Effect of 5-E Model of Teaching on Higher Order Thinking Skills in Science at the Upper Primary Level

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Abstract

This study intended to find out the effectiveness of the 5-E model of teaching on higher order thinking skills (analysing, evaluating and creating) in science at the upper primary level. The pre test-post test single group experiment was conducted on 22 Class VII students of Nayagarh Girls' High School, Odisha, India. The investigators taught 15 lessons based on the 5-E Learning Model for the Chapter—Light, of Class VII, Board of Secondary Education, Odisha. The self developed test on higher order thinking skills in science having 30 items was used as the tool. The study found that there is a significant improvement in the higher order thinking skills of students taught by the 5-E model of teaching at 0.01 levels. The study has suggested many implications for the teacher, Teacher Educators, textbook writers and policymakers.

Conceptualisation of the Problem

Science is considered to be an essential part of the curriculum at the school level, as it affords the knowledge of facts and laws, and helps in achieving the main goal of education. It allows the learners to explore their world, discover new things and enhance their curiosity level. Hence, science has been given a core place in the school curriculum. So, the learning of science has become an unavoidable

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part of general education. The Kothari Commission (1964–1966) recommended that science should be taught on compulsory basis to all pupils as a part of their general education during the first ten years of schooling. The vision of science involved three factors—the learner, the environment (physical, biological or social environment) and the object of learning (science). Learning science includes learning scientific ways of thinking and knowing. This involves the development of conceptual and procedural knowledge, and scientific reasoning skills.

The National Curriculum Framework (NCF) 2005 recommended that science education is bridging the world of home and school so that children cognitively interact with each other. The aim of science education is to know the facts and principles of science and its application, acquire the skills, and understand the methods and processes that lead to the generation and validation of scientific knowledge cultivate scientific temper, critical thinking and freedom from fear and prejudice. It provides opportunities for the learners to make sense and enhance their understanding of the disciplinary concept. The basic aim of teaching any subject is to provide opportunities to the learners so that they can think, and are able to connect with their experiences. The aim of science education is comprehensive and stage-specific. At the primary stage, the aim of science education is to develop psychomotor skills; at the upper primary stage, science education is based on the hands-on experience, and emphasises on the acquisition of knowledge. The NCF 2005 mentioned that the main aim of science education at the upper primary stage is to develop a scientific attitude and thinking, creative ideas and problem solving among the learners.

According to constructivism, teaching is no more concerned with the mere process of imparting knowledge, but it is a process of constructing knowledge. In the constructivism approach, the learners are always at the centre. They are not empty vessels that we can pour our knowledge into; knowledge is situated inside the soul that they themselves have actively created. The formalisation of the theory of constructivism is generally attributed to Jean Piaget, who articulated mechanisms by which knowledge is internalised by learners. The theory suggested that through the process of accommodation and assimilation, individuals construct new knowledge from their experiences. Constructivist theories in science education focus on the question as to how an individual learns and find the ways to facilitate that learning in the context of a science classroom (Mintzes and Novak 1998). Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and ideas.

Constructivism is often associated with pedagogic approaches that promote active learning or learning by doing. Based on the constructivist approach, there are three major models—the Learning Cycle Model, the ICON Design Model and the 5-E Model of Teaching–Learning are in practice. Among them, the 5-E Model of Teaching-Learning is widely used in classroom teaching. This model was developed by R.W. Bybee in 1997 based on experiential learning. According to this model, instruction happens through five phases that is, engage, explore, explain, elaborate and evaluate.

Engage

The purpose of this introductory stage, 'engage', is to capture students' interest. Here, you can uncover what students know and think about a topic, as well as determine their misconceptions. Engagement activities might include a reading, a demonstration, or other activities that pique students' curiosity.

Explore

In this stage, the teacher provides students with cooperative exploration activities, giving them common, concrete experiences that help them begin constructing concepts and developing skills. Students can build models, collect data, make and test predictions, or form new predictions. The purpose is to provide hands-on experiences that can be used later to formally introduce a concept, process, or skill. In this phase, the learners get an opportunity to explore through all their senses.

