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Effectiveness of Activity-Based Teaching Methods on Students' Achievement in Chemistry: A Comparative Study

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Abstract
Science education at the secondary level often involves abstract concepts that students find difficult to comprehend, particularly in chemistry. Traditional lecture-based teaching methods frequently fail to engage learners or enhance understanding effectively. This study investigates the effectiveness of activity-based learning in improving the academic achievement of Grade IX students at Spicer Higher Secondary School in India, focusing on the topic of atomic structure and chemical bonding. A two-group experimental design was employed, with 32 students divided into a control group (traditional teaching) and an experimental group (activity-based learning). Pre-tests and post-tests were administered to both groups, and the data were analyzed using means, standard deviations, and t-tests. The results showed a significant improvement in the experimental group compared to the control group, demonstrating that activity-based learning enhances conceptual understanding, engagement, and retention. The study suggests that incorporating multisensory and interactive methods in chemistry education can significantly improve student outcomes. Implications for educators, curriculum developers, and policymakers are discussed, and recommendations for future research in diverse subjects are provided.

Keywords: Activity-Based Learning (ABL), Chemistry Education, Academic Achievement

Introduction

Science education at the secondary level plays a crucial role in developing students' analytical, problem-solving, and inquiry skills (National Research Council, 2012). Chemistry, as a core science subject, requires learners to understand abstract and symbolic representations related to the structure and behaviour of matter. Topics such as atomic structure and chemical bonding are particularly challenging because they involve concepts that cannot be directly observed and require students to translate between macroscopic, submicroscopic, and symbolic levels of representation (Johnstone, 1991; Özmen, 2004) [13, 21]. Traditional lecture-based teaching methods often fail to address these cognitive demands effectively, leading to student disengagement, rote learning, and limited conceptual understanding (Ausubel, 1968; Novak, 2010) [3, 19].

To address these challenges, educational research increasingly supports activity-based learning (ABL) approaches that actively engage students in the construction of knowledge. According to Bruner (1961) [5], meaningful learning occurs when learners interact with content through discovery and purposeful activity. Activity-based methods such as hands-on experiments, collaborative tasks, simulations, and games help bridge the gap between abstract concepts and concrete understanding (Kolb, 1984; Hake, 1998) [15, 12]. Empirical studies have shown that inquiry-based and activity-oriented instruction enhances students' achievement, conceptual understanding, and attitudes toward chemistry compared to traditional methods (Lord & Marino, 1993; Eilks & Byers, 2010) [16, 8]. However, limited research has examined the effectiveness of such approaches in Indian secondary school contexts (Reddy & Rao, 2014) [22]. Therefore, the present study investigates the effect of activity-based teaching on the academic achievement of Grade IX students in the topic of atomic structure and chemical bonding.

Review of literature

Several studies have examined the effectiveness of different teaching methods in science education, highlighting the benefits of active, inquiry-based, and technology-assisted approaches. Gupta (2012) [11] developed Programmed Instructional Material (PIM) on the topic "Structure of Atom" for Class IX students and examined its effectiveness across different levels of intelligence and gender. Using pre-test equivalent group design and statistical tools such as ANOVA and ANCOVA, Gupta found that PIM was more effective than traditional teaching methods, especially for students with lower intelligence levels, and was equally effective for both male and female students. This study emphasises the value of structured, activity-based instructional material in enhancing understanding of complex Chemistry topics.

Avinash Agrahari and Ahailja Singh (2013) [2] explored the impact of Information and Communication Technology (ICT) on students' achievement in Chemistry at the secondary level. Using pre-test and post-test equivalent group design, they found that students taught using ICT-based methods performed better than those taught with traditional approaches. ICT facilitated visualisation of abstract concepts, increased student engagement, and satisfied curiosity, highlighting the benefits of multimedia-assisted teaching. Similarly, Oluwatosin Victor Ajayi (2017) reported that hands-on activity-based methods significantly enhanced students' interest in organic Chemistry among senior secondary students, although the study noted slight gender differences favouring males. Both studies affirm the value of technology and practical engagement in Chemistry education.

