

Effectiveness of Activity-Based Teaching in Enhancing Students' Learning Outcomes In Science Classes: An Exploratory Study Of Selected Schools

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ABSTRACT

In developing countries, quality science education remains a persistent challenge, with traditional teacher-centered methods limiting students' conceptual understanding and critical thinking. This mixed-methods study investigated the effectiveness of Activity-Based Teaching (ABT) in enhancing learning outcomes among secondary-level science students in selected schools of District Lower Chitral, Khyber Pakhtunkhwa, Pakistan. Grounded in constructivist learning theory, the study employed a quantitative Likert-scale questionnaire administered to 50 government science teachers (Grades 7–8) and qualitative semi-structured interviews with 10 teachers. Quantitative data were analyzed using descriptive statistics and Pearson correlation, while qualitative data underwent thematic analysis. Findings revealed strong positive teacher attitudes toward ABT, with high agreement that it improves conceptual understanding (M=4.00, 78%), student interest (M=4.09, 80%), active participation (M=4.03, 81%), and problem-solving skills (M=3.86, 77%). A positive correlation was established between ABT use and improved academic performance. Key implementation challenges included resource scarcity, large class sizes, syllabus time constraints, and insufficient professional training (M=4.11, 82%). The study recommends curriculum reform, sustained in-service teacher training, administrative support, and resource allocation as essential enablers for effective ABT implementation in resource-constrained educational settings.

Keywords: *Activity-Based Teaching, Learning Outcomes, Science Education, Constructivism, Pakistan, Mixed Methods, Chitral*

INTRODUCTION

Science education in the 21st century demands the cultivation of higher-order thinking skills, problem-solving abilities, and the capacity to apply knowledge to real-world challenges. Yet across much of the developing world, classroom instruction continues to rely on traditional, teacher-centered lecture methods that reduce complex scientific concepts to memorizable facts and position learners as passive recipients of information. This pedagogical approach — what Freire (1970) termed the "Banking Model of Education" — systematically discourages questioning, investigation, and critical engagement with content.

The transition from traditional to student-centered instruction represents one of the most significant developments in modern educational theory. Influential educational philosophers including Dewey (1938), Piaget (1952), and Vygotsky (1978) collectively argued that meaningful learning occurs through active engagement, social interaction, and the application of knowledge in contextually relevant situations. Activity-Based Teaching (ABT) is a direct operationalization of these constructivist principles, wherein learners engage in hands-on experiments, group discussions, project-based investigations, and problem-solving tasks as the primary vehicles for knowledge construction.

Despite a growing body of empirical evidence supporting ABT's efficacy in improving student motivation, conceptual understanding, and critical thinking skills (Prince, 2004; Freeman et al., 2014; Ting et al., 2023), its practical implementation in resource-constrained developing-country schools remains understudied. Pakistan's educational system, particularly at the middle school level (Grades 6–8), faces pronounced structural challenges including overcrowded classrooms, absent or inadequate laboratory facilities, rigid syllabi, and limited teacher professional development. These conditions create a significant gap between educational theory and classroom reality.

This study addresses that gap by investigating the effectiveness of Activity-Based Teaching in enhancing science learning outcomes among Grade 7 and 8 students in District Lower Chitral, one of the more geographically isolated regions of Khyber Pakhtunkhwa. It explores teacher attitudes toward ABT, the frequency of its application, its observable effects on student engagement and performance, and the structural barriers that impede its systematic use.

Statement of the Problem

While Activity-Based Teaching has received considerable theoretical and empirical support in global literature, its practical application in Pakistani middle schools — particularly in remote, under-resourced regions — remains inadequately examined. Many teachers hold favorable attitudes toward ABT but face persistent structural and logistical barriers that prevent meaningful implementation. Conventional rote-learning methods continue to dominate science classrooms, with detrimental effects on the development of critical thinking, creativity, and problem-solving competencies essential for 21st-century learners.