Explain

In this stage, the learners articulate their ideas in their own words and listen critically to one another. The teacher clarifies their concepts, corrects misconceptions, and introduces scientific terminology. It is important that the teacher clearly connects the students' explanations to the experiences they had in the engage and explore phases. In this phase, the learners explain their understanding of concepts and processes. New concepts and skills are introduced, as conceptual clarity and cohesion are sought.

Elaborate

At the 'elaborate' point in the model, some students may still have misconceptions, or they may understand the concepts only in the context of the previous exploration. Elaboration activities can help students correct their remaining misconceptions and generalise the concepts in a broader context. These activities also challenge students to apply, extend, or elaborate upon the concepts and skills in a new situation, resulting in a deeper understanding. In this phase, the learners are allowed to expand the concept that they have learned, make connections to other related concepts and apply their understanding to real life situations.

Evaluate

In this phase, the teacher evaluates students' understanding of concepts, and their proficiency with various skills. The teacher can use a variety of formal and informal procedures to assess the conceptual understanding and progress towards learning outcomes. The evaluation phase also provides an opportunity for students to test their own understanding and skill.

This 5-E model is a recurring cycle of experience learning to the construction of knowledge. It is a systematically organised cycle that gives real science experiences that leads to the construction of knowledge. The 5-E Model of Teaching–Learning is an inquiry based constructivist conceptual change model (R.W. Bybee 1997). This model helps the learners in developing higher order thinking skills. Higher order thinking skills can be defined in terms of transfer, critical thinking and problem solving skill. Transfer means the students not only remember the things that they have learned, but can also make sense and are able to use those things. Critical thinking refers to reflective and artful thinking which includes reasoning, questioning, investigating, observing, finding and exploring the viewpoints. In terms of problem solving skills, the students must use higher order thinking skills to recognise the proper way to reach the desired goal. Problem solving skills enable the learners to find a solution that can not be solved by simply memorising. For the first time in 1956, Benjamin Bloom created the taxonomy with the aim to promote higher order thinking skills in education. This taxonomy provides a way to organise the thinking skills into six levels, from the simplest to the complex level of thinking. Anderson and Krathwohl (2001) revisited the taxonomy and made some changes. They divided the taxonomy into six categories, but named it differently that is, remembering, understanding, applying, analysing, evaluating and creating. This taxonomy reflects the different forms of thinking. Among the six, analysing, evaluating and creating come under higher order thinking skills.

Analysing

The analysing skill is the ability to visualise, articulate, conceptualise or solve, both complex and uncomplicated problems. Such skills include the ability to apply logical thinking to breaking complex problems into their component parts.

Evaluating

Students having evaluating ability can make judgment in science, based on certain criteria and standard. They can appraise, argue, judge, select, support and evaluate something.

Creating

Students having analysing ability in science can create a new product or point of view; can assemble, construct, create, design, develop, formulate and

write new things in new ways, and can put elements together to form a meaningful, innovative product.

The purpose of teaching science is to develop scientific process, attitude and temper among learners. This purpose can be realised only by following learner-centred methods of teaching. As per the NCF 2005, the constructivist approach of teaching must be followed in classroom teaching as it can develop higher order thinking skills.

Rationale of the Study

Learning is the process of using appropriate methods and material in order to reach in the most effective manner to achieve the predetermined goals. The 5-E model of Teaching–Learning is an appropriate model which provides a comprehensive idea and develops understanding on a concept. Grounded on the constructivist approach, the 5-E model of teaching–learning promotes higher order thinking skills by stimulating the students to explore, inquire and get experience. The 5-E Model transmits the critical thinking skill to students. It is a learning cycle model that facilitates learning and creates beneficial opportunities for students while learning.

