Effects of 5E's Instructional Model on Academic Achievement in 10th Grade Chemistry

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Abstract

The purpose of this experimental study was to find out Effects of 5E's Instructional Model on Academic Achievement in 10th Grade Chemistry. The research design was true experimental in nature, based on the pre-test, post-test equivalent group design. The population of the study was comprised of all the students (boys) of 10th class studying at secondary level which were administered by Federal Directorate of Education, Islamabad. The sample of the study was consisted of 80 students taken from one boys' school by simple random sampling technique. The sample was further divided into two equal groups by equating them on pre-test scores. One was served as control group while the other as experimental group. The experimental group was taught by 5E's instructional model while control group by traditional teaching method. After the completion of eight weeks' treatment, post-test was administered to both the groups. At the end, data were collected and analyzed. Mean, standard deviation and t-test were used for data analysing. Data were analyzed by applying t-test at .05 level of significance. The major findings of the study were that the overall academic achievements of experimental group in post-test taught with 5E's instructional model enhanced significantly as compared to control group. The study also found significant increase in different aspects of cognitive domain of students' learning; knowledge, application, comprehension and skill development abilities of experimental group taught with 5E's instructional model.

Keywords: Instruction, Model, 5E's instructional model, academic achievement, Chemistry.

Introduction

Education plays an important role in the development of any nation. The progress of nation depends upon the standards of education, especially of science education. Quality of teaching and learning process strengthens the quality of education. Teaching and learning processes go side by side and both have proper place and importance. According to traditional teacher, teaching is the act of communication information to the learner in classroom. Since the start of twentieth century, research on teaching providing knowledge about skills, methods and models usefully employed by teachers for promotion of students learning. Teaching encourage and stimulate learning to achieve the desired educational goals in the learning domains of knowledge, skills and attitudes etc. (Gloria, 2014).

Chemistry is taught at secondary level as a science subject in Pakistan. Its inclusion has been rendered necessary as science subject for nation building. As a subject, chemistry and chemists are linked to everything on earth in appropriate way as what on earth is not chemistry? Chemistry also plays a vital role in sustainable economic growth of any nation. The importance of chemistry in the development of any nation cannot be underestimated especially in agriculture and industrial states like Pakistan (Khalid, 2012).

The poor performance in chemistry is caused by many factors like poor teaching methodology and improper use of instructional materials, large class size, lecture method, untrained teachers, poor vocabulary and students poor comprehension level of basic concepts of chemistry, teaching chemistry not in native languages of the students and difficulty of chemistry courses as a result of use of lecture method. Traditional teaching method is the major cause of poor performance in science subjects especially Chemistry (Pane, 2018).

Science has many branches like Chemistry, Physics, Biology, Agricultural, Medical Sciences, Health Sciences, Geographical Sciences, Mathematics and Anthropology. Chemistry occupies important place and position in secondary school curriculum which when applied in any society can bring rapid national development. Chemistry equip students with skills towards themselves and their environment. It is a subject required in each and every day matters (Ewing, 2012). Chemistry as a subject is important to many related disciplines such as Medicine, Nursing, Biology, Pharmacy, Computer, Geology, Law, Petroleum Industry, Agriculture, Paint, Fiber Industry, Leather and Shoe Industries etc. Without Chemistry, no disciplines is studied in better way by any student (Ibrahim, 2015).

Keeping in view the vital importance of Chemistry in national development, researchers, Chemistry teachers, science teachers and other agencies are trying to encourage achievement in Chemistry. In spite of this, students cannot perform well without better understanding of Chemistry in secondary classes (WAEC, 2010). Some researchers reached to the conclusion that Chemistry is important at secondary level especially in public schools (Njoku, 2009) while Adesoji and Olatunbosu (2008) are of the opinion that students have misconception about Chemistry concepts which lead students' poor performance in Chemistry. These are due to instructional approaches used by science teachers in their teaching. There is dire need for the proper teaching of Chemistry curriculum in secondary schools.

According to Sen and Oskay (2017) Chemistry teaching is a particular field which demands new research and innovation towards latest approaches. It is a fact that today is the age of science and technology and to provide quality education is the need of time. Changes are

continuously occurring in the world of science and technology. It is inevitable to compete with advanced countries in educating various new teaching learning methods and 5E's instructional model are being applied in developing as well as in advanced countries.

The 5E's instructional model was developed in the late 1980s as part of the living science and living curriculum created through the Biological Curriculum Study (BCS). Bybee and Lamdes, 1990. Bybees famous 5E framework has been adopted by different educationist and researchers as a basic tool to checked the effect of instructional model on students' academic performance and other related aspects. Bybee (1989) developed his famous 5E framework for carrying out learning experiences effectively in a class room setting. This framework consists of five processes formerly known as to engage students to explain and to elaborate new knowledge and information and to elevate their skills.

