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INTRODUCTION

The present age is an age of competition in all walks of life. The progress and prosperity of a nation depend on the education of individuals in the society. Hence, education must be sensitive to the demands and wishes of society and should concentrate on the individual needs as well as aspirations of the society. Today what our nation lacks is manpower. High quality personnel in Science, Technology and Engineering, especially in Space and Atomic Research and Genetic Engineering and Biotechnology research are required for the progress of the nation.

The goal of science teaching envisages a different dimension today. In olden days, teaching of science was meant purely for the mastery of the subject. But now this concept has changed. Today science teaching occupies an important role in the educational programme. Adjustment to the problems which the human beings face in modern society is impossible to achieve unless pupils are given adaptive experience in the field of science. Our youth must be prepared to make adaptation which will result in successful living in a strenuous and complicated environment.

The new Education Policy (1986) stressed the need for relating science to everyday life. The Ramamurthi Review Committee (1990) reviewed the National Policy on Education (1986) and emphasised Inquiry Teaching in Science. It is therefore important that teachers should be encouraged to adopt methods that contribute to meaningful attainment of concepts.
The students follow science passively and ineffectively in a science classroom. This is more rightly emphasised in the Education Commission Report (National Policy on Education, 1986). “…if Science is poorly taught and badly learnt, it is little more than burdening the mind with dead information and it could generate even into a new superstition.” Creative and constructive activities on the part of the student are necessary for effective learning of Science. So science teaching should be knit with life activities using environment and community resources.

Science instructions focused around scientific inquiry and modelling can help learners develop deep understanding of subject matter, powerful scientific skills, a strong understanding of the nature of science and scientific creativity. Scientists and science educators agree that such skills and understanding are essential for all citizens. The aim of science should be not only to transmit traditional values and knowledge to the next generation, but also to build a base of responsible citizens and trained power in terms of requirements of human resources for developing the economy.

The most important long-term outcome of instruction may be the student’s increased capabilities to learn more easily and effectively in the future, both because of the knowledge and skill they have acquired and because they have mastered learning processes. This implies that a major role in teaching is to create powerful learners. A modern understanding of science includes an understanding of science concepts, process of science, scientific enterprise and the social implications of science.
Philosophers as well as educationists have deplored methods that emphasised rote memorisation. In the 17th century, Comenius advocated methods of teaching which made the subject interesting, appealing and relevant (Zaghlul, 1997). Rousseau in the 18th century condemned bookish and verbal model of instruction which gave undue emphasis to *words, words and words*. Pestalozzi in the mid 18th century emphasised the need of employing best method for teaching.

A useful procedure to follow when teaching certain topics is to explicitly model a skill or procedure. Model means demonstrating a procedure to learners. This can be more effective than using verbal explanations, especially with younger learners or those who prefer a visual learning style. Models follow this sequence: the teacher (or another person who is perceived to be an expert) demonstrates the behaviour by doing it, linking the behaviour to skills or behaviours that already exist.

Models differ from general teaching strategies in that models are designed to reach specific goals. It is a design for teaching, within which the teacher uses all the skill and insight at his/her command. Models are commonly used in science. They allow scientists to formulate and test hypotheses. Models can serve as an avenue for students to develop and apply a variety of scientific practices valued in science, such as identifying questions, generating explanations and using justifications.

Model Based Teaching and Learning (MBTL) is an approach to changing student conceptions and to improving student scientific understanding (Duit and Treagust, 2003). Model based teaching is any implementation that brings together
information resources, learning activities, and instructional strategies intended to facilitate mental model-building both in individuals and among groups of learners.

The main objective of Biological Science teaching is to provide a systematic and practical idea of the discipline of biological science and to change student behaviour through this knowledge. The second objective of Biological Science teaching is that the students should demonstrate their abilities which are the by-product of the knowledge.

Discovery Learning Model promotes strategies of discovering values and attitudes that are essential for a discovering mind. The method includes science process skills, strategies of creative discovery, active autonomous learning, verbal expression, tolerance of ambiguity, logical thinking and attitude that knowledge is tentative. There is a need to investigate the effectiveness of this model in terms of these effects. Discovery Learning Model in Biological Science improves the power of imagination, which is the best key to develop scientific creativity.

