enhancing scientific process skills related to Biology among girls than the boys.

Objectives No. 10 – To examine relation between faculty of student teachers and effectiveness of the teaching strategies for the scientific literacy and scientific process skills.

1. The teaching strategies for enhancing scientific literature were found to be equally effective on student teacher at Arts/Commerce/Science faculties.

2. The teaching strategies for enhancing scientific process skills are found more effective on students from Science faculty than Arts and Commerce faculty.

3. The teaching strategies are almost equally effective on student from Arts and Commerce faculty.

6.4 Discussion

The teaching strategies implemented are found effective equally on boys and girls of D. T. Ed. Course. Similarly teaching strategies are found equally effective on students from Faculty of Arts/Commerce/Science for enhancing scientific literature.

The teaching strategies implemented are found effective equally on boys and girls of D. T. Ed. Course. Similarly teaching strategies are found equally effective on students from Faculty of Arts/Commerce/Science for enhancing scientific process skills but rigorous training is required for student teachers from Commerce and Arts faculty.

Merit of girls student teachers from Faculty of Science found to be higher than those of boys, this may be due to other opportunities for professional course related with Science are available and feasible to boys. This effect is reflected in the level of acquisition of scientific process skills.

Researcher has selected the sample from urban and rural area. Centrally admitted student teachers were more from rural areas of Maharashtra than from urban whereas in case of girls, more girls were from urban.

6.5 Recommendations

Recommendations based on discussion of conclusion are made for student teacher, teacher educator, training colleges as follows:

6.5.1 Student Teachers

1. Student teachers enrich science content knowledge by using various resources.

2. Student teachers do various small experiment by using house equipment.

3. Student teachers apply teaching strategies in classroom teaching.
6.5.2 Teacher Educators

1 The teacher educators should be resourceful, enthusiastic and conduct some experiments in their regular training programme for enhancement of scientific literacy and scientific process skills.

2 For enrichment of content related to scientific literacy the teacher educator should give proper training to student teacher for the enhancement of scientific literacy among pupils.

3 Conduct regular discussion on contemporary issues in science.

4 Create healthy learning climate by conducting activities inside classroom like using simple tools for experiments, preparing instruments which uses science principles like kaleidoscope, periscope.

6.5.3 Principals of Training Colleges

1 Training colleges should arrange workshop for development of scientific literacy level among student teachers.

2 Training colleges should arrange workshop for development of scientific process skills among student teachers.

3 Training colleges should arrange workshop for enrichment of science content knowledge.

4 Training colleges should arrange expert lectures for enrichment of science content knowledge.

6.5.4 N.C.T.E.

1. To enhance scientific literacy among student teachers, it is necessary to add science content into their curriculum.

2. To enhance scientific process skills, emphasizing student teachers to use handmade tools, simple equipments for carrying out experiments.

6.6 Topics for Further Study

Each research has potential to extend upto very high but due to limits of resources, subject matter and methodology one has two delimit it. But each study in its context provides a platform to proceed forward in many directions. Therefore, it has value to direct by putting issues emerged through its own process. Present study proposes following topics for further study.

1. Research may be conducted to test scientific literacy of school pupils.

2. Research may be conducted to develop scientific literacy inventory.
3. The experiment was conducted on the student teacher who adopted Marathi medium. It can be reproduced in different medium Colleges of Education.

4. Standard scale can be developed for measurement of scientific process skills.

5. Research may be conducted for in-service teacher.

6. Research may be conducted to test scientific literacy of B. Ed. student teacher.

7. This study can be conducted to D. T. Ed. student teachers and replicated to school pupils, higher secondary and college level as per requirement of the content.

8. Standard scale can be developed for measurement of scientific literacy level of citizen.

9. Research may be conducted to analysis of higher secondary curriculum w.r.t. multidimensional scientific literacy level.

10. Research may be conducted to developing scientific literacy: An Integrated teaching strategies approach.