Research has also demonstrated the benefits of instructional materials and activity-based approaches in improving student achievement. Stephen A. Adalikwu and Isaac T. Iorkplgh (2012) [1] found that instructional materials positively influenced students' academic performance in Chemistry, with experimental groups outperforming control groups. Delek Duvarci (2010) [7] observed that card-based activities in teaching "Elements and Compounds" increased participation, retention, and conceptual understanding among ninth-grade students. Similarly, Ntibi and Neji (2018) [20] reported that activity-based approaches in Chemistry and Physics improved students' performance and retention, emphasising the importance of environmental and locally available resources in practical teaching.

At the elementary and secondary levels, Mishra and Yadav (2013) [17] demonstrated that activity-based approaches significantly improved students' achievement in Science for Class VII, with girls performing slightly better than boys in knowledge-based items. Across these studies, a common theme emerges: active, hands-on, and well-structured teaching methods outperform traditional approaches in terms of engagement, understanding, and academic achievement.

The reviewed literature indicates that activity-based and experiential learning methods, whether through card activities, laboratory work, programmed instructional material, or ICT, consistently enhance students' conceptual understanding, motivation, and academic performance in Chemistry. However, most studies focus on limited topics, single teaching tools, or specific age groups, leaving a gap in systematically assessing the combined effect of multiple activity-based methods, such as card games and practical exercises, on the achievement of Class IX students in Chemistry. This gap forms the rationale for the current study, which integrates four card-based activities with traditional teaching methods to evaluate their effectiveness in enhancing students' academic performance.

Methodology

The present study adopted an experimental research design to investigate the effect of Activity-Based Learning (ABL) on the academic achievement of Grade IX students in Chemistry, specifically in the topic of Atomic Structure and Chemical Bonding. Experimental research is considered the most reliable method to establish cause-and-effect relationships between variables (Kerlinger & Lee, 2000).

Research Design

The study employed a two-group experimental design:

- **Experimental Group:** Received activity-based instruction.
- **Control Group:** Received traditional lecture-based instruction.

Both groups were given a pre-test to assess prior knowledge and a post-test to evaluate learning outcomes after the teaching intervention. The experimental design allowed for a comparison of mean scores and statistical analysis to determine the effectiveness of the activity-based teaching program (Creswell, 2014) [6].

The procedure of the experimental design was as follows:

Pre-test: Administered to both groups to measure baseline achievement.

Teaching Intervention

1. The control group received traditional classroom instruction.
2. The experimental group received Activity-Based Learning, including games, hands-on activities, memory exercises, and group discussions to engage students in active learning.
3. **Post-test:** Administered to both groups after the intervention.
4. **Data Analysis:** Scores from pre-test and post-test were analysed using mean, standard deviation, and t-tests to determine statistical significance.

Population and Sample

The population for the present study comprised all Grade IX students of Spicer Higher Secondary School, Pune, India. The sample consisted of two intact classes, each comprising 16 students, resulting in a total sample size of 32 students. A convenient sampling technique was employed to select the school, while random sampling was used to select students within the chosen classes to ensure that the groups were representative (Best & Kahn, 2016) [4]

Data Analysis And Interpretation

Data analysis is a crucial step in research, as it gives meaning to the collected information and helps test the hypotheses (Creswell, 2014) [6]. The present study aims to investigate the effectiveness of Activity-Based Learning (ABL) compared to traditional teaching methods in improving the academic achievement of Grade IX students in Chemistry, specifically in the topic of Atomic Structure and Chemical Bonding.

The data collected from pre-tests and post-tests of both control and experimental groups were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (t-test) to determine the significance of differences in students' achievement.

