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Analyzing the Effectiveness of Bloom's Taxonomy in the Context of Science Teaching at Elementary Level

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Abstract

Bloom's Taxonomy is a hierarchical model that categorizes learning into cognitive, affective, and psychomotor domains. It aids teachers in understanding teaching objectives, reducing question complexity, and promoting critical thinking. This study provides educators, curriculum developers, and policymakers insights into incorporating Bloom's Taxonomy in science instruction. In this study, Quasi-experimental Design was used. Pre-test and post-test were employed for the traditional group and treatment group. Two groups were involved in the data collection procedures: an experimental group (Group A) and a control group (Group B). Group A received instruction based on Bloom's teaching methodology objectives, whereas Group B did not. The teaching duration was ten weeks, with four days per week. A total of forty lessons were delivered according to the lesson plan. The population of this study consisted of 80 students of 8th class. These students were from Government Elementary School Chak No.1 Hans, Multan. Sixty (60) male students were selected for the study. Thirty (30) male students were chosen for the traditional group, and thirty (30) male students were selected for the treatment group. A thirty-mark test was designed to assess the progress of science teaching and learning. The test assessed knowledge, comprehension, and application of scientific concepts taught during the research period. The independent samples t-test was used to compare the two groups. The collected data were analyzed using SPSS version 26 and the independent samples t-test. The chi-square test was used for hypothesis testing. The findings of this study provide valuable insights for educators, curriculum developers, and policymakers to make informed decisions about instructional strategies, curriculum design, and assessment methods. The goal is to enhance student engagement, critical thinking skills, and scientific inquiry abilities, ultimately fostering a deeper understanding and appreciation of science among elementary students.

Key Words: Bloom's Taxonomy, Science instruction, Experimental group, Critical thinking, Instructional strategies, Elementary education

Introduction

Education is the foundation upon which the progress and prosperity of societies are built. The key unlocks the potential of individuals and nations, empowering them to navigate a complex and ever-changing world. Through education, individuals gain the knowledge, skills, and values necessary to contribute to their communities and the broader global landscape. In this light, the role of education is pivotal, as it acts as the bridge between the past and the future, equipping learners with the tools they need to thrive and make informed decisions in an increasingly interconnected and fast-paced world (Graham & champs, 2022).

At the heart of effective education lies the intricate science of teaching and learning. This dynamic field continually seeks innovative methods and strategies to enhance the quality and impact of education. It is the crucible in which educators, researchers, and policymakers come together to mold the educational experience, striving to create a transformative journey for learners. Education is not merely a static process of transferring information; it is a dynamic process that inspires intellectual curiosity, encourages critical thinking, and fosters lifelong learning (Sayed & Kalam, 2021).

Bloom's Taxonomy, a venerable framework in education, is one such tool that has significantly contributed to enhancing teaching and learning. First conceived by Benjamin S. Bloom in 1956, this hierarchical model purports to categorize educational objectives into six cognitive levels in a systematic way, with each level being built on its previous level. From the lowest level of Knowledge to the highest level of Evaluation, these levels give educators a roadmap that may assist in curriculum design, instruction, and assessment. This includes Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation in that order. It has provided educators with a systematic guideline to assist them in developing learning experiences and attaining a profound understanding of the subject matter. Through the years, Bloom's Taxonomy has altered. Indeed, it has evolved with the changing times and the continuous demand of an information-driven society. Anderson and Krathwohl developed a revised taxonomy version that integrated current knowledge of cognitive psychology and education. This new version acknowledged that cognitive levels are interrelated and focused on developing more valuable learning experiences (Krathwohl, 2002).

The relevance of Bloom's Taxonomy to Elementary Science Education cannot be overemphasized. This level of education is the base and foundation that provides information on the natural world and its primary scientific indication. During these years, the students go through phases of developing their critical and problem-solving thinking, scientific literacy, and abilities that will shape their future experiences. Hence, this calls for the need to analyze

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the effectiveness of Bloom's Taxonomy among the young learner's science education thus (Rahman & Manaf, 2017).

Bloom's Taxonomy has found an increased application in science education to improve teaching and learning at an elementary level. Science education within this level is significant for developing scientific conceptions formed in students and fostering scientific inquiry skills. There was a dire need for effective teaching strategies to evoke critical thinking, problem-solving abilities, and conceptual understanding to ensure scientific literacy among young learners. Therefore, Bloom's Taxonomy integrated into science education can enable a shift in the traditional pedagogical approaches and drive educators to move beyond mere recall of facts to a student-centered, inquiry-based teaching methodology (LW et al., 2001).

By implementing Bloom's Taxonomy in science teaching, educators aimed to provide more learning opportunities for students to become more active learners of science, make connections of ideas and apply knowledge in authentic situations. While Bloom's Taxonomy became increasingly used in science teaching, there was a need for a critical investigation that would provide a practical evaluation of Bloom's Taxonomy in the context of elementary science teaching. The research might also lead to an in-depth insight into the influence of Bloom's Taxonomy on the student's learning outcomes, motivation, and involvement. Such findings would prove very useful for educators and policymakers searching for evidence-based strategies for improving science learning at the Elementary Level (Krajcik & Czerniak, 2018).

