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Teaching Science and Technology in Public Schools of Remote Areas

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ABSTRACT

This study explores the multifaceted challenges and emerging opportunities in teaching science and technology in rural public secondary schools of Nepal. Focusing on two geographically distinct schools Shree Langtang Secondary School (pseudonym) in Panchthar and Shree Republic Secondary School (pseudonym) in Taplejung the research examines student attendance, parental involvement, academic achievement, practical and project-based learning, and the integration of information and communication technology (ICT). Findings indicate significant gender disparities favoring female students in attendance and academic performance, alongside low but gradually increasing parental engagement. Practical learning activities are insufficiently implemented due to resource and scheduling constraints. Notably, Shree Langtang Secondary School demonstrates more effective ICT adoption, positively influencing student participation and understanding. The study underscores the urgent need for targeted teacher training, infrastructure development, and community engagement strategies to elevate science education quality in Nepal's remote regions, thereby contributing to national development and global competitiveness.

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1. INTRODUCTION

Nepal, a landlocked country nestled in the heart of the Himalayas, is renowned for its diverse geography and rich cultural heritage (Apollo *et al*., 2021; Bhattarai *et al*., 2005). Despite its breathtaking natural beauty and historical significance, the country continues to face numerous challenges in providing equitable and quality education, particularly in its remote and rural regions. One of the most critical and underserved domains is the teaching of science and technology in public schools, which is vital for equipping students with the competencies necessary for participation in the 21st-century global economy. Science and technology education plays a pivotal role in fostering innovation, improving quality of life, and driving socioeconomic progress especially in a developing country like Nepal, where a large proportion of the population resides in rural areas. However, schools in these remote locations face considerable obstacles, including inadequate infrastructure, lack of laboratory facilities, insufficient teaching materials, and a shortage of qualified teachers who are trained in modern pedagogical approaches. Many classrooms are overcrowded and unequipped with basic amenities such as electricity or internet connectivity, making it nearly impossible to conduct practical experiments or leverage digital tools for learning enhancement.

Beyond logistical limitations, cultural and societal factors also present significant challenges. Nepal is a multilingual and multicultural nation, and in many remote communities, local languages differ from those used in mainstream educational materials, which are typically written in Nepali or English (Paudel, 2023). Moreover, while much of society has moved toward material development and technological integration, rural areas often remain rooted in traditional beliefs and spiritual worldviews. As a result, scientific concepts and technological innovations may appear foreign or even mythical to students whose families have limited exposure to modern education. Parental influence further compounds the issue: when parents themselves are skeptical of or unfamiliar with science, this lack of awareness directly affects their children's perception and motivation toward the subject.

Nevertheless, there are encouraging signs of progress. The expansion of internet access across the country has begun to close the digital divide, even reaching some of Nepal's most remote areas. According to recent data, nearly 94.7% of students from private schools and 58.3% from public schools now have access to the internet (Sherma, 2024; Sherma, 2023). This connectivity opens new pathways for integrating digital learning into classrooms and enables educators to access a wide range of online instructional materials, virtual labs, and professional development resources. In response to these opportunities and ongoing challenges, various initiatives have been launched by the Nepalese government and development partners. Notably, the School Sector Development Plan (SSDP) and the Digital Nepal Framework aim to improve educational infrastructure, provide technological tools, and strengthen teacher training. Through partnerships with international organizations, schools are receiving support in the form of science kits, laptops, and digital content that can enrich the curriculum and make learning more engaging and accessible.

Additionally, non-governmental organizations (NGOs) and community-based efforts have played a vital role in supplementing government programs. NGOs such as The Asia Foundation, Room to Read, and the Nepal Education and Social Development Foundation have been instrumental in training teachers, providing learning materials, constructing schools, and even offering scholarships to disadvantaged students. In many communities, local volunteers and leaders have stepped in to mentor students, organize extracurricular science activities, and mobilize resources for classroom experiments. Such efforts not only address resource gaps but also foster a sense of ownership and sustainability in education.

Despite these multifaceted interventions, a significant gap remains between national educational goals and the actual implementation of science and technology curricula in rural schools. Many students continue to lack the necessary exposure, practice, and critical thinking opportunities that science education should provide. Therefore, this study aims to examine the persistent challenges and explore practical strategies to enhance the teaching of science and technology in public schools located in Nepal's remote areas. Specifically, the objectives of this research are to assess the differences in educational practices and learning outcomes between rural and urban regions; evaluate the methods and extent of technology integration in classroom instruction; and investigate the roles of student engagement and community involvement in supporting science and technology education. By addressing these areas, the study seeks to contribute meaningful insights toward the formulation of more effective, inclusive, and sustainable educational practices in Nepal.

