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Impact of Concept-Based Activities Using the E-7 Learning Model on Students' Academic Achievement and Critical Thinking in General Science

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Abstract

The study aimed to compare two teaching strategies for general science at the elementary level: concept-based activities (CBA) and traditional lecture methods (TLM). The experimental group received instruction through concept-based activities, while the control group was taught using traditional lectures. The primary purpose of the study was to enhance students' critical thinking abilities. A factorial design was employed, and student achievement was measured using 80 multiple-choice questions (MCQs) on the SAT. The E-7 learning model was applied, and four null hypotheses were tested before and after treatment. Findings revealed that both boys and girls showed significant improvement in mean achievement scores after treatment. A sample of 100 students was selected from Government Girls Primary School Dingi, Haripur, and Government Boys Primary School Dingi. Data were analyzed using mean scores, standard deviation, and independent sample t-tests, with Cohen's d used to measure effect size. Overall, the study suggests that concept-based activities are an effective teaching strategy for general science at the elementary level. Moreover, they foster critical thinking skills among students. Specifically, the use of the E-7 learning model supports concept development more effectively than traditional lecture methods.

Key words: E-7 Learning Model, Concept Based Activities (CBA), General Science (GC), Academic- Achievement (AC), Paired Sample t-test, Critical Thinking Ability (CTA), Traditional Lecture Method (TLM).

Introduction

The concept-based method involves in the critical thinking process and concept clearance. For this purpose, different models are used for learning science at various levels for teachers and students to enhance their learning and increasing their critical thinking ability. The E-5 model is based on following; Engage, Explore, Expand, Elaborate, Evaluate (Trowbridge & Bybee, 1990). This model is again recommended as E-6 Model, consisting of six basic elements including; Excite, Explore, Explain, Enrich, Excel, and Evaluate (Chessian & Moore, 2004). The E-5 Model is used in the training manual for the capacity building of elementary teachers in different training institutions of Khyber Pakhtunkhwa (CIDA-ASSISTED) for training of teachers and learning process of students at classroom level producing critical thing ability among students (Bybee & Landes, 1990; Spaulding et al., 2003). Moreover, this model is designed for the training of teachers and the effective learning of students at the elementary level. This manual is based on Dimension of Learning (DOL). On the other hand, Marzano et al., (1997), who wrote the second version of the Dimension of Learning manual, were the ones who first advocated the E-6 Model. This second edition handbook is based on

a variety of previously related publications, including classroom management and instructions that work for student learning and critical thinking ability production (Marzano et al., 2001), The Marzano teacher evaluation model is also based on number of previous related work which basically means for concept clearance and concept building of learners, including what work in schools (Marzano, 2003) which were methods for concept-based activities (CBA) and self-concept development of students (Marzano, 2006).

The art of science and teaching helps in effective outcomes of learning of students and producing critical thinking ability (Marzano et al., 2011). These works were generated from synthesis of educational research and theory. Therefore, the model can be considered as an assemblage of different researches on those elements that have traditionally be shown to correlate with learners' academic achievements. The E-7 Learning Model incorporates different cognitive levels in hierarchical manner used by researcher Eisenkraft (2003), for planning lessons in general science and based on Elicit, Engage, Explore, Explain, Elaborate, Evaluate, Extend. Accordingly, this learning model is helpful for understanding of basic concept of science subject at elementary level. One of the major impacts of concept-based learning is the use of E-7 model on student's mental growth and their capabilities of understandings through systematic way, Moreover, it increased critical thinking ability among students. Hence, this model is also used to improve the scientific literacy among students at elementary level and creates critical thinking ability among students (Anggrisia & Fatimah, 2019). Therefore, these models are helpful for learning process of students and making concept-based method of teaching for students meaningful at various levels (Muslim & Setiawan, 2017; Anggrisia & Fatimah, 2019).