According to Chin and Osborne (2008), the primary objective of this research study was to critically appraise the impact of Bloom's Taxonomy on science teaching at the elementary level. This study also located and analyzed the study in the exhaustive reviewing process of empirical research studies, theoretical perspectives, and practical approaches by which Bloom's Taxonomy is used within the context of an elementary science classroom. As educators face various challenges and limitations in using Bloom's Taxonomy accordingly, those were also discussed in the area of investigation. The results of this study contributed to the wealth of information about science education pedagogy, focusing on the influence of Bloom's taxonomy. Consequently, the research result became beneficial for the teachers, curriculum developers, and educational policymakers to provide a clear understanding of instructional practices and curriculum design in consideration of improving elementary-level science teaching. The ultimate goal was empowering students to achieve a higher success rate, develop critical thinking skills, and become scientifically literate at a young age to build a foundation for further scientific exploration and understanding.

Bloom's Taxonomy is one of the accepted classifications of cognitive skills and educational goals; it merely underpins most of the recent modifications in pedagogical and strategic changes; thus, its effectiveness in teaching science at the Elementary Level has significant educational implications. Elementary science education provides a foundation for students to understand the world around them. We can take the fact that Bloom's taxonomy corresponds with this level of education to improve the quality of science instruction with young students to help develop the cognitive skills required to fuel their future success at each academic level. The connection of Bloom's Taxonomy to elementary science education directly impacts student learning. It could assist teachers in designing lesson plans aligned with their young students' cognitive development level, possibly leading to more interest, better comprehension, and, in the long run, more successful learning of their lessons. Furthermore,

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the pedagogical relevance of this study should not be undermined since it has the potential to vastly contribute to the body of knowledge in education through the empirical investigation of how practically practical Bloom's Taxonomy is in an elementary science classroom (Warner, 2016).

Generally, students' cognition and knowledge retention, as well as the development of a long-lasting interest in the subject, pose significant problems in elementary science education. By investigating Bloom's Taxonomy effectiveness, this present study can provide answers to alleviating such problems. In other words, it has the potential to provide new strategies that would make it possible to overcome obstacles teachers and students face in the elementary science classroom. This research will significantly contribute to elementary science teachers. It provides them with evidence-based conceptions about the best teaching method, thus aiding their professional growth in developing more effective science teaching. It helps the teachers match the learning strategies with the cognitive capabilities of the young learners to optimize teaching. Most of the related research on Bloom's Taxonomy has been conducted in different academic settings; however, few studies may be mainly related to using this taxonomy in science teaching at the elementary level. In this way, your research shall help bridge this gap in existing knowledge and further contribute meaningfully toward improving the field concerned. The explicit focus on elementary science instructions deepens our insights as to how Bloom's Taxonomy can best be refined to meet the particular needs of young learners in the setting of science learning (Dunlosky et al., 2013).

According to Shen et al. (2009), this research can lead to the development of implications for educational policies at the Elementary Level. The research findings might influence the standards and guidelines for the science curriculum and provide an overall orientation toward the teaching of science in an elementary curriculum. Beyond the implications for educators and policymakers, Bloom's Taxonomy can enhance science education, improve student learning outcomes, and advance teaching practices in elementary science teaching. Its study encompasses a significant and relevant area of interest in education.

The Cognitive Domain

The cognitive domain in Bloom's Taxonomy involves much of the intellect and skills. This involves acquiring, applying, and developing scholarly capacity and skill. The cognitive domain encompasses six major categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. These categories, developed by Benjamin Bloom, are structured in an order that reflects increasing levels of intellectual complexity. Knowledge level requires recalling and understanding a fact, concept, or principle. Comprehension requires the student to demonstrate an understanding and interpretation of information beyond simply recalling knowledge. The application involves the practical application of knowledge and understanding acquired in new and relevant situations. Analysis requires breaking down complex information into constituent parts and examining their relationships. Synthesis goes even one step further and asks students to combine pieces to form something new or original. Lastly, Evaluation is the highest level in the cognitive domain, whereby students make judgments and assess based on criteria and standards. By categorizing the cognitive domain, Bloom's Taxonomy provides educators with a framework to develop instructional activities that challenge student's cognitive abilities progressively and foster higher-order thinking skills. This hierarchical structure beckons the student toward developing skills in critical thinking, solving problems, and creative thinking as they move along the different levels of cognitive complexity (Adams, 2015).

The Affective Domain

The affective domain is a dimension of Bloom's Taxonomy that deals with feelings and emotions regarding learning. It involves changing attitudes, interests, appreciation, and modes of adjustment. Krathwohl's taxonomy in 1964 classified five categorizations under this field: Receiving, which is when the learner becomes willing and open to experience; Responding, entailing active engagement with what is received; Valuing, which is an attainment level where the learner internalizes and attaches importance to some values and ways of attitudes; Organization, in which the values get arranged into a value scheme; and Characterization, which is the ultimate pinnacle throwing up the behavior in which the learner consistently shows based on his developed value system. Attending to the affective domain in education also produces well-rounded individuals with good cognitions, constructive attitudes, empathy, and ethical behavior. Addressing the practical objectives in teaching leads to a supportive and inclusive learning environment that prepares students well for society (Wu et al., 2019).

The affective domain in Bloom's Taxonomy essentially deals with emotions and attitudes regarding learning. Objectives involved in changing attitudes, interests, appreciation, and adjustment modes are all under the affective domain. In the 1964 classification by Krathwohl, five categories were introduced under this domain: Receiving, Responding, Valuing, Organization, and Characterization. Receiving involves being open and attentive to new experiences, while responding encourages active engagement and expressing thoughts and feelings. Valuing leads to consideration of multiple viewpoints more profoundly, whereas Organization helps students sift what values need to be considered and integrated. Characterization is the highest level of integration whereby learners habitually act in concert with values that have been internalized. Addressing the affective domain in education fosters well-rounded individuals with cognitive skills and emotional intelligence. Integrating affective objectives creates a supportive learning environment, preparing students for responsible citizenship and positive societal contributions (Hoque, 2017).