2. LITERATURE REVIEW

The delivery of science and technology education in the rural and remote community schools of Nepal has been the subject of numerous academic and institutional investigations. These studies have consistently identified a range of structural, pedagogical, and contextual challenges that impede the effectiveness of science and technology instruction in such settings. Significant number of community schools in remote areas lack fundamental infrastructure such as science laboratories and experimental apparatus, severely limiting students' opportunities for hands-on learning and practical engagement (Bhatta, 2018). This absence of experiential learning environments diminishes students' ability to internalize scientific concepts and apply them in real-world contexts. Similarly, the combined effect of insufficient teacher training, minimal access to digital tools, and a continued reliance on outdated, lecture-based teaching methods contributes to an overall stagnation in science and technology pedagogy in these areas (Adhikari & Shrestha, 2021).

Teacher deployment and retention have also been highlighted as critical issues. many qualified and experienced science educators are reluctant to serve in rural or geographically isolated schools, primarily due to inadequate incentives, lack of professional development opportunities, and challenging living conditions (Dahal, 2019). This has led to a shortage of subject specialists, with many schools relying on underqualified or multi-subject teachers who are ill-equipped to teach complex scientific material effectively.

Several scholars have proposed context-sensitive solutions to mitigate these challenges. Some research (Kandel, 2016) advocated for the creative use of locally available materials and resources to contextualize science lessons, thereby increasing student engagement and reducing dependence on expensive, imported laboratory equipment. In line with this, some research (Poudel & Sharma, 2017) underscored the impact of linguistic and cultural barriers in science education. They argued that when instructional materials are not aligned with students' local languages or cultural experiences, it can significantly hinder comprehension and interest, especially in early learning stages.

In addition to local research, international organizations have contributed valuable insights. Reports by UNESCO in 2020 and the World Bank in 2019 highlight the transformative potential of integrating Information and Communication Technology (ICT) into rural classrooms (see https://www.worldbank.org). These reports advocate for blended learning approaches that combine traditional instruction with digital content delivery, as well as community-based engagement models that involve parents, local leaders, and civil society in the educational process. The "Mobile Science Lab" initiative by Teach for Nepal in 2022 provides a practical example of this approach (see https://www.teachfornepal.org). The

initiative brought portable science kits and guided experiments to remote schools, demonstrating that high-quality, experiential science education can be delivered even in resource-constrained settings when innovative, mobile, and context-aware strategies are employed.

While these prior studies have contributed significantly to understanding the multifaceted nature of science and technology education in Nepal's rural schools, most have focused on either infrastructure deficiencies or instructional limitations in isolation. This study, however, seeks to adopt a more holistic approach by investigating the intersection of infrastructural readiness, teacher competence, student engagement, and technology integration. Furthermore, it aims to provide updated empirical insights on the current obstacles and propose actionable interventions that are both sustainable and scalable. In doing so, this research intends not only to build upon existing literature but also to extend its scope by identifying practical strategies to enhance science and technology education in Nepal's most underserved educational contexts.

3. METHODOLOGY

3.1 Research Design

This study employed a mixed-method research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of the academic engagement and performance of secondary-level science students in rural Nepal. Quantitative data were obtained through structured questionnaires and academic result evaluations, while qualitative insights were gathered via action research, case studies, and semi-structured interviews. The use of multiple methods allowed for data triangulation, thereby strengthening the validity and reliability of the findings by capturing different dimensions of the educational context.

3.2 Study Sites and Sample

Two rural public secondary schools were purposively selected as representative case studies based on their distinct geographical, administrative, and demographic characteristics:

(i) Shree Langtang Secondary School, located in Yangwarak Rural Municipality, Panchthar District (hilly region).
(ii) Shree Republic Secondary School, located in Phungling Municipality, Taplejung District (Himalayan region).
(iii) Shree Langtang had a moderate student population, while Shree Republic represented a smaller, less dense educational setting. These contrasting contexts enabled comparative analysis regarding school infrastructure, student demographics, and science learning environments in remote areas.

During the academic year 2081 B.S. (2024/2025 A.D.), the study focused on Grades 9 and 10, as these are critical transition years in Nepal's secondary education system. The total sample included 114 students, distributed as follows:

(i) 72 students from Shree Langtang Secondary School
(ii) 42 students from Shree Republic Secondary School

This sample was considered representative of typical rural student populations in Nepal, allowing for the examination of common trends and challenges in science education.