Most of the study found that the 5-E Model of Teaching–Learning is an appropriate strategy to increase the level of achievement, scientific aptitude, scientific skills and critical thinking skills among students. Sen and Oskay (2016) found that there was a significant effect of the 5-E Model of Teaching–Learning on students' achievement in chemistry. Chowdhury (2016) reported that students taught through the constructivist approach score higher than those taught through the traditional approach and a significant difference was found between the mean scores on understanding, application and skills. Tuna (2013) found that a significant effect of the 5-E Model of Teaching–Learning on students' academic achievement in trigonometry. Bera and Mohalik (2013) revealed that there is a significant difference in the mean achievement score of students taught by concept mapping and convectional method of teaching at 0.05 levels and a majority of students expressed that concept mapping is really helpful for learning science and understanding the structure and interrelations of the concept. Raval (2012) found that the constructivist instructional programme was significantly effective on the entire sample as compared to the traditional approach. Verma and Tyagi (2012) found a significant difference between the mean scores of the experimental and control group on achievement, creative thinking and academic motivation in science. Walia (2012) conducted a study to examine the effect of the 5-E model on mathematical creativity on Grade 8 students, and found that the experimental group has higher post test scores than the control group. Tyagi (2010) revealed that the use of

constructivism in teaching affected elaboration, flexibility and creative thinking, but it was found to the no significant effect on originality. John (2005) found that when students were actively engaged in a computer stimulation of a science task, there was a promotion in higher order thinking skills among the students.

From the above research, it is found that studies were conducted on the effectiveness of the constructivist approach of teaching and its different models in enhancing achievement and thinking skills. But limited studies were conducted on the effectiveness of the 5-E model of teaching on higher order thinking skills (Chowdhury 2016, Walia 2012, Raval 201 and Tyagi 2010). Further, most of the studies were undertaken in English medium schools and few at the regional medium school (Sen and Oskay, 2016, Bera and Mohalik, 2013). In this context, the study on the effect of the 5-E Model of teaching on higher order thinking skills in science at the upper primary level is relevant.

Statement of the Problem

The present study would be stated as 'Effect of the 5-E Model of Teaching on Higher Order Thinking Skills in science at the upper primary level students of Odisha.

Objectives

1. To study the effect of the 5-E model of teaching–learning on higher order thinking skills (analysing, evaluating and creating) in science at the upper primary level.

Hypotheses

1. There will be no significant effect of the 5-E model of teaching on higher order thinking skills in science at the upper primary level. This hypothesis has the following sub-hypotheses—

1.1 There will be no significant effect of the 5-E model of teaching on analysing skills in science at the upper primary level.

1.2 There will be no significant effect of the 5-E model of teaching on evaluating skills in science at the upper primary level.

1.3 There will be no significant effect of the 5-E model of teaching on creating skills in science at the upper primary level.

Methodology

The investigator used the pretest-post test single group experimental design having 5-E teaching model as the independent variable and higher order thinking skills as the dependent variable for conducting this study. The Class VII students of Nayagarh Girls' High School, Odisha were taken as sample. The investigator prepared 15 lesson plans based on the 5-E Learning Model for the Chapter—Light of Class VII, Board of Secondary Education, Odisha. The sub chapters are—reflection of light; types of images; plane, concave and convex mirror. In order to measure the level of higher order thinking skills among students, the investigator prepared a test in science on higher order

thinking, having 30 items which was used for both pre and post test. The content validity of the tool was ensured by taking expert comments and suggestions during the tool development. The reliability of the test is .68. The collected data were analysed by using both descriptive and inferential statistics.

Analysis and Interpretation

For determining the effect of the 5-E model of teaching–learning on higher order thinking skills (analysing, evaluating and creating), the investigator compared the pre test and post scores by using t-test, which is given in the tables.

Table 1 indicates that the difference between the means of pre and post test analysing score is 3. The t-value is 8.060, which is significant at 0.01 levels. The p-value indicates that there is a significant difference between means of pretest and post test score of analysing. Hence, the null hypothesis 'there will not be significant difference between means of pretest and post test score of analysing' is rejected at 0.01 levels and we accept the alternative hypothesis. So, it can be concluded that teaching through the 5-E model significantly enhances the analysing skills among students. The pre and post test score of students in analysing skill is graphically shown in Figure 1.