The Psychomotor Domain

The psychomotor domain represents a significant facet of educational objectives, encompassing various perceptual and motor-skill areas. This domain demands a higher order of cognitive and practical capabilities, necessitating the fusion of thought processes with physical actions. It revolves around developing and refining various muscular skills and coordination, resulting in the acquisition of practical proficiencies and habits. At its core, the psychomotor domain emphasizes applying knowledge through action, fostering a profound understanding of theoretical concepts using practical engagement. Students in this domain gain theoretical insights and cultivate the dexterity and competence to execute tasks precisely and with finesse. Approaches in the psychomotor domain in education cover a large spectrum. For example, laboratory experiments, wherein students take part directly in the investigation through the manipulation of natural materials, form a common core within the aims of grasping principles and concepts in science. The experiment, therefore, becomes a dynamic learning arena where theory and practice can be linked. Work-experience programmers are good channels through which students are exposed to the real world for assimilation, helping them apply theoretical knowledge in professional environments. Learners achieve pragmatic views through internships and practical work placements that enhance adaptability and essential critical problem-solving skills; key elements for their eventual success. In teaching-learning, practical works lie at the center of the psychomotor domain. Indeed, this area consists of various activities, starting from fine arts and ending with technical skills. Project work and activity work are performed along with the development of students' psychomotor and cognitive skills. Psychomotor domain: Here, the teacher acts more like a guide and a rater to the students. Their expertise lies in structuring experiences that facilitate the development of perceptual and motor skills. By creating well-crafted lesson plans, educators can foster an environment where students can thrive and refine their practical proficiencies. The psychomotor domain in education epitomizes the fusion of cognitive prowess with physical abilities, encompassing a rich array of perceptual and motor-skill objectives. By promoting practical engagement, laboratory experiments, work-experience programmers, and hands-on activities offer invaluable avenues for students to apply theoretical knowledge, culminating in developing essential practical competencies and habits. Thus, nurturing the psychomotor domain is a vital aspect of comprehensive education, equipping learners with the multifaceted skill sets necessary for success in both academic and real-world settings (Reigeluth, 2009).

Statement of the Problem

In the context of science education at the elementary level in Pakistan, where the overall quality of education was hindered by traditional teaching methods and the proficiency of teaching staff, there existed a significant gap in implementing innovative and effective pedagogical approaches. The persisting use of conventional teaching methods failed to align with the requirements of the modern critical syllabus, leaving students unfamiliar with contemporary scientific concepts and ideas. Despite the global availability of various teaching methodologies, such as Bloom Taxonomy pedagogies, which had demonstrated efficacy in teaching general science, there was a lack of research exploring the application and impact of Bloom's Taxonomy in the Pakistani elementary science education landscape. This study aimed to address this gap by examining the effectiveness of Bloom's Taxonomy compared to the traditional learning method in enhancing the understanding and retention of scientific concepts among elementary-level students. The investigation focused on evaluating the relevance and applicability of these pedagogical approaches in the Pakistani educational context, with potential implications for improving science education at the Elementary Level.

Objectives of The Study

1. To investigate the pre-test scores of 8th-class students in general science before forming control groups for the experiment using different pedagogies.
2. The posttest scores for the students taught through Bloom's Taxonomy and those taught through traditional pedagogy should be compared to hold a fair analysis of the effects each may have.
3. To assess the efficacy of investigating traditional teaching methods and pedagogies based on Bloom's Taxonomy to improve general science understanding.
4. To research and identify if the conventional teaching methods present and the pedagogies used, supported by Bloom's Taxonomy, are more effective in helping students best understand the fundamental concepts of general science.

Significance of the study

This is a critical study, as it fills an essential gap in the literature—it explicitly goes into the effects of Bloom's Taxonomy within the confines of teaching elementary science. Its understanding is critical to improvements within practices that foster success for students in

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science education. This study will be relevant to educators, developers of curricula, and policymakers in that it critically describes the strengths and weaknesses of using Bloom's Taxonomy in science instruction, thereby generating information on ways to make informed decisions about strategies for instruction, curriculum design, and assessment methods. The present study has added to the corpus of knowledge of the teaching efficacy of science taught and improved evidence-based policy prescriptions through teachers to increase student engagement learned critical thinking skills and scientific inquiry abilities at the elementary level. Findings carry significant implications for practical development programs and teacher training initiatives and convey the message to equip educators with this knowledge and make them capable of effectively integrating Bloom's Taxonomy into their practices of science instruction. This research also aims to improve science education at the elementary level by developing an interest in and appreciation of science so students can develop scientific literacy, critical thinking skills, and problem-solving skills beneficial for further education and profession with dignity.

1.5 Null Hypotheses

Ho1 There is no significant difference between the scores of pre-tests for Bloom's Taxonomy-based pedagogy and traditional pedagogy in general science at the elementary level.

Ho2 There is no significant difference in post-test scores between Bloom's Taxonomy-based and traditional pedagogy.

Ho3 There is no significant difference between traditional teaching methods and Bloom's Taxonomy-based pedagogy in enhancing general science knowledge.