Concepts serve as mental categorization for events, images, ideas, skills, objects and people that share some common features across multiple contexts and situations for learning of science which increased critical thinking ability among students. Concept based activities (CBA) in science education method is defined as large or wide picture, ideas and learning activities that explains the organization and categorization of information in a systematic way. Similarly, traditional learning patterns or models help in concentrating on the capabilities of recalling specific facts and concept-based activities (CBA) that assists to focus on understanding wider principles or ideas called by researcher's concepts that enhanced critical thinking ability among students. These concepts can then later be applied to a variety of several examples of general science subject producing critical thinking ability. Moreover, these concepts range from simple to complex according to how researcher has defined relationship of a teacher and student. Concept based activities (CBA) are implemented as top-up approach verses the bottom-up model used in more traditional learning ways for understanding ideas. While, traditional learning activities (TLA) left as a rote memorization of facts and figures in general science subject. The concept-based activities (CBA) empower the students' critical thinking abilities while they encounter new situations or contexts. In order to achieve teaching objectives of student learning, it is essential to select and use the conceptual teaching strategies and tactics which enhanced critical thinking ability (Higgins et al., 2005).

The basic purpose of this study was to see the impact of concept-based activities (CBA) on academic achievement of mean score, in subject of general science at elementary school level which create critical thinking ability among students. This study also reveals the contrasted link between the concept-based technique (CBA) and the traditional teaching method (TLM).

THE E-7 LEARNING MODEL There have been further developments. Eisenkraft (2003) has proposed a E-7 learning cycle approach. National science education standard (NRC, 1996) also recommended the E-7 modelE-7 Model as a learning model, depending on the nature of the activity related to student's interest, needs and preferences and enhanced their critical thinking abilities. The model is summarizing below

The E-7 'learning cycle model

Elicit	This established the prior understandings of students, often by means of brain-storming and visual creative activities
Engage	This aimed to motivate learners by introducing areas where the topic to be studied was relevant or important.
E**xplore**	Involve the students in making predictions, designing experiments, and collecting and analyzing data
Explain	Here the teacher develops the key ideas, concepts and terminology, with students helped to express understandings
Elaborate	The teachers provide opportunities for students to practice and transfer their learning into to new contexts
Evaluate	The teacher uses both formative and summative evaluation to address all aspects of the entire learning experience.
Extend	Understandings were broadened and expanded into wider scientific areas.

Research Question

Q1 What is the impact of concept-based activities on students' academic mean scores achievement in General Science subject at elementary level before and after treatment?

Research Hypothesis

$H_{01:}$ There is no significant difference between mean students' achievement scores (SAT) of boys experimental group taught through concept-based activities (TTCBA) in general science before and after treatment.

$H0_2$: There is no significant difference between the mean students' achievement test (SAT) scores of girls experimental group taught through concept-based activities (TTCBA) in general science before and after treatment.

Ho_3: There is no significant difference between the mean students' achievement test (SAT) scores of boys control group not taught through concept-based activities (NTTCBA) in general science before and after treatment.

Ho_4: There is no significant difference between the mean students' achievement test scores (SAT) of girls control group not taught through concept-based activities (NTTCBA)in general science before and after treatment.

Research Methodology

This study employed an experimental research design using 2×2 factorial design involving two variables and two groups both formed through random assignment (Lodico &Voegtle, 2010), as guided literature (Cresswell,2014). The first variable was the teaching method, the experimental group received through concept-based method using the 7-Elearning model, while the control group taught through traditional lecture methods. The second variable was gender. Their mean score achievement of boys and girls shows which method is more effective either concept-based method or traditional lecture methods., The second variable was gender, their mean achievement of boys and girls which method is more effective either concept-based method or traditional lecture method. Two government schools (one for girls and one for boys) were selected for the study. Total of 100 students

(50 boys 50 girls) were chosen from population of 107 and randomly assigned to either the experimental or control group. The experimental group consisted of 107 and randomly assigned to either experimental or control group. The experimental group consisted of 25 boys and 25 girls taught through conventional instructions. Outliers were removed from the data (Mujis, 2004). Grouping was based upon pre test scores to ensure equivalence between two groups, Content validity of achievement test was established through expert's review, while reliability was assessed using Cronch's Alpha, yielding a coefficient of 0.818, including high internal consistency.