1.1 IMPORTANCE OF DISCOVERY LEARNING MODEL

Discovery Learning Model emerged not only to minimize lecture method or memorization, but also to use that approach which is practiced by scientists. Discovery teaching is that teaching where teachers and children study scientific phenomena with the approach and the spirit of development of intellectual capacities, information and problem solving skills. Students learn how to discover, how to learn and how to organize what they have learned. Discovery Learning Model enhances motivation, interest and satisfaction. Satisfaction is associated with intrinsic
motivation which is derived from a drive towards competence. A generalisation of the heuristics of discovery which has been developed enables the students to solve problems in new contexts, thus increasing transfer of learning. By practising in this method, students develop the ability to sense the relevance of variables, make intuitive leaps and cost problems into forms with which they know how to work. Thus, they learn to organize and conduct investigation. The instruction becomes student-centred rather than teacher-centred. Discovery Learning Model increases manifold talents in the learners in addition to the academic one. It minimizes verbal learning and gives more time to the student, to assimilate and accumulate information. The discovery model of instruction generally brings about better outcomes – both cognitive and affective.

1.2 IMPORTANCE OF SCIENCE PROCESS SKILLS

Science process skills refer to a cluster of intellectual skills which account for covering a significant stage of a scientific investigation identified as forming a part of the behavioural changes to be attained by the students as a consequence of learning science. They are desirable outcomes of science education which provide sufficient instructional experiences as regard to the acquisition of skills, which will function at various levels of proficiency as the growing children pass through successive grade.

Students use process skills to formulate responses to questions, to justify point of view, to explain events or procedures and to interpret or describe results. There are several arguments for the inclusion of process skills activities in science curriculum. One is the characteristic of generalisability of the process skill to life. Students can
solve many of the life problems by using these skills. Another important factor is that these activities reflect the nature of science and the typical activity of scientists. Process skills emphasize a doing dimension, pupils are active not passive beings. Thus pupils are involved in identifying purposeful problems.

The science process skills enable individuals and the society at large to approach their problems in life in a systematic and orderly fashion. The science processes are basically thinking processes that can be applied to any set of problems. However, science does provide conceptual opportunities and an environment conducive towards the development of these skills, provided, science instruction is arranged with this objective in mind. If these process skills are made part of instructional process, then there is every likelihood that a majority of children, if not all, will become more skilful in using these process skills consciously and deliberately to make sense of natural phenomena.

1.3 IMPORTANCE OF SCIENTIFIC CREATIVITY

Creativity is the type of talent that can make history through reshaping man’s world. Creative thinking is a unique power of human mind for lifting man to higher levels of intellectual functioning, human dignity and achievement. Bruner (1961) argues that man’s creative faculties restore his dignity in the computer dominated age. The discovery and development of creative talent has become essential in our modern world. The national interest now demands increased emphasis on creativity and superior thinking ability in all branches of science. Moreover, for the process of
national reconstruction, we require efficient engineers, doctors, scientists, technicians, teachers, administrators, architects and other such professionals.

Scientific creativity is one of mankind’s greatest assets. It is essential in meeting life’s daily stress. Creativity is needed as much in common occupations like housekeeping and salesmanship as in scientific discovery or original inventions. Creative insights, as an essential part of the survival process, hold the key to the stability and prosperity of future society.

Sensitivity to science problems is also considered a component dimension of scientific creativity. It is concerned with creative science experiments, creative scientific problem finding and solving, and creative science activity. Scientific creativity must depend on scientific knowledge and skills.

Creativity is the source, the process and the method of all human progress, therefore, it has rightly been said that the cultural, scientific and social progress of any country depends on the extent of the development of creativity of its citizens, the foundation of which lies in education. Today every progressive country needs scientific creativity in almost every field of life and therefore there is a constant effort for the development of students with scientific creativity.