3.3 Data Collection Methods

Primary data were prioritized to capture authentic classroom and community experiences. The following tools were employed:

(i) Structured Questionnaires: Used to collect data on student attendance patterns, parental involvement, and engagement in project-based and practical science activities.
(ii) Result Evaluation: Analysis of academic records from four major examinations—First Trimester, Second Trimester, Third Trimester, and Final Examination—was conducted to assess academic performance in science subjects.
(iii) Case Studies and Action Research: Applied to monitor classroom participation, the implementation of ICT-based teaching strategies, and the outcomes of various instructional approaches.
(iv) Semi-Structured Interviews: Conducted with students, teachers, and parents to explore underlying factors contributing to absenteeism, low academic achievement, and meeting participation.

3.4 Key Variables and Indicators

To ensure focused and meaningful analysis, the following core indicators were examined:
(i) Student Attendance in Science Classes: Categorized into attendance brackets (>90%, 80–90%, 70–80%, <70%) and analyzed by gender and school.
(ii) Parental Involvement: Measured through the number of parents attending each of the seven scheduled meetings throughout the academic year.
(iii) Student Academic Achievement: Evaluated through pass rates and performance trends in four successive examinations, with gender-disaggregated analysis.
(iv) Implementation of Practical and Project-Based Learning: Assessed based on the frequency and variety of science-related activities conducted during the school year.

3.5 Use of ICT-Based Teaching and Learning

The study also assessed the integration of ICT-based instructional strategies in both schools. Data analysis incorporated descriptive statistics (frequencies and percentages) to quantify attendance, parental engagement, and academic performance. Comparative bar charts were generated to illustrate differences between schools and gender groups. For qualitative data obtained through interviews and case studies, thematic analysis was used to extract key themes related to student engagement, teaching effectiveness, and environmental barriers.

3.6 Ethical Considerations

Ethical integrity was maintained throughout the research process. Informed verbal consent was obtained from all participating students and their guardians. Confidentiality and anonymity were assured for all respondents. The research was conducted in accordance with local educational policies and received formal administrative approval from both participating schools. No identifying personal information was recorded or published.

4. RESULTS AND DISCUSSION

4.1 Results

The results are presented in a comparative manner between the two selected rural secondary schools in Nepal, focusing on four key areas: attendance, parental involvement, academic performance, and practical/project implementation, along with the integration of ICT-based teaching and participation patterns.

4.1.1 Student attendance in science classes

Table 1 presents the comparative student attendance rates for Grade 9–10 science classes in both schools, disaggregated by gender. In observation, in both schools, female students had higher attendance consistency. Qualitative interviews identified online gaming (e.g., PUBG, Free Fire) as a major contributor to male student absenteeism, especially in Langtang SS.

Table 1. Comparative Student Attendance Rate (Grade 9–10, Science Subject, by Gender and School).

Attendance Range	Langtang SS (Boys)	Langtang SS (Girls)	Republic SS (Boys)	Republic SS (Girls)
> 90% Days	1	2	1	1
80–90% Days	9	20	7	6
70–80% Days	8	8	6	10
60–70% Days	5	4	2	3
< 60% Days	7	8	4	2

4.1.2 Parental involvement in academic meetings

Table 2 shows the trend of parental attendance in scheduled academic meetings throughout the school year for both schools. In observation, both schools showed gradual increase in parental engagement. End-of-year meetings had relatively higher attendance, indicating delayed but rising concern about student progress.

Table 2. Parental Meeting Attendance Trends Across Academic Year

Meeting Number	Ganesh SS (Out of 61)	Janata SS (Out of 38)
1st	13	7
2nd	18	11
3rd	21	10
4th	15	14
5th	27	16
6th	28	17
7th	30	17

4.1.3 Academic performance in science (pass rates)

Table 3 illustrates the number of students who passed the science subject in each of the four exams throughout the academic year, by school and gender. In observation, continuous academic improvement was observed in both schools. Girls consistently outperformed boys. The trend suggests increased seriousness toward studies over time, especially among girls.

Table 3. Student Pass Count in Science – All Four Exams (by School and Gender)

Exam Period	Langtang SS (Boys)	Langtang SS (Girls)	Republic SS (Boys)	Republic SS (Girls)
First Trimester	13	28	8	11
Second Trimester	15	28	7	9
Third Trimester	16	29	9	13
Final Exam	20	32	11	16

4.1.4 Practical and project-based learning participation

Table 4 presents the completion status of practical and project-based assignments for each school. In observation, despite assignments, not all students completed or submitted practical and project tasks. Reasons included:

(i) Inadequate time allocation in daily routine
(ii) Lack of resource materials and lab access
(iii) Limited student accountability
(iv) A traditional focus on theoretical rather than experiential learning

Table 4. Practical and Project Work Submission Status.