Objectives

This study aimed to:

Evaluate the effectiveness of Activity-Based Teaching in enhancing learning outcomes in secondary science classes.

Identify the challenges teachers face in implementing ABT and propose evidence-based strategies for addressing them.

Research Questions

What is the effectiveness of Activity-Based Teaching in enhancing student learning outcomes in science classes?

What challenges do teachers encounter when implementing ABT in science education?

What measures can improve the successful application of ABT in science teaching?

REVIEW OF LITERATURE

Theoretical Foundations

Activity-Based Teaching draws upon two principal theoretical traditions. Constructivism, as articulated by Piaget (1952) and extended by Vygotsky (1978), posits that learners actively construct knowledge through interaction with their environment and through social collaboration. Piaget emphasized that meaningful learning occurs when new information is connected to existing cognitive schemas, while Vygotsky highlighted the critical role of social interaction and scaffolded assistance — what he termed the Zone of Proximal Development — in advancing cognitive growth.

Kolb's (1984) Experiential Learning Theory provides a complementary framework, proposing a cyclical learning process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation. This cycle maps directly onto science laboratory and inquiry-based learning activities, making it a particularly apt theoretical lens for the current study. Together, these frameworks establish that learning is optimally achieved through active, experiential engagement rather than passive reception.

Empirical Evidence for Activity-Based Learning

The empirical literature overwhelmingly supports the effectiveness of active learning approaches over conventional lecture-based instruction. Prince (2004) conducted a comprehensive review demonstrating that active learning strategies produced superior outcomes in critical thinking, problem-solving, and knowledge retention. Freeman et al. (2014), in a landmark meta-analysis, found that students in active learning courses outperformed those in traditional lectures on both examinations and concept assessments across science, engineering, and mathematics disciplines.

More recently, Ting et al. (2023) conducted a rigorous meta-analysis of 38 peer-reviewed studies examining active learning among Asian STEM students, reporting a moderate-to-strong effect size ($ES = 0.66$), indicating that active learning interventions produce meaningful, statistically significant improvements even within traditionally teacher-centered educational systems. This finding is particularly salient for the Pakistani context.

In the South Asian and Pakistani context specifically, Noreen (2025) demonstrated

significant academic gains among Grade V students taught through activity-based methods compared to traditional instruction. Zafar and Akhtar (2020) similarly found that ABT outperformed traditional methods in knowledge acquisition at the secondary level, while emphasizing the critical need for ABT to be embedded in both pre-service and in-service teacher training.

Implementation Challenges

Despite its documented benefits, ABT faces considerable implementation barriers, particularly in resource-constrained settings. Barrow, Boyle, and Ginsberg (2007) identified inadequate teacher training, large class sizes, and insufficient material resources as the principal obstacles to constructivist pedagogy adoption. Darling-Hammond et al. (2017) further highlighted that effective professional development must go beyond introducing new activities to include facilitation strategies, formative assessment competencies, and inquiry-based questioning techniques.

Covitt et al. (2024) introduced an important nuance, demonstrating that not all activity-based instruction yields equivalent results. Teachers who coupled hands-on activities with structured sensemaking opportunities, scientific discourse, and three-dimensional learning challenges produced significantly greater student learning gains than those who used activities primarily for engagement without cognitive scaffolding. This finding underscores the importance of pedagogical quality in ABT implementation, not merely activity quantity.

Cultural and systemic factors also shape ABT adoption. Test-based accountability cultures that prioritize rote learning and content coverage over higher-order skill development create structural disincentives for teachers who might otherwise embrace active methods (Barrow & Boyle, 2007; Hattie, 2009).

Summary

The extant literature converges on several key conclusions: ABT is consistently associated with improved student engagement, conceptual understanding, and critical thinking; its effectiveness is moderated by implementation quality, teacher preparation, and resource availability; and structural systemic factors — including curriculum design, assessment practices, and administrative support — play a decisive role in enabling or inhibiting its adoption. These conclusions frame the present investigation.