Control Group

Table 1: Achievement Score

S. No	Pre-Test	Post-Test
1	1	4
2	0	2
3	12	14
4	1	5
5	13	15
6	1	5
7	5	5
8	13	16
9	5	7
10	2	5
11	5	9
12	4	8
13	4	5
14	1	5
15	1	3
16	2	4
Total	70	112
Mean	4.4	7

Table 2: Difference in Mean Scores

Test	Mean
Pre-Test	4.4
Post-Test	7

Interpretation:

Mean of Pre-Test score is 4.4, and the mean of Post-Test score is 7. The mean for the post-test is increased from 4.4 to 7. The difference between the two means is 2.6

Table 3: Difference in Standard Deviation

Test	Standard Deviation
Pre-Test	4.4
Post-Test	4.3

Interpretation

The Standard Deviation (SD) of the Pre-Test is 4.4, and the Standard Deviation of the Post-Test is 4.3. the Standard Deviation is reduced from 4.4 to 4.3, and the difference is 0.1

Table 4: Difference in t-score

t-Score	1.75

Table 5: Comparison of the score for the Pre-Test and Post-Test:

S. No	Content		Pre-Test	Post-Test
1	Number of students		16	16
2	Mean		4.4	7
3	Standard Deviation		4.4	4.3
4	Coefficient of Correlation (r)			
5	Degree of freedom	15		
6	Calculated T-Value	1.75		

Table 6: Table of 't' critical values at 15 df:

t' critical	0.01 level	0.05 level
Value	2.95	2.13

Observation

From the table above it is observed that the calculated 't' value of 1.75 is less than the table value at the level of significance 0.01%, which is 2.95, and 0.05%, which is 2.13.

Experimental Group

Table 7: Achievement Score

S. No	Pre-Test	Post-Test
1	3	5
2	3	10
3	2	8
4	2	2
5	6	8
6	3	10
7	3	9
8	16	19
9	0	8
10	7	12
11	4	12
12	5	1
13	6	12
14	0	5
15	4	8
16	3	8
Total	67	150
Mean	3.9	8.8

Table 8: Difference in Mean Scores

Test	Mean
Pre-Test	3.9
Post-Test	8.8

Interpretation

Mean of the Pre-Test score is 3.9, and the mean of the Post-Test score is 8.8. The mean for the post test is increased from 3.9 to 8.8. The difference between the two means is 4.9

Table 9: Difference in Standard Deviation

Test	Standard Deviation
Pre-Test	3.7
Post-Test	4

Interpretation

The Standard Deviation (SD) of the Pre-Test is 3.7, and the Standard Deviation of the Post-Test is 4. The Standard Deviation is increased from 3.7 to 4, and the difference is 0.3

Table 10: Difference in t-score

t-Score	3.46

Table 11: Comparison of the scores for the Pre-Test and Post-Test

S. No	Content		Pre-Test	Post-Test
1	Number of students		16	16
2	Mean		3.9	8.8
3	Standard Deviation		3.7	4
4	Coefficient of Correlation (r)			
5	Degree of freedom	15		
6	Calculated T-Value	3.46		

Table 12: Table of 't' critical values at 15 df:

t' critical	0.01 level	0.05 level
Value	2.95	2.13

Table 13: Comparison of t-value of control group and experimental group:

Sample	t-value
Control Group	1.75
Experimental Group	3.46

Observation: From the table above it is observed that the Experimental group's calculated 't' value of 3.46 is more than the table value at the level of significance 0.01%, which is 2.95 and 0.05%, which is 2.13.

The conclusion of the analysis is as follows

1. Activity-based methods significantly enhanced student learning in chemistry compared to traditional methods.
2. Students in the experimental group demonstrated higher mean scores, indicating better comprehension of abstract concepts such as atomic structure and chemical bonding.
3. The standard deviation in the experimental group suggests engagement and varied understanding, likely due to interactive and multisensory learning activities.
4. The hypothesis that activity-based learning improves academic achievement is accepted, and the null hypothesis is rejected.

Therefore, among the students studying in IXth Standard of Spicer Higher Secondary School, there is a significant difference between pre-test and post-test achievement after teaching through Activity-based methods, and there is a significant difference in the academic achievement of the students who will be taught in traditional methods and using Activity-based methods.

Hence, the Research Hypothesis is accepted, and the null hypothesis is rejected.