Traditional teaching method is used by a majority of teachers in Pakistan for teaching all subjects, the researcher compare this method with 5E's instructional model to see the effectiveness of inquiry based 5E's instructional model in science subjects especially Chemistry. Traditional teaching model, as describe by Adam and Engelmann (1996) is widely applied to enhanced teaching learning process. The teacher centred model consists of different steps, followed by people in a special and slow manner in ordered to achieve the objectives comprehensively. Various steps like introduction, development, guided practice, closure, independent practice and evaluation are the part of the model.

Statement of the Problem

Chemistry is the science of finding information about an innate phenomenon in an empirical way. It is generally obtained by using a specific method for a certain area, which can lead us to keep up with the knowledge about that specific phenomenon. It is a proven fact that science teaching models are gaining popularity all over the world these days and are being used in science teaching at various levels such as primary, secondary and tertiary levels. Although these models may have been used in our educational institutions for a long time, systematic examination of their intentional use and corresponding effects on student learning, achievement, and attitudes toward science has yet to be explored. Considering the importance of such models, the researcher intended to investigate the effects of the 5E's Instructional Model on Academic Achievement in 10th Grade Chemistry.

Objectives of the study

1. To investigate the effect of 5E's Instructional Model on students' academic achievement in 10th grade Chemistry.
2. To compare the effect of 5E's Instructional Model and Traditional Teaching Method on students' academic achievement in 10th grade Chemistry.

Hypothesis of the Study

Ho1: There is no significant difference between mean posttest scores for students' taught through 5E's Instructional Model and Traditional Teaching Method.

Literature Review

5E's Instructional Model

In Democracy and Education (1916), John Dewey supported child rather than the curriculum

at the centre of classroom. Dewey saw education as a social interactions between children and adults. He believed that knowledge could not be given to a student but students must be engaged in ordered to learn (Twyman, 2016). John Dewey was of the view that students must learn more. Students should experience science according to the scientific method. Students should be able to define a problem and its solution. They should made supposition, observe and evaluate and test the supposition. Students should follow the defined process in this learning cycle. After completion "hands-on" step, they should use "minds-on" to reflect on their experience (Brown and Abell, 2007).

Atkin and Karplus argued in 1962 that three components are necessary for learning i.e., exploration, term introduction and concept application through the development of Science Curriculum Improvement Study (SCIS), they recognized the original learning cycle for teaching inquiry based science (Atkin and Karplus, 1962). The original learning cycle was based on ideas and work of Friedrich Herbart, Dewey, Atkin and Karplus (Bybee et al., 2006). Exploration allowed the learners to become interested in the subject by hand, ask question and identify of dissatisfaction in the science curriculum improvement study's model of learning cycle (Tanner, 2010). According to 5E's model it allows the students to avail opportunity to practice science and sequence of model for effectiveness (Bybee, 2014). Teachers omit and shift the order of the model for making learning process effective (Tanner, 2010).

Herbert developed a philosophy of teaching comprising two main components namely conceptual understanding and interest in the beginning of 20th century. Herbart's philosophy was one of the first approaches (Hanuscin and Lee, 2008). Instructional model is a sequential process designed for teaching and learning (Marek, 2008). Students would be given chance of discovery first and then build on prior experiences and knowledge. Teachers would guide the students through experiences. Teachers would also explain the expected result for students through their learning experiences and students are allowed to apply new knowledge to their new experiences. According to Herbert if student discovers science concept, he / she would have more knowledge (Bybee, et al., 2006).

The 5E's instructional model was developed in 1987 by the Biological Science Curriculum Studies and five phases of learning. According to 5E's model, learning is an active process of building knowledge than gaining it (Richards, 2015). This knowledge is more personalized to students through use of phenomenon an all students to practice science as they learn (Bybee, et al., 2006).

The 5E's model has been used in subjects of science and applied in education (Hu, Gao & Liu, 2017). History of researchers tell us that 5E's model is effective in traditional way of life. Concept formation method with 5E's model is more effective as compared to traditional method (Jack, 2017). Students and teachers are allowed to engage in the learning experience and to create meaning learning of what is being taught (Ergin, 2012). Exploration of each aspect of various stages is necessary in the said model. Details are of five stages are below:

Figure: 5E's instructional model (Roger Bybee (2006).