1.4 IMPORTANCE OF SCIENCE CURIOSITY

Curiosity is acquired as in the case of any other learning process. Certainly any good learning procedure in science will attempt to develop more science curiosity. The experiences of the pupils in a science class should lead to an increased science curiosity in scientific activities and discoveries.
Although the existing science curiosity of a particular child may be fain or limited in scope, it furnishes the basis for possible expansion towards new experience. It should be clearly understood that classroom motivation is not as much a matter of creating science curiosity. A high degree of curiosity in a given area is generally considered to be advantageous for achievement in that area. It is due to curiosity that the scientists, philosophers and artists find out new facts which ultimately lead to the new creations. Curiosity leads to divergence in perception, thinking and behaviour.

1.5 IMPORTANCE OF BIOLOGICAL SCIENCE

The study of Biological Science is becoming important because of the following reasons. Biological Science teaching helps in use of national resources systematically, helps to produce good breeds of animals and healthy crops, helps to develop healthy living conditions, helps in the control of diseases, improves scientific understanding, develops human thinking and love, helps in modern living, and it is a must for career planning and population education. The study of Biological Science is quite helpful in eradication of certain problems.

With the fast changing times more and more emphasis is put on man’s health. India shall need specialists in the field of medicine, health, agriculture, animal husbandry, genetic engineering and biotechnology. The talent in these fields shall come from the Biological Science. It is for these reasons that the subject has become so popular in our schools. It has not been realized that Biological Science has a great role to play and so it be given its proper place in school curriculum.
1.6 NEED AND SIGNIFICANCE OF THE STUDY

Today, science teaching occupies an important role in the educational programme. Adjustment to the problems, which the human being faces in modern society is impossible to achieve unless pupils are given adaptive experience in the field of science. Our youth must be prepared to make adaptation which will result in successful living in a strenuous and complicated environment.

Any change in the instructional techniques should never be the result of a strong opinion of somebody. A change in the approach in science teaching should be the result of careful experimentation. Experimentation is needed in different areas related to the teaching of science. The present experimental study is related to one of the major aspects of teaching science. It is concerned with the “how” of science and not the “what” of science. It seeks to find out the impact of the creative methods of teaching on the attainment of higher objectives in science. Such a study appears to be very relevant in the present context, when there is world-wide attempt to improve the quality of science education in schools.

Biological science education helps to shape modern scientific world outlook and overcome the superstitions of the past. In the dull bookish and passive environment of the school, there is very little room for creative and constructive activities of the students. So science teaching must be related to life activities, environment and community resources.

Studies have shown that Lecture Method is the most commonly used method of teaching Biological Science including Zoology. The major drawback of Lecture
Method is its excessive domination of verbalism. Higher secondary school students are seldom able to assimilate adequately and immediately any lengthy, rapid and hurried flow of ideas in a lecture. Points of difficulty will inevitably arise and may easily result in blocking the understanding of the subsequent ideas or topics, development of science process skills, curiosity and scientific creativity. In Lecture Method, the student may remain passive, since there is no chance for experimentation and independent thinking and it affects the development of science process skills, science curiosity and scientific creativity.

The main purpose of education is to influence the development of an individual to produce personal qualities of physical, social, intellectual and emotional readiness to meet the complex life situations. Teaching learning thus becomes a goal-oriented activity in which priority may be given to changes like acquisition of knowledge, skills, development of creativity, curiosity, development of understanding and application of theories and laws to a particular situation.

Children should be able to apply the learning acquired from classroom to real life situations. Children must have opportunities for free exploration and should be given chances to participate actively in the learning activity and to process information through first-hand experiences. The active participation enables the students to acquire an ability to use the reasoning power and to make their own discoveries. Moreover, outcomes of learning become more meaningful when classroom activities stress free discovery learning.
The Discovery Learning Model can be used to nurture the development of science process skills, scientific creativity, science curiosity and values, since social and personal concerns can be subject of intellectual inquiry and discovery. It is assumed that a study of this type will be useful to collect necessary data to develop innovative model in Biological Science to make the teaching learning process more interesting and meaningful.

We are living in the age of science and technology. The individual who possesses high curiosity in science can move the world ahead by discoveries and inventions in the field of science and technology. The findings of the study will help the teachers and administrators to decide the type of method to be selected in teaching our children.