Procedure

The experiment was conducted at Government Girls Primary school Dingi District Haripur. Out of 107 enrolled students,7 outliers were removed, leaving a final sample of 100 students,7 outliers were removed, leaving a final sample of 100 students(50 Boys and 50 Girls).Participants were randomly assigned to two groups: experimental group(25 boys and 25 girls) and a control group (25 boys and 25 girls).The experimental group was taught using the Concept- Based Approach(CBA) before and after treatment following the E-7 learning model, while control group revised instructions through the traditional lecture method(TLM) before and after treatment. The intervention covered six chapters from Grade 5 General Science Curriculum KPK-TEXT BOOK BOARD over a period of 8 weeks. 01Sort of chapters were taught in one week, while long one completed within (02) two weeks. Lesson plans for the experimental group were developed with the guidance of subject specialists, research advisors using E-7 learning model for experimental group and general lecture method format were prepared for traditional lecture method (TLM).The lessons included interactive and enquiry based teaching which creates critical thinking ability among students , moreover, the lesson plans included such as flow charts, web Diagrams, Jigsaw activities, environmental observations, microbic studies of microbes, chart analysis, diagrammatic sketch completion, mapping of flow chart diagrams, study of plants and animals structures. A pilot test of students Achievement Test (SAT) was conducted to refine the instrument. Both on the pilot results, 20 items were removed, leaving 80 multiple-choice questions (MCQs)c for final version. Both groups completed a PRE-TEST prior to intervention and POST-TEST after measure the learning outcomes. Two trained volunteer teachers (0ne male, one female) conducted the classes Teachers were briefed during the first week regarding the implementation procedures. The experiment lasted for 08 weeks during which the control group were taught through traditional lecture method.

Data Collection

Data were collected by the researcher and subject experts before and after intervention using the students, Achievement test (SAT) score. The data consisted of student's achievement test score from the both groups for example, experimental and control groups

Data Analysis

Data were analyzed using descriptive and inferential statistical techniques for subject of general science. Descriptive statistics, including mean scores and standard deviations, were computed to summarize the performance of students in both groups (Experimental & Control group). To determine the significance of difference of pre test and post test scores, a paired sample t-test was applied. Additionally, Cohens' d was calculated to measure the effect of size, assessing the magnitude of the treatment's impact on students' academic achievements which produce in students creative and critical thinking ability in the subject of general science.

Results

Following are the results of the study before and after treatment

Comparison of Mean Scores of Experimental Groups before and After Treatment

Table 1

Comparisons of Boy's Experimental Group in SAT Scores Before and After Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	66.88	7.63	1.53	0.845 (0.000)	23.48	5.55	1.11	21.139 (0.000)
Pre	25	43.40	10.22	2.04					

Table 1 shows that student achievement test (SAT) scores of boys experimental group TTCBA group in pre- test (N=25, Mean=43.40 SD Score=10.22, SE Mean=2.04) and in posttest (N=25 Mean = 66.88, SD Score =7.63 SE Mean=1.53). The value of correlation (r=0.845) p=0.000 <0.05 also showed very strong significant relationship between post and pre-SAT scores. Paired differences of posttest and pre-test Mean=23.48 SD=5.55 SE Mean=1.11. The difference of SAT scores between pre-test and post-test is statistically significant as t-value=21.139, p=0.000 < 0.05. Table 2

Comparisons of Girl's Experimental Group in SAT Scores before and after Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	64.88	8.82	1.76	0.843 (0.000)	21.96	5.25	1.05	20.126 (0.000)
Pre	25	42.92	9.69	1.94					

Table 2 shows that student achievement test (SAT) scores of boys experimental group TTCBA group in pre- test (N=25, Mean=42.92 SD Score=8.82, SE Mean=1.94) and in posttest (N=25 Mean = 64.88, SD Score =9.69SE Mean=1.94). The value of correlation (r=0.843) p=0.000 <0.05 also showed very strong significant relationship between post and pre-SAT scores. Paired differences of posttest and pre-test Mean=21.96 SD=5.25 SE Mean=1.05. The difference of SAT scores between pre -test and post-test is statistically significant as t-value=20.126, p=0.000 < 0.05.

Comparison of mean scores of control groups before and after Treatment

Table 3

Comparisons of Boy's Control Group in SAT Scores before and after Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	53.88	7.14	1.43	0.804 (0.002)	10.72	5.59	1.12	9.582 (0.00)
Pre	25	43.16	9.38	1.88					

Table 3 shows that SAT scores of boys control group NTTCBA group in pre- test (N=25, Mean=43.16 SD Score=9.38, SE Mean=1.88) and in posttest (N=25 Mean =53.88, SD Score =7.14 SE Mean=1. 43). The value of correlation (r=0.804) p=0.000 <0.05 also showed very - significant

relationship between post and pre-SAT scores. Paired differences of posttest and pre-test Mean=10.72 SD=5. 59 SE Mean=1.12. The difference of SAT scores between pre -test and post-test is statistically significant as t-value=9.582, p=0.000 < 0.05