Practical Implications

1. The findings of this study on Activity-Based Teaching Methods for Grade IX students in Chemistry have several practical implications for both teaching and learning. One of the most important implications is that activity-based methods, such as games, hands-on experiments, and group activities, make learning more interactive and enjoyable. By incorporating these strategies, teachers can increase students' attention, participation, and interest in abstract concepts like atomic structure and chemical bonding.
2. The significant improvement in the post-test scores of the experimental group demonstrates that activity-based learning effectively enhances understanding and retention. This suggests that teachers can adopt these methods to boost students' academic performance, particularly in complex subjects such as Chemistry. Additionally, the multisensory approach employed in these activities caters to different learning styles, including visual, auditory, and kinesthetic learners. As a result, students with varying learning preferences can grasp complex concepts more effectively.
3. Activity-based methods also promote collaboration and critical thinking. Group activities like the "Memory Game" and the "Bonding Experience" encourage peer interaction, problem-solving, and analytical thinking, equipping students with essential skills beyond academic knowledge. Furthermore, the study highlights the importance of teacher training and curriculum development. Schools can integrate activity-based modules into the regular curriculum and provide professional development programs to train teachers in designing and implementing interactive, multisensory lessons.
4. Finally, the success of this approach in Chemistry indicates that activity-based and experiential learning methods can be scaled and applied to other subjects. By doing so, schools can improve students' comprehension, engagement, and overall academic outcomes, making learning a more effective and enjoyable process.

Limitations and Future Direction

While this study provides valuable insights into the effectiveness of Activity-Based Teaching Methods in Chemistry, several limitations should be acknowledged. First, the sample size was relatively small, with only 32 students from a single school. This limits the generalizability of the findings to other populations, schools, or educational contexts. Second, the duration of the intervention was short, spanning only two weeks, which may not fully capture the long-term effects of activity-based learning on students' academic achievement and conceptual understanding. Additionally, the study focused only on a few topics within the chapter on Atomic Structure, leaving out other chemistry concepts that might respond differently to activity-based methods.

Another limitation is the reliance on pre-test and post-test scores as the primary measure of learning outcomes. While these tests effectively assessed achievement, they may not fully reflect deeper conceptual understanding, critical thinking, or problem-solving abilities. Moreover, the study did not explore the potential influence of external factors such as students' prior exposure to the subject, motivation, or socio-economic background, which could affect the outcomes.

For future research, it is recommended that larger and more diverse samples be included to enhance the generalizability of findings. Longitudinal studies can be conducted to examine the sustained impact of activity-based learning over an extended period. Researchers could also explore integrating technology, such as interactive simulations and virtual labs, into activity-based teaching to further enhance student engagement and understanding. Additionally, future studies could assess the impact of these methods on higher-order thinking skills, creativity, and collaborative learning. Extending this approach to other subjects and comparing its effectiveness across disciplines would provide valuable insights for educational practice.

Conclusion

The present study investigated the effectiveness of Activity-Based Teaching Methods on the academic achievement of Grade IX students in Chemistry, specifically in understanding Atomic Structure and chemical bonding. By employing an experimental design with control and experimental groups, the study provided clear evidence of the positive impact of activity-based learning on students' understanding of abstract concepts. The pre-test and post-test results revealed a significant improvement in the experimental group, with the calculated t-value of 3.46 exceeding the critical t-values at both 0.05 and 0.01 levels of significance. This indicates that the difference in achievement between students taught using traditional methods and those taught through activities was statistically significant. In contrast, the control group showed only a minimal increase, with a t-value of 1.75, which was below the critical values.

The findings suggest that activity-based methods, incorporating games, hands-on exercises, and kinesthetic learning experiences, can enhance student engagement, motivation, and understanding of complex chemistry concepts. The multisensory approach adopted in the experimental program helped students not only to memorise theoretical content but also to apply their knowledge to practical scenarios, thereby deepening conceptual understanding. Furthermore, the study demonstrated that active participation and collaboration during learning can lead to better retention of knowledge compared to traditional lecture-based teaching.