A thorough, careful and critical analysis of related studies compelled the investigator to study the effectiveness of an Instructional Material in Biological Science based on Discovery Learning Model for fostering science process skills, scientific creativity and science curiosity. Researches on ‘Science curiosity’ and ‘Scientific creativity’ have not yet come up to the expected number even in the developed countries. The investigator, as a specialist in Biological Science, has, therefore, made an attempt to conduct a study on the ‘Effectiveness of an Instructional Material in Biological Science based on Discovery Learning Model for Fostering Science Process Skills, Scientific Creativity and Science Curiosity’ in Higher Secondary Students’.
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It is presumed that a study of this type may be useful to collect necessary data for curriculum planners and teachers to develop suitable innovative models for teaching Biological Science to make the teaching-learning process more child-centred, meaningful and interesting.

1.7 STATEMENT OF THE PROBLEM

The present study was intended to prepare an instructional material in Biological Science based on Discovery Learning Model and to find out its effectiveness for fostering science process skills, scientific creativity and science curiosity in higher secondary school students. Hence the study is entitled as

“EFFECTIVENESS OF AN INSTRUCTIONAL MATERIAL IN BIOLOGICAL SCIENCE BASED ON DISCOVERY LEARNING MODEL FOR FOSTERING SCIENCE PROCESS SKILLS, SCIENTIFIC CREATIVITY AND SCIENCE CURIOSITY IN HIGHER SECONDARY STUDENTS”

1.8 DEFINITION OF IMPORTANT TERMS AND TERMINOLOGY

The important terms used in the study are defined below for the sake of clarity.

Effectiveness

The word ‘effective’ means ‘producing the intended result’ (Oxford Advanced Learner’s Dictionary, p.285). ‘Effectiveness’ is the quality of being effective’. This study is a plan of instruction and presentation, which causes a desired change in the behaviour of the learner. An assessment of this change leads to the determination of “Effectiveness”. (Hornby et al., 1963)
Instructional Material

Anything used for teaching purposes, including textbooks, supplementary reading materials, workbooks, visual aids, and materials or specimens with which to conduct experiments (Good, 1945).

Discovery Learning Model

Instead of being given verbal descriptions of a concept or principle, the learner is put in a position whereby he can develop the concept or arrive at the principle himself out of LEARNING EXPERIENCES that have been structured, to a greater or lesser extent, by his teacher. Advocates claim that things we find out for ourselves are usually better understood and remembered longer than things simply told by others. Discovery learning can be defined as the learning that takes place when students are not presented with subject matter in its final form but rather are required to organize it themselves. This is assumed to involve discovering relationship that exists among items of information.

A model is a pattern or plan. When it is a teaching model, it can be used to shape a curriculum or course, to select instructional materials and to guide a teacher’s actions. Prescriptive teaching strategies known as models are designed to accomplish particular instructional goals. A model of teaching consists of guidelines for designing educational activities and environments.

Biological Science

Biological Science include all those areas of study that deal with living things, in general study of the origin, development, structure, function, evolution and distribution of living things.
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Science Process Skills

Skills in science denote the techniques students learn in science classrooms. Science process skills are the learned mental behaviours, i.e., skill in processes are reinforced over a period of time due to increased emphasis on “Science Process” during teaching learning. Science process skills are initiation, hypothesizing, manipulation, processing data, conceptualization, generalization and open-endedness.

Scientific Creativity

Creativity is defined as “the ability to see new relationships, to produce unusual ideas and to deviate from traditional pattern of thinking. (Eysenck and Meili, 1972, p.228)

Scientific creativity is creative thinking through the media of science.

On the basis of Torrance’s (1967) definition, scientific creativity may be defined as “a process of becoming sensitive to problems related to science, deficiencies, gaps, missing elements, disharmonies and so on in scientific knowledge, identifying the difficulty, searching for solutions, making guesses or formulating hypothesis and deficiencies testing and retesting of these hypotheses and possibly modifying and retesting them and finally communicating the results.”

Operationally speaking, scientific creativity is a multidimensional attribute differently distributed among people and includes chiefly the factors of fluency, flexibility, originality, sensitivity to problems and elaboration and redefinition.
Science Curiosity

Science Curiosity means an eager concern to get scientific knowledge or a feeling of interest leading on to inquire about anything.