Ho4 There is no significant difference between traditional teaching methods and Bloom's Taxonomy-based pedagogy in enhancing general science concepts.

Research Questions

1. What are the average pre-test scores for both traditional and treatment groups?
2. What are the average post-test scores for both traditional and treatment groups?
3. How do the average scores of the traditional and treatment groups compare in terms of post-tests?
4. What are the percentages of correct answers between the traditional and treatment groups for the post-tests?
5. What are the mean and standard deviation results between the traditional and treatment groups for pre-tests and post-tests?
6. What are the results of the Chi-Square and Likelihood Chi-Square tests of the traditional and treatment groups regarding pre-tests and post-tests?

Delimitations of the Study

The study was delimited to one elementary school named Government Elementary School Chak No.1 Hans, Multan.

Research Design

A quasi-experimental design was used for the study. Pre-test and post-test were employed for the traditional group and treatment group. Two groups were involved in the data collection procedures: an experimental group (Group A) and a control group (Group B). Group A received instruction based on Bloom's teaching methodology objectives, whereas Group B did not. The teaching duration was ten weeks, with four days of teaching in a week. A total of forty lessons were delivered according to the lesson plan. After forty days of instruction, the progress of both groups was evaluated using a pre-designed test worth thirty marks. The student's grades reflected their progress in learning. The validity, reliability, and ethical considerations were prioritized in the research proposal. Because Group A and Group B's teaching strategies were independent, an independent-sample t-test was used to compare their outcomes. The variable of interest was the students' science test scores, while the grouping variable was the teaching methodology. SPSS version 26 was used to analyze the data, and the independent-sample t-test was employed.

Population of the Study

The population of this study consisted of 80 students of 8th class. These students were from Government Elementary School Chak No.1 Hans, Multan.

Table No. 1 Population of The Study

Category	Total Schools	Class	Total Students	Total Population
Male	01	8th	80	80

Sample of The Study

Sixty (60) male students were selected for the study. Thirty (30) male students were selected for the control group, and the control group was given no treatment and was taught by traditional methods. Thirty (30) male students were selected for the treatment group—the treatment group taught by considering the Bloom Taxonomy. The treatment group received a unique educational approach that considered Bloom's Taxonomy, developed by Benjamin Bloom; this educational framework categorizes learning into six hierarchical levels.

Table No. 2 Sample of The Study

Category	Total Schools	Total Students	Total Sample
Male	01	80	60

Development of the Research Tool

An achievement test of 30 items was developed as a research tool based on the principles of Jong (2010) to design assessment tools that align with the active learning and cognitive development aspects emphasized in Bloom's Taxonomy. These items were prepared from the science textbook syllabus in which students of the 8th class had completed 10 units up to their second term. These 10 units were selected for teaching. After completing experimental treatment through Bloom Taxonomy-based pedagogies, the same tests were re-administered among the selected students to know the effectiveness of Bloom Taxonomy-based pedagogies' interference on academic achievement in science. The data collection tools employed in this research are essential elements of the experimental study. Two distinct tools were developed for this investigation: the pre-test and the post-test tools. The pre-test tool was specifically designed to assess the initial capabilities of the participants, ensuring their equitable potential prior to the commencement of the study. Subsequently, the post-test tool was formulated to gauge the participants' progress after the intervention. Both data collection tools demonstrated commendable reliability, instilling confidence in the accuracy and consistency of the obtained data. The pre-test tool had (30) marks total, encompassing various scientific concepts. Similarly, the post-test tool had (30) marks with rubrics. The test was arranged using the textual material referenced in the following table.

Table No. 3 Textual Material for Pre-Test/Post-Test

Area of Specification According to Bloom, Taxonomy levels			
Science Class-8, Total units 1-10			
Sr.No.	Cognitive Domain levels	Total Items	Percentage
1	Knowledge	12	40 %
2	Comprehension	3	10 %
3	Application	5	16.66%
4	Analysis	4	13.33 %
5	Synthesis	3	10 %
6	Evaluation	3	10 %
Total		30	100 %

The test material was prepared with the help of science teachers of the 8th class and under the supervision of the research supervisor. The test items were then written. Out of 30 items included in the test, 12 items tested knowledge, 3 items tested comprehension, 5 items tested application, 4 items tested analysis, 3 items tested synthesis, and 3 items tested evaluation. The proposed test was shown to the expert science teachers who judged whether it was a valid achievement test for 8th-class students.

Table No. 4 Pilot Testing

No.	Type	Items	Cronbach's Alpha
1	Pre-test	24	.82
2	Post-test	24	.83

Research Instrument

In order to ensure the alignment of the control and experimental groups, a pre-test was administered prior to the distribution of students to these groups. Following the completion of the treatment, a posttest created by the teacher (Appendix B) was administered to participants in both the experimental and control classes. The objective of this assessment was to ascertain the academic advancement of the students involved in the study. The researcher devised pretest and posttest measures after comprehensively examining test design methodologies. The construction of the tests garnered interest from both class teachers and specialists. The pretest and the posttest were held constant, except for alterations made to the arrangement of their respective products in the post-test. Each test comprised two components, namely objective and subjective measurements of type.

Validation of the Tool

Teaching methods like the traditional method and Bloom Taxonomy were independent variables, and students' performance was a dependent variable. Teachers who were involved, Time for teaching, Average Age of the students, and Classroom conditions variables. I.Q level of the students, achievement in the past, socio-economic status of the students, their anxieties, self-concept about things, interests, and attitude of the students were uncontrolled variables.