Engaging

Engaging is a stage in which learners mentally involve in problems, situations or objects through teachers using pre text tasks. According to Zakaria, Solfitri, Daud and Abidin (2013), teachers should involve students in a task to gain knowledge, increase curiosity and establish between past and present learning experiences. Students explore the topic through one or more related activities to challenge their comprehension level of the concept. Teacher should provide necessary information on the subject to the students. Teachers should revealed new experiences to inspire the understanding of students so that they can apply their understanding to the new situation. According to Williams (2019), a focus on content at the expense of process in STEM education (and indeed in all education) will inhibit student learning because important learning occurs through process activities. When learning content is necessary to be able to apply it through an activity to a situation, such content is perceived as relevant and thus will be learned more effectively and efficiently. Bybee (1997) argued that students used previous information about the topic being studied. The previous information is also helpful for solution of problems relative to current topic. Students are engaged to use discovery method for asking questions. Problems can be introduced by defining problem to solve by using actual methods. Teacher plays a role of facilitator. He/she instils the principles when setting a mission. Therefore, the situation of "unbalance" is seeing (Bulbul, 2010).

Exploring

According to (Lawson and Thompson, 1995) learners need a time frame for the development of concept related to problems. Therefore, exploration based activities are designed to enables learners engagement in topic and about new skills perceptions or procedural aspects of problem solving. In the start of phase learners used "Balance" for the solution of the

problem (Bulbul 2010). Bybee (1997), describes that various methods are used for teaching learning process. But to support scientific and logical approval of concepts, software should be carefully designed. Students' earlier rehearsals can be explored by the activities so the students, can develop novel ideas, skills and processes to apply them for bringing innovative ideas to gather exploring objects, specific events and situations are the central targets. Students become able to learn new things. As the role of teachers as facilitators and they to guide them (Bulbul, 2010). The teacher made this point for learner when the learners tried to comprehend the world around them provided essential condition and time distribution (Bybee, 2006). The idea of facilitator is reinforce when students rebuild their experiences.

Explaining

The explaining process introduces learners and teachers to the terms used in subsequent works (Bybee, 1997). Teachers strive for attracting the attention of students to reached specific points in the previous stages of participation and exploration. Proper environment is required for sharing experiences by learners. Afterwards, teachers take turns to provide description about science and technology in a clear, direct and formal manner. The exploration arrangement is a so called interpretation (Bulbul, 2010). The teacher asks about connection between experience and interpretation based on the previous knowledge, stage, participation and exploration.

The relevant features provide the essential conceptual knowledge of the topic being studied in simple, flawless, inclusive and upright manner. Bulbul (2010) Narrates the teachers can give strategies and techniques and concentrate on successful learning styles and strategies for promotion of students' depiction. Verbal descriptions with collaborating of others tools like course instruments, videos movies and computer applications. This phase allows psychological organization for continuity. This stage also shows the ability of the students to describe practices based on exploration (Bybee, et al., 2006).

Elaborating

The students are required to be involved in experience to widen their thinking about the studied topic. Therefore, the elaboration phase contributes to the transfer of learning (Bulbul, 2010). Learners exploratory phase activities provide learners the opportunity to capture enormous concept with more learning experiences. One of the opportunities is to assess the level of understanding by using the learners' skills. This skill is develop self-respective perspective. Students should be provided necessary feedback from the learners (Bybee, et al., 2006).

Evaluating

Informal and initial assessment level starts and lasts during the 5E instructional sequence teacher can conduct formal assessment (Bulbul, 2010). To assess the level of individual understanding being studied (Bybee et al., 2006).

Research Methodology

This study was true experimental. In which a pre-test, post-test equivalent group design was employed by the researcher. It was consisted of two groups; experimental and the control,

which were equated on the basis of marks achieved by the students in the pre-test from grade 10th Chemistry, published by the National Book Foundation, Federal Textbook Board, Islamabad (2022). In this study, the participants consisted of all 10th grade boys science students enrolled in 45 Boys Secondary Schools which were administered by Federal Directorate of Education, Islamabad. The achievement of 10th grade students studying chemistry was measured by applying the pre-test and post-test developed by the researcher. Data of the study were consisted of the scores achieved from the pre-test and post-test of 10th grade students. After scoring the responses of students on pre-test and post-test SPSS, version-22 (Statistical Package for the Social Sciences) were used. After collecting data from the students, the data were analysed. The descriptive analysis was used to calculate the measures central tendency (mean) and measures of dispersion (Standard Deviation). The researcher applied dependent t-test to compare the achievement of students of the same group in pre-test and post-test. Another inferential statistic test was used called the independent sample t-test, which is a statistical test to compare the achievements of experimental and control groups and to determine the significant difference in both groups. Correlation (r) also used to find out the strength of the relationship between the groups.

Results

Table 1 *Experimental Group Pre-Test Post-Test Mean* (Paired Samples Statistics)

Group (Pair)	Mean	N	Std. Deviation	Std. Error Mean
Pre-Experiment	35.7750	40	9.55547	1.51085
Post-Experiment	65.5000	40	5.76906	.91217

Table 1 indicates that there were 40 students in the experimental group who were tested before and after the experimentation. The pre-test mean scores of the experimental group was 35.78 and the mean scores in post-test of the same group after treatment was 65.50. The standard deviation of the pre-experimental and the post-experimental groups were 9.56 and 5.77 respectively. Moreover, the standard error mean of the pre-experimental and the post-experimental groups were 1.51 and 0.91 respectively.