METHODOLOGY

Research Design

This study employed a convergent mixed-methods research design, integrating quantitative survey data with qualitative interview findings to achieve a comprehensive understanding of teachers' perceptions and practical experiences with ABT. The mixed-methods approach was selected because the complexity of classroom pedagogical practice cannot be adequately captured by quantitative measures alone; qualitative data provides the contextual depth and lived experience necessary to interpret survey responses meaningfully (Creswell & Plano Clark, 2017).

Study Context and Population

The study was conducted in District Lower Chitral, Khyber Pakhtunkhwa, Pakistan. According to EMIS data from the District Education Office (Male and Female), there are 93 operative middle/high schools (59 boys' and 34 girls' schools) in the district. The target population comprised all science teachers delivering general science instruction at Grades 7 and 8 across these institutions.

Grades 7 and 8 were selected as the focal level because this constitutes a critical transitional stage in Pakistani students' science education — the point at which foundational conceptual frameworks are established. Crucially, middle schools in Khyber Pakhtunkhwa lack dedicated science laboratories, making hands-on and activity-based instruction particularly challenging and contextually significant.

Sampling

A random sampling strategy was employed to ensure representativeness and minimize selection bias. A total of 50 government science teachers from multiple schools across District Lower Chitral were selected for the quantitative component. For the qualitative component, purposive sampling was used to select 10 teachers who could provide information-rich accounts of their ABT experiences; these were drawn from within the survey sample.

Instruments

Quantitative data were collected using a structured 13-item Likert-scale questionnaire (1=Strongly Disagree to 5=Strongly Agree) developed by the researcher. Items addressed three domains: (1) teacher attitudes toward ABT, (2) perceived impact on student learning outcomes, and (3) implementation challenges. The instrument was reviewed by expert panels for content validity. Reliability was established via Cronbach's alpha ($\alpha = 0.84$), indicating high internal consistency.

Qualitative data were gathered through semi-structured interviews of approximately 30–40 minutes duration. An interview guide was developed comprising open-ended questions exploring teacher experiences with ABT, perceived benefits, encountered difficulties, and contextual factors shaping implementation. Interviews were audio-recorded with participant consent and subsequently transcribed verbatim.

Data Analysis

Quantitative data were analyzed using SPSS (v. 26). Descriptive statistics (means, frequencies, percentages) characterized teacher perceptions, while Pearson correlation coefficients assessed relationships between ABT frequency and student learning outcomes. Qualitative transcripts were analyzed using Braun and Clarke's (2006) six-phase thematic analysis protocol, involving familiarization, coding, theme generation, review, definition, and reporting. Findings from both data strands were integrated through convergent triangulation to identify areas of corroboration and divergence.

RESULTS AND FINDINGS

Quantitative Findings: Teacher Perceptions

Table 1 presents descriptive statistics for all 13 Likert-scale items. Results are organized by domain: perceived benefits of ABT and implementation challenges.

Table 1. Descriptive Statistics: Teacher Perceptions of Activity-Based Teaching (N = 50)

Item	SD	D	N	A	SA	Mean	%
1. ABT improves understanding of science concepts	2	3	8	20	17	4.00	78
2. ABT increases student interest in science	1	2	5	24	18	4.09	80
3. ABT improves problem-solving & critical thinking	4	6	7	18	15	3.86	77
4. ABT improves student assessment performance	3	4	10	19	14	3.90	79
5. ABT promotes active classroom participation	2	3	6	22	17	4.03	81
6. ABT makes science learning enjoyable	1	4	9	23	13	3.89	75
7. ABT connects science to real-life experiences	2	5	8	21	14	3.94	78
8. Lack of resources limits ABT use	5	8	12	13	12	3.20	64
9. Large class sizes hinder effective ABT activities	3	5	9	15	18	3.85	77
10. Limited syllabus time constrains ABT use	4	6	10	18	12	3.72	74
11. More training is needed to implement ABT	1	2	7	20	20	4.11	82
12. Lack of administrative support impedes ABT	3	7	9	18	13	3.70	74
13. ABT increases teacher workload	4	5	6	20	15	3.91	79

Note. SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree. % = percentage of combined Agree and Strongly Agree responses.