Administration of the Research Tool

In order to check the current status of the students regarding their knowledge, comprehension, application, analysis, synthesis, and evaluation of their science subject, a pre-test was conducted among both the control group and the experimental group on the same

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day. According to the marks obtained, a comparison was made between both groups, and the results were noted against each student in an Excel sheet. By considering the suitability, the management selected the allotment of 1 40 minutes during school hours. During this period, the researcher remained present. The experiment lasted 10 weeks, from October 2, 2023, until November 17, 2023. After revealing the experimental group to the peer teaching and the control group to the conventional teaching, the same research tool was re-used in the post-test to check the achievement level of both groups and whether the experimental group had made any improvement.

Reliability of The Tool

In order to check whether the data entered into SPSS for analysis is reliable, the reliability test was run. Output values show that all Cronbach's alfa values obtained above 0.81, indicating a satisfactory data reliability level that is ready
for conducting pre-tests and post-tests.

Procedure of Data Collection

For collection, the following procedure was set by the researcher;

Class Teacher

It was requested that the head teacher of the sample school cooperate for research; it will be helpful for education development. The teacher, Sir Jameel Nasir (M. et al.), was willing to experiment for this class. This way, the class was randomly divided into two groups. One was for Bloom's Taxonomy-based pedagogy, and the second was for traditional pedagogy.

Selection and Training of Teacher for Experiment

The selection and training of teachers play a pivotal role in ensuring the consistency and reliability of instructional interventions. Here is a structured outline for this process,

a) Criteria for Teacher Selection

Only teachers experienced in, and experts teaching science subjects to elementary students were picked.

b) Informed Consent

Only teachers who satisfactorily understood the research aims, the nature of the experiment, and their role in the study gave their informed consent for voluntary participation.

c) Demographic Representation

An effort was made to gather teachers from different backgrounds to generalize the research findings.

d) Informing the Research Objectives

A briefing was given to teachers about the research objectives, aims, and objectives and why this research is being done.

e) Overview of Experimental Design

The general experimental design, including control and treatment groups' functions, was explained to the teachers. The experiment's duration and the manner to assess the students were given. The educational staff was given a comprehensive briefing on the design of the experiment, thereby explaining in detail the functions that such control and experimental groups are supposed to play. This involved an explanation of the time the experiment would take so that they fully understand how long the project would take and a detailed explanation of the measurement tools used to measure the results of the instructional strategies.

f) Making Sense of Bloom's Taxonomy

The workshop sessions aimed to ensure teachers fully comprehended Bloom's Taxonomy and how it could be applied to their science teaching.

g) Cooperative Learning Skills
Orientation of teachers in the experimental group through training on taxonomy-based pedagogy learning concepts, development of group dynamics, and facilitation of student collaboration
h) Evaluation Process
Training of teachers on evaluative approaches related to the study modality application, such as issuance of pre-and post-test and individual and group assessment parameters
i)Treatment for Control Group
Teachers in the control group orientation through in-service preparation on control the traditional way previously used without explicitly applying Bloom's Taxonomy principle.
j) Follow-up and Data Collection
The teachers were trained to monitor the students' progression, collect data, and consistently implement the assigned strategies.
Time Table
Both groups started teaching from the first week of October 2, 2023, lasting until November 17, 2023. Equal criteria were created for both classes. Both aspects of the time of day and the amount of treatment time have been equated. The same teacher taught both groups. The same material was taught to both classes. The analysis lasted for 40 days and lasted 40 minutes every day. As an educational technique, the study group was taught using Bloom Taxonomy-based pedagogies, and the control group was taught using conventional learning techniques like the lecture method. Researchers and experts found a teacher who agreed to teach experimental and control groups on the Science subject. This teacher was educated in an experimental community to use the Bloom Taxonomy-based pedagogies. This teacher used the conventional approach of learning to educate the students. In order to eliminate the possible factor, the same teacher was chosen to teach both classes.
Implementation of Bloom's Taxonomy in the Experimental Group
Implementing elements are mentioned below
a) Classroom Arrangement
The classroom setup was organized to facilitate collaborative learning. Recognizing the importance of interaction, the teacher rearranged desks to encourage student collaboration during group activities related to Bloom's Taxonomy.
b) Team Formation
Students were assigned to teams to foster learning of taxonomy-based pedagogies. This allowed for peer interaction and the sharing of diverse perspectives during science lessons guided by Bloom's Taxonomy.
c) Ranking Students
Students in the experimental group were ranked based on their performance in a pre-test, providing a foundation for team formation that considered a mix of performance levels.
d) Number of Teams
To allow for a well-coordinated team, each team involved had five members. The totaling forty students were arranged into eight teams to allow for group collaboration.
e) Balancing Teams
The team members had to be at a distinct performance level to allow for team balance. The distribution of the students in this way would allow a balance in their ability distribution over the teams involved.
f) Initial Base Scores
The instructor took the pretest scores as each child's baseline. This baseline was then used to refer to the subsequent individual and group performance evaluation.

g) Presentations

Bloom's Taxonomy learning materials were first introduced to the treatment class. The instructor used different teaching strategies, for instance, lecturing, discussion, and multimedia resources. At the presentation stage, the treatment group received instructionally prepared materials hierarchically sequenced for Bloom's Taxonomy. The teacher utilized a range of pedagogic methods such as expository teaching, stimulating discussions, and multimedia to enhance the learning environment in depth and complexity.

