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Effectiveness of Ict Integrated 5E Learning Model on Higher Order Thinking Skills in Biology at Secondary Level

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Abstract

The present study ascertains the effectiveness of ICT integrated 5E learning model on higher order thinking skills in biology over 5E learning model at secondary level. Quantitative design and quasi-experimental method was used in this study. Total 65 students were divided in experimental group (34) and control group (31) by taking two sections of class-IX randomly. The experiment was continued for two months with 5E learning model and ICT integrated 5E learning model strategy with control and experimental group respectively. The self-developed test on higher order thinking skills on biology sectionof class-IX science textbook of National Council of Educational Research and Training was used as an instrument. The collected data was processed and analysed with the help of jamovi (1.6) open-source software and descriptive and inferential statistics are calculated. The study found that the learners taught through ICT integrated 5E learning model were significantly better in higher order thinking skills in biology than those who were taught through the 5E learning model at 0.01 levels. The ICT integrated 5E learning model is suitable for improving students' higher order thinking skills in biology subject. This study has suggested that the ICT integrated 5E learning model can be utilized in teaching learning of biological science for the improvement of student's higher order thinking skills.

Conceptualisation of the Problem

In present days, many methods and approaches are used to teach science subjects at school level. One of the approaches of teaching presently widely used in teaching learning processes is constructivist approach. There are different models of teaching in the constructivist approach like the 5E model; problem-based learning model, Interpretation Construction (ICON) model and Meta-cognitive learning cycle model etc. are well known in present

days (NCERT1, 2013). The 5E model is different from general teaching strategies because of its process of student engagement. It has five steps to engage students and create interest such as Engage, Explore, Explain, Elaborate and Evaluate.

Due to the rapid growth of Information and Communication Technology (ICT), educators have also integrated ICT in teaching, learning and assessment. The National Policy on Information and Communication Technology in School Education (MHRD2, 2012) recommended that use of ICT in teaching learning for quality improvement of education should be mandatory at school level. It has tremendous potential in teaching and learning process while using ICT integration at school level. ICT integration can be defined as using ICT tools as a web, multimedia, program in CD-ROM, teaching-learning objects and other tools to enhance students' teaching (Williams & Easing[3], 2003). The effective use of ICT integration in the teaching learning process has great potential to engage the learners. For learner interface, ICT can be used in different types of interaction like learner content, learner and learner, learner and teacher to make teaching learning more effective and efficient (Chou[4], 2003; Moore[5], 1989). These processes influenced the teaching learning process and made students more active and engaged in particular tasks. ICT integrated teaching can develop higher order cognitive processes among learners. ICT can be integrated with the 5E learning model to bring quality enhancement in teaching and learning. All the steps of the 5E learning model can use different ICT resources during the classroom teaching.

With the help of ICT integrated teaching can enhance the Higher Order Thinking Skills (HOTS) among learners. HOTS are the upper part of the pyramid of Bloom's Taxonomy. It includes applying, analysing, evaluating and creating. HOTS demands higher order cognitive process from students relating subjects. It can promote creativity, critical thinking, and problem-solving abilities among students. Both the 5E learning model and ICT integrated 5E learning model have potential to enhance higher order thinking skills among school students.

Rationale of the Study
The constructivist approach of teaching and its different models have been widely used in teaching

at school level. Due to advancement of digital technology, ICT integrated teaching approach has also been used in schools for teaching. Both models have their own importance to teach at school level; the 5E model is focused on meaning making while ICT integrated teaching is focused on creating interest among the students with audio, video and audio-video teaching aids. These two methods 5E learning and ICT integrated 5E learning enhance higher order thinking skills among the students. Different researchers have conducted study on the various aspects of the 5E learning model and ICT in education, which are discussed in the following paragraphs.

Deepshikha, Mohalik and Mohapatra[6] (2021) found that ICT integrated pedagogy has motivated the children to perform better than chalk and talk methods. Su K[7] (2021) reported that students are learning of Marzano's taxonomy step by step, and succeed in constructing the higher order thinking skills abilities than the higher order cognitive skills which are brain based learning for the chemistry subjects. Kalaitzi & Volioti[8] (2020) reported the integration of the 5E learning model into the ICT based activities for developing the specific methodology to teach specific learning contents. Mnguni & Mokiwa[9] (2020) found that online teaching and learning in STEM is the 4th industrial revolution in the 21st century. Tambaya & Lawal[10] (2017) reported that the 5E teaching cycle had a significant impact on academic performance of Pre-NCE Biology students with varied abilities than the lecture method of teaching. Alshehri[11] (2016) revealed the achievement of mathematics and retention of learning among fifth grade students had a positive impact through the 5E instructional model. Yildiz and Koçak[12] (2015) stated that the students in the classroom showed positive contribution to achieve high marks who have taught through the ICT integration in 5E lesson plans. Zhao, Zeng, Rush and Kosorok[13] (2012) and Su, Tsai, Wang and Li[14] (2010) reported the effects in participants' pedagogy and practice has been changed after using the 5E learning cycle model of teaching. Wanjalaet, Khaemba and Mukwa[15] (2011) stated that the role of teachers was significantly changed from transferring of knowledge into facilitating learning, from a main source person to a manager of learning while using ICT based teaching learning process among them.