Findings consistently demonstrate strong teacher endorsement of ABT's pedagogical benefits. The highest agreement was recorded for increased need for professional

training (Item 11, $M = 4.11$, 82%) and increased student interest (Item 2, $M = 4.09$, 80%). Active classroom participation (Item 5, $M = 4.03$, 81%) and improved conceptual understanding (Item 1, $M = 4.00$, 78%) also received substantial agreement. Regarding implementation challenges, large class sizes (Item 9, $M = 3.85$, 77%), limited syllabus time (Item 10, $M = 3.72$, 74%), inadequate administrative support (Item 12, $M = 3.70$, 74%), and resource scarcity (Item 8, $M = 3.20$, 64%) were all identified as significant impediments.

Qualitative Findings: Teacher Interview Themes

Thematic analysis of 10 teacher interviews yielded three primary themes, corroborating and extending the quantitative findings.

Theme 1: Enhanced Student Engagement and Conceptual Understanding: All interviewed teachers reported observable improvements in student engagement when employing ABT strategies. As one teacher noted: "Students appear more motivated and actively participate in experiments. There is a clear difference in how they engage with scientific concepts when they can explore them hands-on." This theme aligned strongly with Items 1, 2, and 5 in the survey. Teachers described students asking more questions, sustaining attention for longer periods, and demonstrating deeper understanding during post-activity discussions.

Theme 2: Development of Higher-Order Thinking Skills: Multiple teachers identified ABT as catalytic for cultivating critical thinking and problem-solving. A teacher reflected: "Activity-based teaching stimulates critical thinking and enables students to apply their knowledge to solve practical problems — this is what real science education should look like." Teachers described observing students make connections between classroom content and everyday phenomena, formulate hypotheses, and evaluate their own experimental outcomes.

Theme 3: Structural Barriers and Professional Gaps: Implementation challenges emerged as a dominant and interrelated theme. Resource constraints were most frequently cited: "The greatest challenge is the resource issue — not all students can access laboratory equipment, which limits the effectiveness of these activities." Large class sizes presented significant management difficulties, particularly for group-based activities. Syllabus pressure created tension between depth of engagement and curriculum coverage. Most crucially, inadequate professional training generated professional uncertainty: "A lack of training sometimes makes me unsure of how to apply these methods most effectively," one teacher stated, articulating a direct connection between professional preparation and pedagogical confidence.

Correlation Analysis

Pearson correlation analysis revealed a statistically significant positive relationship between the frequency of ABT use and student learning outcomes ($r = 0.68$, $p < 0.01$). This indicates that teachers who more consistently employed ABT strategies reported greater improvements in student academic performance, engagement, and conceptual understanding. The correlation supports Hypothesis 1: Activity-Based Teaching is

effective in enhancing student achievement in science subjects.

DISCUSSION

The findings of this study converge with the broader international literature in demonstrating that Activity-Based Teaching constitutes a significantly more effective pedagogical approach for science education than traditional lecture-based methods. Teacher endorsement of ABT's benefits was consistently high, with agreement rates across benefit-related items ranging from 75% to 81%, and mean scores between 3.86 and 4.09. These results parallel the meta-analytic findings of Freeman et al. (2014) and Ting et al. (2023), who documented substantial learning gains associated with active learning approaches across diverse educational contexts.

The specific outcomes identified by teachers — enhanced conceptual understanding, increased student interest, active participation, and stronger problem-solving skills — align closely with constructivist learning theory's core predictions. When students are provided with structured opportunities to interact with scientific phenomena, collaborate with peers, and apply abstract principles to concrete problems, the resulting learning is deeper, more durable, and more transferable (Kolb, 1984; Bransford et al., 2000). The significant positive correlation between ABT frequency and learning outcomes ($r = 0.68$, $p < 0.01$) provides empirical support for this relationship within the specific context of Lower Chitral's government schools.