Table 1
Comparing Pretest and Post Test Scores in Analysing

Group	N	Mean	Standard Deviation	Mean Difference	df	t-value	p-value
Pretest score in analysing	22	2.727	1.202	3	21	8.060	0.000
Post test score in analysing	22	5.727	1.420				

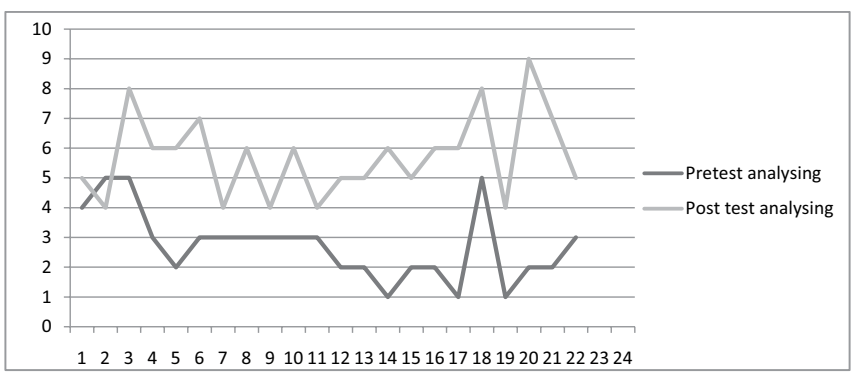

Figure 1. Pretest analysing score and post test analysing score

Hence, it is concluded that there is a significant effect of the 5-E Model of Teaching–Learning in enhancing the analysing skills among learners.

The investigator also compared the pretest and post test evaluating scores by using t-test, which is given in Table 2.

Table 2 reveals that the difference between the mean of pretest and post test scores in evaluating is 1.545. The t-value is 4.106, which is significant at 0.01 levels. The p-value indicates that there is a significant difference between the means of pretest and post test score of evaluating. Hence, the null hypothesis, 'there will not be significant difference between the means of pretest and post test score of evaluating' is rejected at 0.01 levels and we accept the alternative hypothesis. So, it can be concluded that teaching through the 5-E model significantly enhanced the evaluating skills among students. The pre and post test scores of students in the evaluat skill is graphically shown in Figure 2.

Table 2
Comparing Pre and Post Test Scores in Evaluating

Group	N	Mean	Standard Deviation	Mean Difference	df	t-value	p-value
Pretest score in evaluating	22	3.318	0.839	1.545	21	4.106	0.001
Post test score in evaluating	22	4.864	1.699				

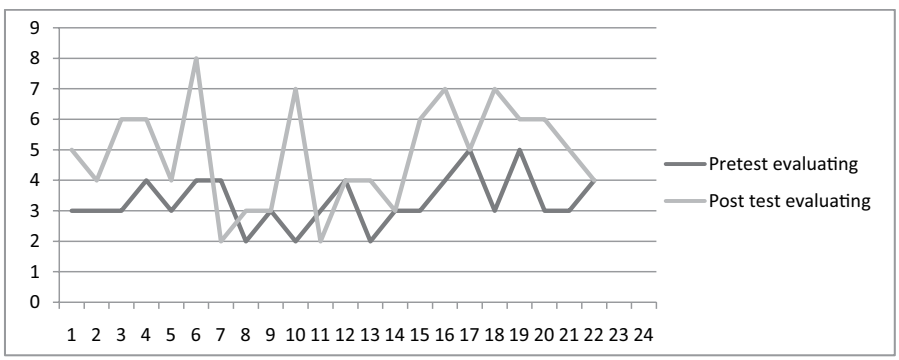

Figure 2. Pretest evaluating score and post test evaluating score

Hence, it is concluded that there is a significant difference between the pretest and post test evaluating scores. So, we can say that teaching through the 5-E Learning Model significantly enhances the evaluation skills among learners.

The investigator compared the pretest and post test creating scores by using t-test, which is given in Table 3.

Table 3 reveals that the difference between the mean of pretest and post test scores in creating is 3.409. This table also indicates that the standard deviation of pretest creating group is 1.181 and post test creating group is 1.716.

The t-value is 9.209, which is significant at 0.01 levels. The p-value indicates that there is a significant difference between the means of the pretest and post test scores of creating. Hence, the null hypothesis, 'there will not be significant difference between means of pretest and post test score of creating' is rejected at 0.01 levels and we accept the alternative hypothesis. So, it can be concluded that teaching through the 5-E Model significantly enhanced the creating skills among students. The pre and post test scores of students in creating skill is graphically shown in Figure 3.