The analysis of the above research studies indicates that few researchers have conducted research on ICT integrated 5E learning model. Further majority of the research has been conducted on the effect of ICT and 5E learning model on academic achievement and classroom management. But a few studies found the effectiveness of ICT integrated 5E model on higher order thinking skills in science. Hence, the present study on effectiveness of ICT integrated 5E model on higher order thinking skills in science at secondary schools' level is relevant. The investigator has raised the following research question for investigation.

• Whether ICT integrated 5E learning model can enhance higher order thinking skills in biological science at secondary level?

Operational Definition of the Key Terms
ICT Integrated 5E Learning
In the present study, different ICT resources in form of text, image, audio, video and animation available in open source are used in the 5E learning process such as engage, explore, explain, elaborate and evaluate for teaching learning.

Higher Order Thinking Skills (HOTS)
In the present study, higher order thinking skills refers to the performance of the students in science in terms of analyse, evaluate and create in written tests based on biology section of class IX science textbook developed by the NCERT.

Secondary Level
Secondary level covers the education of students from class IX to X nationwide in India. However, in the present study, secondary level connotes the class IX of CBSE affiliated schools.

Objective
• To study the effectiveness of ICT integrated 5E learning over 5E learning on higher order thinking skills in biology at secondary level.

Hypothesis
• There is no significant difference in the means of students in higher order thinking skills of biology taught through ICT integrated 5E learning and 5E learning.

Methodology
Design and Method
The present studyadopted quantitative design and quasi-experimental research method. ICT integrated 5E learning was the independent variable and 'Higher Order Thinking Skills (HOTS)' was the dependent variable in this investigation. The researcher selected the school purposefully and randomly selected two sections of class IX and assigned the group as experimental for the treatment. Before treatment, two groups were given the same pre-test. Then, the treatment was given to the experimental group by ICT integrated 5E Learning (ICT5EL) and control group by 5E Learning (5EL). After that, two groups were given post-test. The study was confined to the biology section of science textbook of class-IX developed by the National Council of Educational Research and Training, New Delhi. The tabular presentation of the research design is presented in the table-1

Table 1: Research design of the study

Group	Pre-test	Treatment	Post-test
Experimental Group	T_1	X_1 (ICT Integrated 5E Learning)	T_2
Control Group	T_1	X_2 (5E Learning)	T_2

Participants
The present study was conducted at Greenwood High School, Hasanparthy, Warangal, Telangana, India. The present study was concerned with the class IX students of secondary level in English medium school affiliated to Central Board of School Education Board, New Delhi, India. The researchers used purposive sampling for selecting school and random sampling method for selection and assignment of groups for experimental and control group in this study. The investigators conducted this experiment on 65 students of class IX including

both gender, i.e., girls and boys. There were three sections in the class i.e., IX-A, IX-B and IX-C in the school. The researcher had taken two sections from class IX, i.e., a control group (31 students of class IX-A section) and experimental group (34 students of class IX-B section) randomly. The control group (IX-A) was instructed through 5E learning and the experimental group (IX-B) was instructed through ICT integrated 5E Learning. The details of sample represented in the table-2

Table 2: Details of samples for the study

Group	Class	Number of Students	Instruction
Control Group	IX-A	31	5E Learning
Experimental Group	IX-B	34	ICT Integrated 5E Learning

Instructional Tools
ICT Integrated 5E Learning Lesson Plan
The investigators developed lesson plans on the selected topics of biological science and used for experimental treatment. At first, researchers had selected the six chapters of the science textbook of NCERT class IX (biology section) containing tissue. It has many sub-topics like types of tissues, plant tissue, meristematic plant tissue (apical, intercalary and lateral meristem), permanent plant tissues (simple permanent tissue, parenchyma, collenchyma and sclerenchyma; and complex permanent tissue-xylem and phloem). Researchers had identified facts, concepts, rules, principles etc. from the selected topics and developed ICT integrated 5E learning lesson plan by using text, image, slides, audio, video, videos and animations. These e-Materials are curated from different open online sources such as e-Pathashala, DIKSHA, PM-eVidya, NCERT Official YouTube etc.