Table 4

Comparisons of Girl's Control Group in SAT Scores before and after Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	56.52	7.26	1.45	0.570 (0.003)	14.76	8.50	1.709	8.686 (0.000)
Pre	25	41.76	10.18	2.03					

Table 4 shows that SAT scores of boys control group NTTCBA group in pre- test (N=25, Mean=41.76SD Score=10.18, SE Mean=2.03) and in posttest (N=25 Mean =56.52, SD Score =726SE Mean=1.45). The value of correlation (r=0.570) p=0.003 > 0.05 also showed non-significant relationship between post and pre-SAT scores. Paired differences of posttest and pre-test Mean=14.76SD=8.50SE Mean=1.709. The difference of SAT scores between pre -test and post-test is statistically significant as t-value=8.686, p=0.000 < 0.05.

The above results showed that the performance of boys and girls were better when taught them through concept-based activities (CBA) as compared to traditional lecture methods (TLM) before and after treatment using their mean scores, It also increased their critical thinking ability when taught through concept-based activities.

Discussion

The purpose of this study was to compare the effectiveness of **concept-based activities (CBA)**, implemented through the **E-7 learning model**, with **traditional lecture methods (TLM)** in teaching general science at the elementary level. The findings consistently demonstrated that students taught through CBA achieved significantly higher mean scores and exhibited stronger **critical thinking abilities** compared to those taught through TLM. The results revealed that both boys and girls in the experimental group improved substantially in their post-test scores compared to their pre-test scores. The paired sample t-tests confirmed that these differences were statistically significant, with large effect sizes (Cohen's d). This suggests that concept-based activities foster deeper engagement, active participation, and enhanced conceptual understanding. In contrast, while the control group also showed improvement, the magnitude of gains was smaller, indicating that traditional lecture methods are less effective in promoting higher-order thinking skills. Both boys and girls benefited from CBA, with improvements in mean scores observed across genders. Importantly, the factorial design allowed examination of gender as a variable, and results showed no substantial gender differences in the effectiveness of CBA. This implies that concept-based approaches are equally beneficial for boys and girls, supporting equitable learning outcomes in science education. A central aim of the study was to examine whether CBA enhances **critical thinking ability**. The inclusion of interactive strategies such as flow charts, jigsaw activities, environmental observations, and diagrammatic analyses encouraged students to question, analyze, and synthesize information rather than passively receive it. The significant improvements in achievement scores suggest that CBA not only improves factual knowledge but also cultivates critical thinking, aligning with constructivist theories of learning. Although students in the control group (TLM) showed some improvement, their gains were modest compared to the experimental group. The lecture method, while efficient for content delivery, lacks

the interactive and inquiry-based elements necessary for fostering critical thinking. The weaker correlations and lower effect sizes in the control group reinforce the limitations of TLM in promoting higher-order learning outcomes. The findings have important implications for **curriculum design and instructional practices**. Science educators should integrate concept-based activities into classroom teaching to enhance student achievement and critical thinking. The E-7 learning model provides a structured framework for implementing such activities, ensuring that lessons are inquiry-driven, student-centered, and conceptually rich. This approach aligns with global educational trends emphasizing active learning and competency-based education.

In summary, the study demonstrates that **concept-based activities significantly outperform traditional lecture methods** in improving students' academic achievement and critical thinking in general science. Both boys and girls benefited equally, highlighting the inclusive potential of CBA. The results underscore the need for educators and policymakers to adopt innovative, concept-driven teaching strategies to prepare students for the demands of modern science education.

Conclusions

Before the treatment, the pretest scores of students taught through concept-based activities (TTCBA) and those taught through Traditional LectureMethod (NTTCBA) were nearly identical, with no outliers, indicating the both groups were equally matched through stratified sampling techniques and enhanced critical thinking ability among students. After intervention, the post test scores of TTCBA groups were significantly higher than those of NTTCBA group. This demonstrate that students taught through concept – based activities (TTCBA) achieved better academic performance., likely due to increased engagements and enhanced conceptual understanding which increased their critical thinking ability. The findings suggest that contemporary science educators which adopt concept-based activities and Concept-based teaching strategies (CBA) to improve students, critical thinking, cognitive skills and overall academic achievement in their mean scores.

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