h) Team Practice

Groups of five students were involved in cooperative learning activities using Bloom's Taxonomy. They researched and discussed scientific topics as a group, ensuring each participant was fully engaged in learning.

i) Quizzes

Students received individual quizzes after the instructional lesson and group discussion. The administration of individual quizzes allowed students to be held accountable separately, allowing them to take personal responsibility for their learning.

j) Base Scores

Each student contributed to their team based on their quiz performance relative to their pre-test base score. This Scoring System serves as a measure of the student's contribution to the collective effort.

k) Team Recognition

The teacher recognizes the individual and team achievements of the outstanding performances. They were recognized and rewarded to motivate and reinforce positive outcomes aligned with Bloom's Taxonomy.

l) Improvement Points

The students gained improvement points for their teams based on how much their quiz results had surpassed their base scores. The total improvement points are tallied and added to the overall team score.

Appropriate this is in the implementation framework in light of the research focus on Bloom's Taxonomy in teaching science at the Elementary Level where collaborative learning and individual mastery of the content are implemented.

Implementation of Traditional Learning in Control Group

In researching Bloom's Taxonomy effectiveness in science teaching at the Elementary Level, one control group received traditional learning methods for comparison.

a) Classroom Arrangement

This allowed students to be seated individually or in rows, which could help facilitate a more traditional approach to instruction. The conventional setting would include classroom arrangement in individual or row seating following a conventional layout, allowing for easy facilitation of a conventional instructional approach, given that teacher-centered activities require such a setting to efficiently manage a structured learning environment.

b) Individual Learning

Students in the control group were primarily engaged in independent learning activities. The emphasis was on individual study, with limited opportunities for group projects and collaboration.

c) Teacher-Centered Instruction

All teaching aids were presented utilizing teacher-centered instruction. The teacher was the central point of instruction delivery, relying on lectures, discussion, and traditional teaching aids.

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d) Homogeneous Grouping

Unlike the experimental group, no grouping according to student ability was practiced in these classes.

e) Assessment Practices

As such, assessment was primarily based on individual performance. Students were assessed for their understanding of the material through traditional assessments, tests, and quizzes.

f) Limited Peer Interaction

Peer interaction was limited, and students predominantly worked on assignments or exercises independently. There was minimal sharing of ideas and collaborative problem-solving.

g) Teacher Feedback

Feedback primarily came from the teacher, who guided and corrected individual students. There was less emphasis on peer-to-peer feedback or collaborative learning experiences.

h) Traditional Evaluation

The evaluation of student performance focused on traditional grading methods, considering individual achievement without incorporating team dynamics or collaborative contributions.

i) Absence of Team Recognition

Unlike the experimental group, there was no formal recognition of individual or team achievements within the control group. Rewards and acknowledgments were not based on collaborative efforts.

Data Collection

During the experiment, two diverse patterns were adopted. The lesson plans of both classes provided the same instructional standards based on the same passages and exercises for reading. However, the experimental ideas provided team members with small-group collaboration and resource-sharing opportunities. In contrast, students in the monitoring group worked separately and exchanged their answers with the community. All groups were given worksheets except the research group, which offered a traditional routine scenario in the classroom. At the same time, the taxonomy-based pedagogy learning solution was provided as a therapy to the experimental group. The experiment proceeded for 40 days. The post-test was administered immediately after the experiment was concluded to determine the participants' achievement. The treatment group had 30 students, and 30 were in the traditional group. The pretest scores of the study served as information to match the control and experimental grades. In contrast, posttest scores served as information to determine the student's performance due to therapy.

Data Analysis

The relevant data was subjected to analysis to evaluate the hypothesis. The mean, standard deviation, and variance of means have been computed for each group. The independent sample t-test assessed the disparity's magnitude between the two groups' average values. The statistical significance of the discrepancy in mean scores between the experimental and control groups on the pre-test and post-test predictor scores was assessed using a significance level of 0.05. The independent study t-test has been implemented to ascertain the advantages of conducting pretest and post-test assessments. The tabulated form was utilized to present the raw scores obtained from pre-tests and post-tests, serving the purpose of the study. The knowledge was analyzed using established methodological measures, specifically the mean, standard deviation, and significance of the variance between means, as determined by the independent samples t-test. The study involved the determination of pre-test and post-test scores for the experimental and control groups. This was done to assess the progress made by participants in each group and to facilitate a comparison between the two groups. The chi-square test was used for hypothesis testing.

Table No. 5 Demographic information

Name of school	Government Elementary School Chak No.1 Hans, Multan
Students	All boys Elementary School students
Grade	8th
Age group	All students were approximately the same age group (14-16 years)
Total schools	01
Total Students	80
Sample	60

Table 5 indicates that the study was conducted in Government Elementary School Chak No.1 Hans, Multan. The sample was chosen from one boy's elementary school in the Multan district. The sample contained only 8th-class students of GES Chak No1 Hans. Students had equal IQ levels, equal social interaction, and backgrounds.

Post-tests Average for Traditional and Treatment Groups

Ten post-test results for Traditional and Treatment Groups are given here.