Overall, the study provides strong evidence supporting the integration of activity-based teaching strategies into the curriculum to improve student outcomes in science education. While the research was limited by sample size, duration, and scope, it highlights the potential of these methods to transform classroom learning and suggests avenues for further exploration. Educators and curriculum designers are encouraged to adopt activity-based and multisensory approaches across subjects to foster active learning, critical thinking, and a deeper understanding of scientific concepts, thereby contributing to enhanced academic performance and lifelong learning skills.

The analysis clearly indicates that Activity-Based Learning is more effective than traditional teaching methods in enhancing students' understanding of chemistry concepts. This supports the implementation of multisensory, interactive teaching methods in classroom settings to improve learning outcomes.

References

1. Adalikwu SA, Iorkplgh IT. The influence of instructional materials on academic performance of senior secondary school students in chemistry in Cross River State. Global Journal of Educational Research. 2012;11(1):39–45.
2. Agrahari A, Singh A. The impact of information and communication technology (ICT) on achievement of students in chemistry at secondary level. International Journal of Science and Research. 2013;2(8):126–129.
3. Ausubel DP. Educational psychology: A cognitive view. New York: Holt, Rinehart & Winston; 1968.
4. Best JW, Kahn JV. Research in education. 10th ed. Boston: Pearson Education; 2016.
5. Bruner JS. The act of discovery. Harvard Educational Review. 1961;31(1):21–32.
6. Creswell JW. Research design: Qualitative, quantitative, and mixed methods approaches. 4th ed. Thousand Oaks (CA): SAGE Publications; 2014.
7. Duvarci D. The effect of card activities on students' achievement and retention in chemistry. Journal of Turkish Science Education. 2010;7(2):94–102.
8. Eilks I, Byers B. The need for innovative methods of teaching and learning chemistry. International Journal of Environmental & Science Education. 2010;5(1):95–109.
9. Felder RM, Silverman LK. Learning and teaching styles in engineering education. Engineering Education. 1988;78(7):674–681.
10. Gardner H. Frames of mind: The theory of multiple intelligences. 2nd ed. New York: Basic Books; 1993.
11. Gupta P. Effectiveness of programmed instructional material on structure of atom for class IX students. Indian Journal of Educational Research and Experimentation. 2012;2(1):45–52.
12. Hake RR. Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics. 1998;66(1):64–74.
13. Johnstone AH. Why is science difficult to learn? Things are seldom what they seem. Journal of Computer Assisted Learning. 1991;7(2):75–83.
14. Kerlinger FN, Lee HB. Foundations of behavioral research. 4th ed. Fort Worth (TX): Harcourt College Publishers; 2000.
15. Kolb DA. Experiential learning: Experience as the source of learning and development. Englewood Cliffs (NJ): Prentice Hall; 1984.
16. Lord TR, Marino S. How university students view a new teaching strategy: A case study of inquiry-based teaching. Journal of College Science Teaching. 1993;22(4):246–250.
17. Mishra R, Yadav A. Effectiveness of activity-based learning in science at upper primary level. Educational Research Journal. 2013;3(1):1–7.
18. National Research Council. A framework for K–12 science education: Practices, crosscutting concepts, and core ideas. Washington (DC): National Academies Press; 2012.
19. Novak JD. Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations. 2nd ed. New York: Routledge; 2010.
20. Ntibi JE, Neji HA. Effect of activity-based teaching methods on students' academic performance in chemistry and physics. Journal of Education and Practice. 2018;9(4):19–25.
21. Özmen H. Some student misconceptions in chemistry: A literature review of chemical bonding. Journal of Science Education and Technology. 2004;13(2):147–159.
22. Reddy MS, Rao DB. Teaching science in Indian secondary schools: Issues and challenges. International Journal of Educational Research. 2014;3(2):89–96.
23. Sharma S, Sudesh. Development of novel methods of teaching chemistry and their impact on academic achievement, self-concept, and attitude. Journal of Indian Education. 2009;35(2):85–97.