Plato called curiosity as "The Mother of Knowledge", and it may be thought of as an appetite for new experience or for new kinds of experience. (Tara Chand, 1993, p. 36, p. 110).

Higher Secondary Students

Those students who are studying in the XI and XII classes in the higher secondary schools in Kerala.

1.9 HYPOTHESES

The present study is likely to give information regarding the effectiveness of the instructional material in Biological Science based on Discovery Learning Model for fostering science process skills, scientific creativity and science curiosity in higher secondary students. Based on the theoretical background and assumptions, the following hypotheses are formulated.

1. There is no significant difference between the experimental group (DLM) and the control group (LM) in terms of science process skills, scientific creativity and science curiosity with regard to Pre-test scores.

2. Instructional Material in Biological Science based on Discovery Learning Model will not foster the science process skills of higher secondary students (for the total test scores and for the seven major process skill tests, viz.
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 Initiation, Hypothesising, Manipulation, Processing data, Conceptualization, Generalization and Open-endedness).

3. Instructional Material in Biological Science based on Discovery Learning Model will not foster the scientific creativity of higher secondary students (for the total test scores, and for the five component tests viz. Fluency, Flexibility, Originality, Sensitivity to problem and Elaboration and Redefinition).

4. Instructional Material in Biological Science based on Discovery Learning Model will not foster the science curiosity of higher secondary students.

5. There is no significant difference between Instructional Material in Biological Science based on Discovery Learning Model teaching and Lecture Method of Biological Science teaching in Pre-test and Post-test with regard to academic achievement of higher secondary students.

1.10 OBJECTIVES

The major objectives of the study are :-

1. To prepare an Instructional Material in Biological Science based on Discovery Learning Model on the topic “Phylum Mollusca” at higher secondary level.

2. To find out the difference between the experimental and the control groups (pre-test) in terms of science process skills, scientific creativity and science curiosity of higher secondary students.

3. To study the effectiveness of the Instructional Material in Biological Science based on Discovery Learning Model for fostering science process skills of higher secondary students with respect to the total test scores and for the seven
major process skills tests, viz. Initiation, Hypothesising, Manipulation, Processing data, Conceptualization, Generalization and Open-endedness.

4. To study the effectiveness of the Instructional Material in Biological Science based on Discovery Learning Model for fostering scientific creativity of higher secondary students with respect to the total test scores and for the five component tests viz. Fluency, Flexibility, Originality, Sensitivity to problem and Elaboration and Redefinition.

5. To study the effectiveness of the Instructional Material in Biological Science based on Discovery Learning Model for fostering science curiosity of higher secondary students.

6. To compare the effectiveness of the Instructional Material in Biological Science based on Discovery Learning Model teaching and the Lecture Method on the achievement of higher secondary students.

7. To give some possible suggestions for fostering science process skills, scientific creativity and science curiosity.

1.11 METHODOLOGY IN BRIEF

Method adopted for the study

The investigator adopted Experimental method for the present study.

Sample for the study

The study was conducted on a sample of 322 students of standard XI selected from three Higher Secondary schools in Trivandrum district.
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Tools Used

1. Instructional Material in Biological Science based on Discovery Learning Model.
2. Test of Process Skills in Biological Science
3. Test of Creativity in Biological Science
4. Science Curiosity Inventory
5. Achievement Test in Biological Science.

Statistical Techniques Used

The following statistical techniques were used for analysis.

1. Test of significance of difference between means.
2. Analysis of variance and covariance

Procedure

The instructional material prepared by the investigator on the topic Phylum Mollusca of Standard XI was tested through experimental method to find out its effectiveness on a sample of 322 students (162 students belong to experimental group and 160 students belong to control group). The control group was taught this topic by Lecture Method and the experimental group was taught the instructional material based on Discovery Learning Model. An achievement test in Biological Science based on the instructional material, Test of process skills in Biological Science, Test of Creativity in Biological Science and Science Curiosity Inventory were administered to both the groups. The pre-test and post-test scores obtained were compared to determine the effectiveness of an Instructional Material in Biological
Science based on Discovery Learning Model for fostering science process skills, scientific creativity and science curiosity through the teaching of Biological Science at higher secondary level.