5E Learning Lesson Plan
The researchers prepared lesson plans for all selected science (biology section) topics and sub-topics based on 5E Learning. The learning plans follow five steps such as engage, explore, explain, elaborate and evaluate. The researcher taught the same topics from the same chapter which were used in the experimental group. Here, only PPT and Jam Board were used as learning methods for the control group.

Measuring Tools
Higher Order Thinking Skills Test
The researchers developed a test to assess the HOTS in biology section of class IX having 30 marks. The researcher distributed 30 marks among the units and HOTS learning outcomes such as analysing, evaluating and creating by taking view of the subject experts. The test contains multiple choices, matching and interpretative items having equal marks i.e.one marks for each question. The duration of the test was one hour. The test was validated by taking experts' comments and suggestions during the test development and Cronbach Alpha (.67) reliability was estimated. HOTS test was used for both pre and post-test and on both the control and the experimental group.

Procedure of Data Collection and Analysis
After getting written permission from the principal of the Greenwood High School, the researchers selected two sections of class IX randomly and assigned IX-A as the control group and IX-B as the experimental group. Self-developed higher order thinking skills test was used during pre-test in both the groups. The experimental group was taught through ICT integrated 5E learning and 5E learning was used to teach for the control group. All topics were instructed in the same sequence in both groups. Both experimental and control group students' did not know that they were engaged with an investigation. The experiment was done for two months. At last, a post test was conducted on both the groups.

The acquired data were analysed by using descriptive and inferential statistics such as mean, standard deviation and t-test. The significance level of 0.01 was used for testing null hypothesis. All these quantitative data were analysed by using jamovi[16] version1.6 and accordingly interpretation was

made. The jamovi is a project founded by scientific community from Sydney, Australia to help researcher in quantitative data analysis for research purpose. This is anopen-source free software for quantitative data analysis.

Table 3: Independent t-test for means of pre-test, post-test and gain score of experimental and control group

Groups	N	Mean	SD	Mean Difference	df	t	P
Pre-test control group	31	8.23	2.57	0.226	63	0.326	0.74
Pre-test experimental group	34	8	2.98				
Post-test control group	31	15.8	2.38	2.867	63	4.795	0.001
Post-test experimental group	34	18.7	2.43				
Gain score control group	31	7.61	1.09	3.093	63	7.63	0.001
Gain score experimental group	34	10.7	1.99				

Result

To study the effectiveness of ICT integrated 5E learning over 5E learning model on higher order thinking skills in biological science at secondary level, the investigator calculated the independent t-test for control and experimental group, which is given in the table-3.

The table-3 indicates that the mean of the control group and experimental group in pre-test is 8.23 and 8 out of 30 marks respectively and the data shows that there is no significant difference in the means of both the groups. The P value for means of post-test control and experimental group is 0.001. Hence, it can be concluded that the group taught by ICT integrated 5E learning method have significantly higher mean in higher order thinking test in biology than the group taught by 5E learning method. Further, the P value of gain score means of control and experimental group is 0.001, which indicates that there is a significant difference in the means of control and experimental group. The null hypothesis "there is no significant difference in the means of students in higher order thinking skills of biology through the ICT Integrated 5E learning and 5E learning model" is rejected at 0.01 levels. The scores of experimental and control group are presented in violin graph with boxplot to compare the distribution of scores with median in following figures.
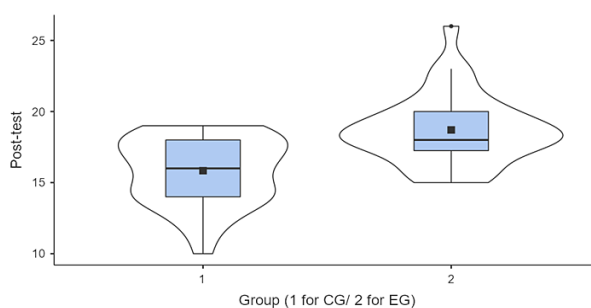