Table 3
Comparing Pre and Post Test Scores in Creating

Group	N	Mean	Standard Deviation	Mean Difference	df	t-value	p-value
Pretest score in creating	22	1.818	1.181	3.409	21	9.209	0.000
Post test score in creating	22	5.227	1.716				

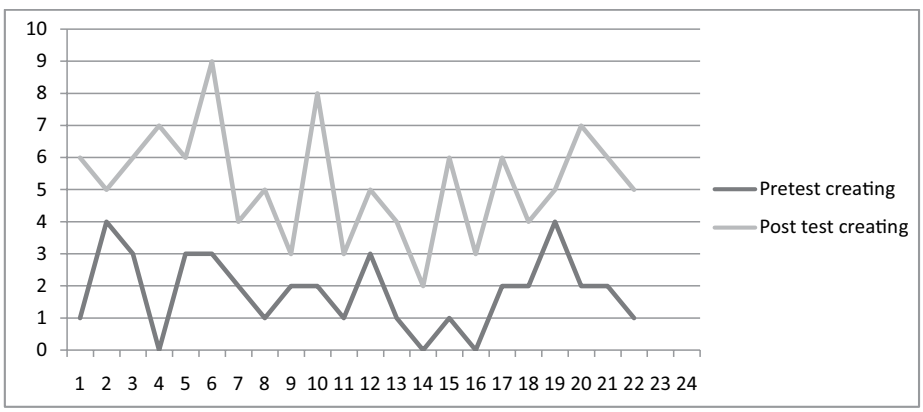

Figure 3. Pretest creating score and post test creating score

Hence, it is concluded that there is a significant difference between the pretest and post test creating score. So, we can say that teaching through the 5-E Model of teaching-learning significantly affect the creation skills of learners.

To study the effect of the 5-E Model of Teaching in learners' higher order thinking skills, the investigator compared the pretest and post test scores by using t-test, which is given in Table 4.

Table 4 reveals that the mean score of the pretest group is 7.818 and post test group 15.818. The difference between the means of the pretest and post test score is 8. The standard deviation of pretest group is 2.015 and post test group is 4.031. The t-value is 9.114, which is significant at 0.01 levels. The p-value indicates that there is a significant difference between means of pretest and post test score of evaluating. Hence, the null hypothesis 'there will not be significant difference between means of pretest and post test scores' is rejected at 0.01 levels and we accept the alternative hypothesis. So, it can be concluded that teaching through the 5-E Model significantly enhanced the higher order thinking skills among students. The pre and post test scores of students are graphically shown in Figure 4.

Table 4
Comparing Pretest and Post test Scores in HOT Skills

Group	N	Mean	Standard Deviation	Mean Difference	df	t-value	p-value
Pretest score	22	7.818	2.015	8	21	9.114	0.000
Post test score	22	15.818	4.031				

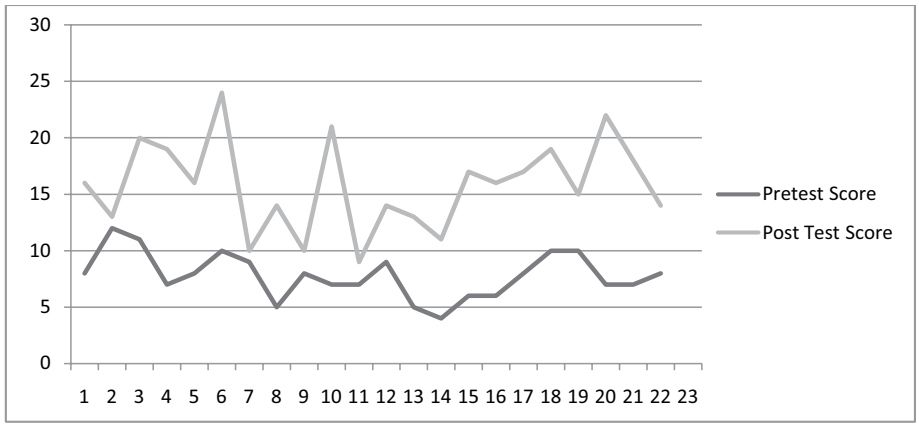

Figure 4. Pretest score and post test score

Hence, it is concluded that there is a significant effect of the 5-E Learning Model in developing higher order thinking skills in science.