**Variables of the Study**

"Variables are the conditions or characteristics that the experimenter manipulates, controls or observes". (Best, 1998). In experimentation manipulated variable is called as independent variable. It is under the direct control of the experimenter who may vary it any way desired. (Sax, 1968). The variable to which students will be asked to respond is called a dependent variable. In educational research an independent variable may be a particular teaching method, a type of teaching material, a reward, or a period of exposure to a particular condition. The dependent variable may be a test score, the number of errors or measured speed of performing a task.

The independent variables selected for the present experiment were instructional strategies, namely Discovery Learning Model and Lecture Method. The dependent variables in this study were the science process skill scores, scientific creativity scores and science curiosity scores obtained by the students in the standardized tests. In this study the scores of the achievement tests are treated as dependent variables.

The graphical representation of the variables used in the study is presented in Figure 1.1.
1.12 SCOPE AND LIMITATIONS OF THE STUDY

In spite of the great significance of Discovery Learning Model, it has been neglected in our present day education system. This may be due to lack of literature, knowledge about innovative models or methods. Most of the teachers use Lecture Method for teaching. Under such formalised circumstances, pupils remain placid and indifferent which in turn makes the educational system more rigid, less interesting and less utilitarian.

Modern science education is concerned with developing an inquiring mind. To develop this, pupils should engage in free exploration and should provide opportunities for the development of various process skills such as observation, identification, formulation and verification of hypotheses, classification, discrimination, analysis, interpretation, experimentation, prediction and problem
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solving. Discovery learning which helps to bring about an awareness of nature is also helpful in realising the objectives of teaching science.

Discovery Model of teaching provides a newer outlook to teaching. Discovery Learning Model based instructional material can assist the teacher to have a variety of interactive environment for learning. An intelligent use of this model enables the teacher to adapt himself to the learning needs of the students. The teaching model acts as a blueprint designed in advance for providing necessary structure and direction to the teacher for fostering science process skills, scientific creativity and science curiosity in our students.

Through enhancing science process skills, scientific creativity and science curiosity, the performance of students can be raised, measures to spend their leisure time fruitfully can be found out and a strong foundation of Biological Science education can be laid. Instructional material based on Discovery Learning Model has to reach the millions of classrooms and the glorious manifestation of scientific creativity is to be made possible. Identifying and nurturing creativity should be the major aspect of science education of higher secondary students. Therefore, the investigator made an attempt to study the effectiveness of an instructional material in Biological Science based on Discovery Learning Model for fostering science process skills, scientific creativity and science curiosity in higher secondary students.

Discovery Learning Model holds promise for future because the schools of the future will be designed not only for learning, but also for acquiring science process skills, scientific creativity and science curiosity. The study is founded upon Bruner’s
theory of learning by discovery. This study is related to fostering science process skills, scientific creativity and science curiosity. So it would be of great help to the planners of higher secondary curriculum in Kerala/India.

Every attempt was taken to make the study as valid and reliable as possible.

Limitations

1. The study was confined to a single topic viz. Phylum Mollusca.

2. The experimental teaching was limited to three higher secondary schools selected from Trivandrum Revenue District.

3. The experimental teaching was limited to a sample of 322 higher secondary students.

4. Owing to lack of time the study has been limited to Higher secondary classes only.

Delimitations

1. Slow learners may face difficulties during the experimental teaching.

2. The science text books do not provide sufficient scope for discovery learning.

1.13 ORGANIZATION OF THE REPORT

Chapter I Presents the need and significance, statement of the problem, definition of the key terms, statement of objectives, hypotheses, scope and limitations of the study.

Chapter II Presents a theoretical overview of the model under study.
Chapter III  Presents a review of studies related to the topic under investigation.

Chapter IV  Describes the methodology of the study. The chapter includes tools employed, experimental design, procedure and statistical techniques applied for the study.

Chapter V  Presents details regarding analysis of data, findings and discussions.

Chapter VI  Summarises the study in retrospect. It presents the summary of the procedure, conclusions and recommendations, followed by a few suggestions for further research in this area.

The Appendices related to the study are presented after Chapter VI which is followed by a Bibliography pertaining to the study.