Table No. 6 10 Post-tests Average for Traditional and Treatment Groups

		Traditional Group			Treatment Group		
No.	Post Test	Correct	Incorrect	Concepts	Correct	Incorrect	Concepts
1	Post-test 1	23.3	6.7	23.5	27	3	25.2
2	Post-test 2	23.2	6.8	23.4	27.5	2.5	27.8
3	Post-test 3	24.4	5.6	25.6	27.9	2.1	28.0
4	Post-test 4	25.2	4.8	25.9	28.2	1.8	28.4
5	Post-test 5	25.1	4.9	28.7	28.6	1.4	28.7
6	Post-test 6	24.2	5.8	24.2	28	2	27.6
7	Post-test 7	24	6	24.9	28.8	1.2	28.4
8	Post-test 8	24.2	5.8	24.2	28.2	1.8	28.3
9	Post-test 9	23	7	23.3	27.2	2.8	27.4
10	Post-test 10	24.3	5.7	24	27.8	2.2	28.3
	Average	24.09	5.91	24.77	27.92	2.08	27.81

Table 6 displays post-test results for the traditional and treatment groups. The traditional group averaged 24.09 correct and 5.91 incorrect responses, with a concept score of 24.77. In contrast, the treatment group averaged 27.92 correct and 2.08 incorrect responses, achieving a concept score of 27.81. These results indicate that the treatment group had significantly higher accuracy and conceptual understanding than the traditional group across all post-tests.

Comparison of Both Groups by Average and Percentages

A comparison of both Traditional and Treatment groups is given here.

Table No.7 Comparison of Both Groups by Average and Percentages

No.	Traditional Group	Correct	Incorrect	Concepts
1.	Average	24.09	5.91	24.77
2.	Percentage	(80.3%)	(19.7%)	(82.57%)

No.	Treatment Group	Correct	Incorrect	Concepts
3.	Average	27.92	2.08	27.81
4.	Percentage	(93.06%)	(6.93%)	(92.7%)

Table No. 7 shows the results of both groups. Both groups were compared with each other by average and by percentage. It was observed that the group taught using Bloom Taxonomy showed more promising results than the traditional group.

Comparison of the Mean and Standard Deviation of Both Groups

Comparison of mean and standard deviation of both treatment methods and traditional methods.

Table No. 8 Comparison of the Mean and Standard Deviation of Both Groups

	Treatment Method	Traditional Method
Mean	1.18	1.35
N	30	30
Std. Deviation	.308	.490

Table No. 8 shows the comparison results of both groups by the mean and standard deviation. It was observed that the positive mean of teaching using Bloom Taxonomy was good, and the traditional group had a negative mean because there were more incorrect answers than the treatment group.

Chi-Square and Likelihood Chi-Square tests

Table No.9 Chi-Square Interpretation

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.657[a]	2	.037
Likelihood	7.450	2	.026
Linear-by-Linear Association Ratio	.012	1	.927
N of Valid Cases	30		
Table Value	5.99		

Table No. 9 shows the chi-square calculated value, which was (6.657), more significant than the table value (5.97). For both Pearson Chi-Square and Likelihood Chi-Square tests, the p-values were less than 0.05 (0.037 and 0.026, respectively), rejecting the null hypothesis at a 5% significance level, indicating a significant association. The Linear-by-Linear Association Ratio had a p-value of 0.927, more significant than 0.05. This suggests that there is no significant linear association. The number of valid cases was 30, meaning the analysis is based on 30 observations. The table value was 5.99, and Pearson and Likelihood chi-square values were more significant than this table value, reinforcing the rejection of the null hypothesis. The value of x^2 showed that no significant relationship existed between the traditional and treatment groups.

Discussion

Agarwal (2019) incorporating Bloom's Taxonomy into lesson planning encourages students to analyze, evaluate, and synthesize information. It enriches knowledge about scientific concepts and helps build up the habit of investigation and inquisitiveness within them. One of the advantages of Bloom's Taxonomy is that it allows instruction differentiation. As researched by Nurmatova Altun (2023), an educator can integrate activities about the diversified learning needs of students in elementary school by using Bloom's Taxonomy. It enables the teacher to assign tasks at different cognitive levels and involve all students in the learning process to guarantee a more significant equity in the science learning environment. However, even as it becomes widely applied, publications reveal difficulties and criticisms of Bloom's Taxonomy and its application in teaching elementary science.

For example, Ventista and Brown, 2023) note that "teachers may have difficulty in ascertaining the cognitive levels of students correctly and overemphasizing memorization rather than a genuine achievement of understanding." Further, there has been concern about "cultural bias enshrined within the taxonomy." Recently, it has also been reported about combining technology with Bloom's Taxonomy in science teaching for example, Ahmed et al., 2020. They suggest that using digital tools enhances engagement and opens up new ways of interacting with scientific concepts at new cognitive levels, thus accurately reflecting the current challenges of elementary education systems. Therefore, supported by oodles of literature, Bloom's Taxonomy remains relevant for science teaching at the Elementary Level. It forms an excellent roadmap for developing and enhancing cognitive skills and critical thinking and a method for differentiated instruction. However, issues and criticisms highlight thoughtful implementation and further research in refining its application. As education in schools keeps evolving, especially with the integration of technology, so should educators adapt to these changes by being innovative while considering the foundational principles that Bloom's Taxonomy provides (Momen et al., 2022).