Major Findings

1. There is a significant difference in the means of pretest and post test analysing scores at 0.01 levels. Hence, teaching through the 5-E Model of Teaching-learning is effective to enhance students' skill of analyzing in science.
2. There is a significant difference in the means of pretest and post test evaluating scores at 0.01 levels. Hence, teaching through the 5-E Model of Teaching–Learning is effective to enhance students' skill of evaluating in science.
3. There is a significant difference in the means of pretest and post test creating scores at 0.01 levels. Hence, teaching through the 5-E Model of Teaching–Learning is effective to enhance students' skill of creating in science.
4. There is a statistically significant difference in the means of pretest and post test scores in higher order thinking skills at 0.01 levels. This indicates that the 5-E Model of Teaching–Learning significantly helps to improve students' higher order thinking skills in science.

Discussion of the Result

The present study is different in the sense that it was conducted in government schools having Odia as the medium of instruction and the students are from rural areas. The investigators intended to study the effect of the 5-E Model of Teaching–Learning in the regional medium schools. The study found that the 5-E constructivist model of teaching has significantly contributed to the development of higher order thinking skills (analysing, evaluating and creating). This result is supported by Chowdhury (2016), Walia (2012), Verma & Tyagi (2012) and Raval (2012), but Tyagi (2010) reported that the 5-E Model of Teaching–Learning has no significant effect on the originality of participants. It can be said that students taught by the 5-E Model of Teaching–Learning will develop better higher order thinking skills than students taught by the conventional method. It may be due to the fact that the 5-E model of teaching actively engages the learner during the entire duration of teaching, by providing opportunities to explore, discuss, debate and work in groups in the learning situations. Here the teacher acts as a facilitator and the student as an independent learner. The 5-E Model of Teaching–Learning is very useful in the teaching of science as it stresses on the process of learning science such as enquiry, observation, manipulation, problem solving, recording and reporting. Finally, it can be concluded that the 5-E Model of Teaching–Learning is very effective in enhancing higher order thinking skills in science.

Educational Implications

The study found that the 5-E Model of Teaching–Learning has a significant impact on students' higher order thinking skills (analysing, creating and evaluating) in science. The study has many implications for the teachers, Teacher Educators, as well as textbook writers.

- The teachers teaching science need to be oriented in the process of teaching by following the 5-E model of teaching. Because the 5-E Model develops higher order thinking skills among students, so the educational administrators and policymakers may organise in-service training programmes and workshops for teachers on the 5-E Models of Teaching–Learning. The science teachers need to be motivated to use the 5-E Model in their regular teaching.
- The pre-service teacher education courses must include the 5-E Model of Teaching–Learning in their pedagogy course so that the trainee can develop the skills and competencies for using the 5-E Model of Teaching–Learning. Teacher Educators may use the 5-E Model of Teaching in their regular classes so that trainees can get first-hand experience on it.
- The existing science textbook may be revised in the light of the constructivist approach, especially on the 5-E Model of Teaching. The textbook can be written based on the steps and principles of the 5-E Model of Teaching–Learning. Similarly, teachers' handbook may be written based on the 5-E Model of Teaching–Learning which can be of great use for teachers.
- Researchers can explore the process of integrating ICT and the 5-E Model of Teaching–Learning for teaching different subjects. Training modules and programmes can be organised for integrating ICT and the 5-E Model of Teaching–Learning, so that teachers can get familiarity and orientation in it.

Conclusion

The 5-E Model of Teaching is effective in developing higher order thinking skills among students in science. It is an appropriate method to actively engage the students in the classroom process. Hence, it is time for all the stakeholders in education to use this model of teaching in classrooms. Teachers need to be oriented and motivated to follow this model in their classes. The educational planners and administrators must plan in-service training programmes on the 5-E Model of Teaching–Learning at the school, block, and district levels so that the maximum teachers can be covered. The success of this model is largely dependent the on motivation and training of teachers.

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