Fig.1: Violin graph for post-test of control and experimental group

The figure-1 reveals the marked difference in the distribution of the experimental and control group in post test scores. The peak of distribution is higher in experimental group than control group but the tails of the distribution is lower in control group than experimental group. Further the violin graph indicates that median is higher in experimental group than control group in post-test.
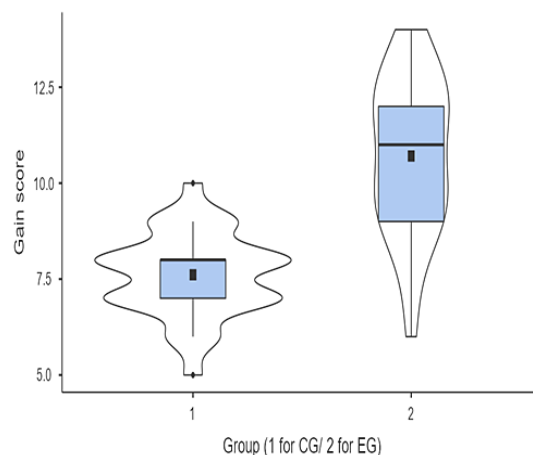
Fig. 2: Violin graph for gain scores of control and experimental group

The figure-2 indicates the distribution of gain scores of control group and experimental group. The peak of the distribution in gain scores of experimental group is higher than the peak of the gain scores of control group. There is a marked difference in the median of distribution of gain scores between the groups. The graph supports the findings of t-test that there is a significant difference in the gain scores of experimental group and control group.

The researcher also compared the means of control and experimental group in pre-test and post-test, which is presented in the table-4.

Table 4: Paired t-test for mean of pre-test, post-test and gain score of experimental and control group

Groups	N	Mean	SD	Mean Difference	df	t	P
Pre-test control group	31	8.23	2.57	7.61	30	39.05	0.001
Post-test control group	31	15.84	2.38				
Pre-test experimental group	34	8	2.98	10.71	33	31.32	0.001
Post-test experimental group	34	18.71	2.43				

The P value for means of pre-test and post-test control group and experimental group is 0.001. Hence, it can be said that both 5E learning and ICT integrated 5E learning model is effectively enhancing higher order thinking skills of students in biology at 0.01 levels.

Discussion

The investigator intended to study the effectiveness of the ICT integrated 5E learning model on higher order thinking skills in biology at secondary level. The study found that the ICT integrated 5E learning model has significantly contributed to the development of higher order thinking skills in biology of class IX students. This result is supported by Deepshikha[3], Mohalik and Mohapatra (2021) who found that ICT integrated pedagogy has motivated the children to perform better than chalk and talk methods. Su K[9] (2021) reported that students are learning Marzano's taxonomy step by step, through higher order thinking skills than higher order cognitive skills in the chemistry subject. Kalaitzi &Volioti[4] (2020) found that the effective practitioners follow a developed methodology to lead specific learning through use of 5E learning teaching with the help of ICT based activities. Yildiz & Koçak[16] (2015) reported

that ICT integration in 5E lesson plans has a great positive contributions to achieve high marks while using teaching learning process, sharing contents and activities-based contents to the learners. This result may be due to the fact that the ICT integrated 5E learning engages students in content through text, audio, video, simulation, animation etc. which enables learners in the construction of knowledge and development of higher order thinking skills. Finally, it can be concluded that the ICT integrated 5E learning model of teaching-learning is more effective in enhancing higher order thinking skills in biology at class IX than only the 5E learning model.

Educational Implications
The present study has many implications for teachers, teacher educators, educational planner, textbook writers as well as educational administrators. The study found that both the 5E learning model and ICT integrated 5E learning model is effective in improving students' performance and higher order thinking skills in biology. But the ICT integrated 5E learning model is significantly better than 5E learning. Teachers can be oriented to use ICT integrated 5E learning models in teaching different subjects because it provides multimedia experience to the students which help learners in the construction of knowledge. Teacher education curriculum can incorporate ICT 5E learning model as one of the learning strategies in the pedagogy courses so that prospective teachers can develop skills and competencies in using the ICT integrated 5E learning in teaching.

Conclusion
The present investigation uncovers that the ICT integrated 5E learning strategy has significantly better effect on learners' higher order thinking skills in biology. Science teachers need decent knowledge on constructivist learning and the manners by which ICT integrated 5E Learning model can be utilized to facilitate learners' higher order thinking skills. Consequently, it is recommended that teachers should utilize ICT integrated 5E learning model in curriculum transactions at school level. Teachers need to develop technological pedagogical content knowledge in their subject so that ICT can be effectively integrated in teaching.

Conflict of Interest
This research work has no conflict of interest.

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