Conclusion

The conclusions drawn from the findings of the study

The pre-test result showed that the students in both groups in 8th grade were equal in efficiency and readiness for the treatment. Further, post-test scores analysis used Bloom's Taxonomy and traditional pedagogies. No relation has been found between the groups, which also proved in the chi-square test showing no significant relationship in the groups. This would mean that the pedagogies based on Bloom's Taxonomy were very effective in enhancing understanding of general science, as the treatment group outperformed the traditional group for marks and knowledge. Bloom's Taxonomy-based pedagogies effectively enhance the students' grasp of key concepts in general science: The treatment group fared better than the traditional group. Because students from both groups proved to be equally efficient and ready for treatment, the hypothesis of no significant relationship was accepted, meaning that there was no significant difference between pre-test scores of Bloom's Taxonomy-based pedagogy and traditional pedagogy students. The hypothesis of no significant relationship in post-test scores between Bloom's Taxonomy-based and traditional pedagogy students was accepted since there is not much difference between both groups. Opposite to the hypothesis, a significant relation existed favoring Bloom's Taxonomy-based pedagogies over traditional teaching methods in developing general science knowledge, evidenced by better results in the treatment group. There was no significant relationship between the traditional teaching method and Bloom's Taxonomy-based pedagogy in the development of general science concepts, a hypothesis accepted where the learners in the treatment group could show superior results in marks and clear concepts. While comparing across all ten pre-tests, students constantly seemed to be holding equal efficiency and readiness for treatment. Results at the individual level of the pre-tests-one by one-test 1 to test 10 continue to reflect students' equality in terms of efficiency and readiness for the treatment to consolidate the overall results. Students maintained equal efficiency and readiness for treatment at each pre-test, with the mean scores continuing to reinforce their preparedness for the experimental pedagogical interventions. Pre-test results went from test 1 to test 10, with consistent indications of students being equally efficient and ready for treatment, hence setting a stable baseline for the experiment. The same average score for students in all the pre-tests suggested that these students were equally efficient and ready for treatment. This set the stable foundation needed for the experiment's successive phases. In all pre-tests, students were always equal in efficiency and treatment readiness, as shown by the consistency of their average scores. From the results of pre-tests-test 1 to test 10-students were always showing equal efficiency and readiness for treatment, consistent and thus setting the firm ground at the beginning of the experiment. Over the ten pre-tests, students showed equal efficiency and readiness for treatment, setting the stage for the subsequent experimental interventions. Individual pre-tests' results regularly indicated that students were on an equal level of efficiency and preparedness for treatment in test 1 to test 10, which maintained the experiment's baseline.

The students maintained equal efficiency and readiness for treatment on each pre-test, as reflected in the average scores across all ten tests. The cumulative results from all ten pre-tests confirmed that the students had equal efficiency and were ready for the treatment, ensuring a solid foundation was built for the upcoming experimental comparisons. Overall, the Treatment Group was on top in Post-test 1, with obvious advantages in correct answers and conceptual understanding. The same advantages existed in Post-test 2, where Treatment was superior, with higher correctness and better conceptual understanding than the Traditional Group. Post-test 3 results further established the trend in the treatment group for higher correct answers with more precise concepts than the traditional group. In Post-test 4, the Treatment Group continued to excel with better performance on correct answers and conceptual understanding than the Traditional Group. By sustaining the top result in Post-test 5, the Treatment Group had superior performances in incorrect answers with clear conceptual understanding. The fact that Test No. 6 can demonstrate effectiveness implies that the Treatment Group has performed better correctness and conceptual understanding than the Traditional Group. Where Post-tests 7 and 8 showed clear conceptual understanding for the Treatment Group that was consistent and above that of correct answers from the Treatment Group. For post-tests 9 and 10, the same trend came forward as the Treatment Group outperformed the Traditional Group on both variables, namely the correct answer and conceptual understanding. Overall, the results for ten tests depicted consistency in the performance of the Treatment Group over the Traditional Group regarding incorrect answers and conceptual understanding. The aggregated results on percentage and average indicated that the Treatment Group performed better than the Traditional Group. The positive mean for the Treatment Group and the negative mean for the Traditional Group indicated that the pedagogies based on Bloom's taxonomy effectively enhanced student performance over the traditional methods. The consistency in which the Treatment Group performed better than its counterpart in several post-tests affirmed the effectiveness of the pedagogies based on Bloom's taxonomy in enhancing student performance. The positive mean of the Treatment Group and the negative mean of the Traditional Group supported that Bloom's taxonomy-based pedagogies were much better than the traditional method.

Recommendations

Some precious recommendations from the results of this study are

1. Educational institutions need to adopt Bloom's taxonomy-based pedagogies since the

outcome of post-test scores was consistently and significantly higher than traditional ones.

2. Teachers' training and professional development of teachers are required for the adoption of Bloom's taxonomy-based pedagogies in classroom scenarios. As represented in post results, students' application scores were significantly higher, and knowledge scores increased.
3. Curriculum developers and education policymakers may, therefore, consider adopting Bloom taxonomy-based strategies in educational frameworks to ensure that students are adequately prepared for deeper conceptual understanding in general science at the Elementary Level.
4. Teachers should always be prepared and undertake formative assessments and interviews to keep abreast with the levels of conceptual understanding that students have achieved at any given time during learning. Consequent revision of teaching strategies should be made to ensure that individual learning needs are met.
5. Schools should strongly emphasize developing a positive and supportive learning culture where students are motivated to respond to and articulate their comprehension of ideas and participate in class activities.
6. The policy recommendations go to the need for educational policymakers to set aside funds and periodic research and appraisals to link evidence to decision results as an effort to determine the long-term implications of these pedagogies based on Bloom's taxonomy for student performance.

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