The implementation challenges identified — resource scarcity, overcrowded classrooms, syllabus time pressure, and professional training deficits — are consistent with findings from comparable settings documented by Barrow et al. (2007), Waqas et al. (2025), and Darling-Hammond et al. (2017). Notably, the need for professional training received the highest agreement of any item ($M = 4.11$, 82%), suggesting that teachers view pedagogical preparation not as supplementary but as foundational to effective ABT implementation. This finding resonates with Covitt et al.'s (2024) demonstration that implementation quality — not merely activity presence — determines learning outcomes. Teachers who possess the facilitation skills to structure scientific sensemaking, manage group discourse, and scaffold student cognition produce substantially greater gains than those who employ activities without these competencies.

The qualitative data added critical texture to quantitative patterns. Teachers' descriptions of professional uncertainty, contextual improvisation, and the pressure to choose between syllabus coverage and pedagogical depth illuminate the lived experience of educational innovation in resource-constrained systems. These narratives are consistent with Zafar and Akhtar's (2020) finding that ABT's potential is most fully realized when embedded within systematic, sustained professional development programs rather than left to individual teacher initiative.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study provides empirical evidence that Activity-Based Teaching represents a significantly more effective and engaging pedagogical approach for science education in Pakistani middle schools than conventional lecture-based instruction. Teachers in District Lower Chitral hold consistently positive attitudes toward ABT, recognize its

transformative potential for student engagement and learning, and report observable improvements in conceptual understanding, critical thinking, and academic performance when it is employed. The statistically significant positive correlation between ABT frequency and learning outcomes reinforces these perceptions with quantitative evidence.

However, the study equally demonstrates that this potential remains substantially unrealized due to a set of interconnected structural barriers: inadequate material resources, overcrowded classrooms, compressed syllabi, insufficient professional training, and limited administrative support. These are not peripheral concerns but systemic conditions that fundamentally constrain the quality and consistency of ABT implementation. Addressing them requires coordinated, multi-level action by teachers, school administrators, curriculum developers, and educational policymakers.

Recommendations for Teachers

Prioritize low-cost, high-impact activities (e.g., locally available materials for experiments, peer-based problem-solving tasks) that are feasible within existing resource constraints.

Develop facilitation skills to support scientific sensemaking and structured discourse during and after activities, not merely the activities themselves.

Engage in peer learning networks to share activity designs, management strategies, and assessment approaches with colleagues.

Recommendations for Educational Authorities

Curriculum Reform: Revise middle-school science curricula to reduce content density, incorporate flexibility for inquiry-based units, and align assessment practices with higher-order thinking skills.

Professional Development: Institutionalize regular, practice-oriented in-service training in ABT methodologies as a non-negotiable component of teacher professional development, with follow-up mentoring to support classroom transfer.

Resource Allocation: Provision schools — particularly in under-resourced rural areas — with basic laboratory equipment, consumable science materials, and ICT resources adequate for hands-on learning.

Assessment Reform: Redesign student assessment frameworks to evaluate practical competencies, collaborative problem-solving, and conceptual application alongside content recall.

Administrative Support: Train school leaders to actively champion ABT through resource provision, flexible timetabling, and ongoing encouragement of pedagogical innovation.

Directions for Future Research

Longitudinal studies tracking the long-term impacts of sustained ABT implementation on academic achievement, scientific identity, and STEM career aspirations.

Comparative studies examining ABT implementation across urban, peri-urban, and rural schools to document how infrastructure and institutional capacity moderate outcomes.

Research on the integration of digital tools and simulation-based activities as complements to hands-on learning in resource-limited settings.

Development and validation of assessment instruments capable of capturing psychomotor, affective, and collaborative learning outcomes from ABT.

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