The difference in the mean scores (29.73) indicate that there was big improvement in the students' academic achievement before and after the experimentation. The experimental group was treated with the 5E's instructional model.

Table 2 *Experimental Group Pre-Test Post-Test Correlation (*Paired Samples Correlations)

Group (Pair)	N	Correlation	Sig.
Pre-Experiment & Post-Experiment	40	.566	.000

Table 2 indicates the correlation between pre-test and post-test in the experimental group. The correlation coefficient (r) value between pre-test and post-test was 0.57 which shows a moderate positive association between them. Which indicating an increase in student academic achievement from the pre-test to the post test. In addition, the significance level is 0.00, which is less than the alpha value. In this context, a significant value that is less than the alpha value (0.05) indicates a significant difference in the academic performance of the experiment group students before and after the treatment.

Table 3 *Experimental and Control Group Achievement Mean* (Group Statistics)

Group	N	Mean	Std. Deviation	Std. Error Mean
Experimental	40	65.5000	5.76906	.91217
Control	40	53.5750	5.66993	.89649

Table 3 shows that there were same number of students in the control and experimental groups who were tested after the experimentation. The mean score of the experimental group was 65.50 and the mean score of the control group was 53.58. The standard deviation value of the experimental and the control groups were 5.77 and 5.67 respectively. Moreover, the standard error mean of the experimental and the control groups were 0.91 and 0.89 respectively. The mean value of results for the two groups showed that there was significant difference in the mean scores of the experimental group and the control group after the treatment. Therefore, the null hypothesis, "there is no significant difference between mean post-test scores for students' taught through 5E's instructional model and traditional teaching method", was rejected.

Table 4 *Experimental and Control Group Post-Test Mean* (Independent Samples Test)

	Levene's test		t-test for equality of means						
Group	*F*	*Sig.*	*T*	*df*	*Sig.(2-tailed)*	*MD*	*SED*	*95%CI*	
								LL	*UL*
Scores	.070	.79	9.32	78	.000	11.93	1.27	9.37	14.47

Note. MD=mean difference; SED=std error difference; CI=confidence interval; LL= lower limit; UL=upper limit

It is clear from table 4 that the mean difference in post-test of experimental group and control group after the treatment was 11.93 and the standard error difference was 1.27. The t value was 9.32 and the significance level was 0.00 which is less than 0.05. It was interpreted that there was a significant difference in the achievements of control group and experimental group after the treatment. It was observed that there was a significant difference between Effectiveness of 5E's instructional model and traditional teaching method on students' achievements.

Conclusions

1. To investigate the effect of 5E's instructional model on students' academic achievement in 10th grade Chemistry. From the findings it is revealed that the experimental group achieved significantly better in the post-test as compared to the pre-test. It is concluded that the students at secondary level can achieve better knowledge in the subject of Chemistry by applying 5E's instructional model in the classroom.
2. To compare the effect of 5E's instructional model and traditional teaching method on students' academic achievement in 10th grade Chemistry, it is concluded that the significant academic achievement difference in the experimental and control group was found after intervention through 5E's instructional model and traditional teaching method respectively. Students of experimental group performed better because the 5E's instructional model has several advantages like encouraging students to develop their own understanding and perceptions. It also allows the teaching environment to be organized around targeted

concepts and supports the use of different strategies by facilitating an integrated teaching approach. It developed interest in learning of the students due to student centred approach. It is concluded that if teachers have a framework for five stage learning activities in a 5E's instructional model students will perform better as compared to lecture method. It also respects student's differences, ensures the transition from subjectivity to objectivity for integrated learning, and improves the holistic thinking style.

Recommendations

This experimental study concludes that 5E's instructional inquiry based model enhance the academic achievement of science students in Chemistry at secondary level. This experimental study may offer a new platform for upcoming researchers. Therefore, the valuable recommendations for future researchers are given below:

1. The similar study may be repeated with different population to confirm the results of the current experimental study.
2. The researchers can conduct this experimental study at other levels also e.g., primary, middle and higher secondary levels because this study is delimited to secondary schools level.
3. This experimental study was conducted to find out the effectiveness of 5E's instructional model at secondary level in the subject of Chemistry. The other science subjects e.g., Biology, Physics, Computer Sciences and Mathematics may also be investigated by this model.
4. This experimental study may be carried out in girls' school, as this research study is delimited to only one boys' school. Furthermore, boys' and girls' school result findings are also compared with each other.

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