Activity Type	Langtang SS (Total Assigned)	Langtang SS (Fully Submitted)	Republic SS (Total Assigned)	Republic SS (Fully Submitted)
Practical Activities	8	5	6	4
Project Work	6	3	6	2

4.1.5 Use of ICT-based teaching and learning

Both schools have started using ICT tools such as multimedia presentations and internet-based resources. However, their frequency and consistency varied significantly between the two institutions. **Table 4** provides a comparative view of ICT tool usage in both schools based on classroom observations. Langtang SS demonstrated more frequent and varied use of ICT tools, attributed to better infrastructure and teacher initiative. Republic SS faced limitations due to weak internet access and lower digital literacy.

Table 4. ICT Tools Usage Frequency by School (Scale: 0 = None, 5 = Very Frequent).

Tool Type	Janata SS	Republic SS
Multimedia Projector	4	2
YouTube Content	3	1
Simulations (Offline)	2	2
Internet Resources	3	1

4.1.6 Summary of key comparative insights

Table 5 summarizes the comparative performance of both schools across the five analyzed indicators.

Table 5. Summary of Key Comparative Insights.

Indicator	Ganesh SS	Janata SS
Attendance Rate (Avg)	Girls > Boys (Better)	Girls > Boys
Parental Involvement	Gradually increasing	Gradually increasing
Academic Performance Trend	Improving	Improving
ICT Integration Level	Moderate (Growing)	Basic (Needs Support)
Practical/Project Completion	Partial	Lower

4.2. Discussion

This study aimed to explore key dimensions of science education in two rural public secondary schools in Eastern Nepal—Shree Ganesh Secondary School (located in the hilly Panchthar district) and Shree Janata Secondary School (in the Himalayan Taplejung district).

The dimensions included student attendance, parental involvement, academic achievement, practical and project-based learning, and ICT-based teaching practices. The following sections critically interpret the findings in light of the local educational context and relevant literature.

4.2.1 Gender-Based Disparities in Student Attendance

Female students demonstrated comparatively higher attendance rates than male students in both schools. This observation corroborates findings from previous regional studies that have noted increasing engagement among female students in rural educational settings (Sharma & Koirala, 2021). In contrast, male students' frequent absenteeism was linked to excessive time spent on mobile gaming applications such as PUBG and Free Fire. This behavioral trend reflects global patterns of digital addiction negatively impacting adolescent academic engagement (Anderson & Jiang, 2018). Interventions that combine digital literacy with behavioral guidance may be critical to improving male attendance in similar contexts.

4.2.2 Limited but Improving Parental Involvement

Parental participation in academic meetings remained relatively low, averaging only about one-third of the invited guardians across both schools. However, attendance increased in later sessions, suggesting gradual sensitization among parents. The overall low engagement may be attributed to economic hardship and time constraints, which have been commonly reported in rural South Asian education (Poudel & Sharma, 2017). Flexible scheduling, home visits, and parent-focused awareness campaigns could foster stronger school–parent partnerships.

4.2.3 Steady Academic Progress and Gendered Achievement

Students showed a progressive improvement in academic performance across the four periodic assessments, with the highest pass rates observed in the final examination. Notably, female students consistently outperformed male students. These trends indicate that while both genders benefit from cumulative learning over the academic year, female students may be more consistent and attentive in classroom engagement. Early academic interventions may be beneficial to mitigate the initial disengagement observed in male students.

4.2.4 Inadequate Implementation of Practical and Project-Based Learning

Despite the inclusion of some practical and project-based activities, both schools fell short of the recommended frequency and depth of such pedagogical methods. Contributing factors included the absence of credit-hour-based scheduling, limited time allocation for hands-on activities, and an institutional overemphasis on theoretical content. Similar constraints have been widely reported across rural education systems in low-income countries (UNESCO, 2020). Policy-level reforms are needed to promote structured, experiential learning in science education.

4.2.5 ICT-Based Teaching: A Comparative Strength at Ganesh Secondary School

Shree Ganesh Secondary School showed relatively higher engagement in ICT-based teaching-learning activities compared to Shree Janata Secondary School. Teachers at Ganesh were more likely to incorporate digital resources, such as video demonstrations, virtual labs, and PowerPoint presentations, into their science instruction. The increased use of ICT was facilitated by better infrastructure and teacher motivation. This finding aligns with literature suggesting that even modest technological access, when effectively utilized, can enhance student understanding and participation in science subjects (Khanal & Acharya, 2022).

Strengthening ICT capacity across rural schools remains a strategic avenue for improving educational quality.

5. CONCLUSION

This study highlights persistent challenges and emerging opportunities in science and technology education within Nepal's rural public schools. Key findings reveal significant gender disparities, with female students demonstrating higher attendance and academic achievement than their male counterparts. Parental involvement, though currently limited, shows potential for growth and remains critical for sustaining educational improvements. Project-based learning activities face implementation barriers due to resource constraints and time limitations, underscoring the need for targeted institutional support.

Notably, the integration of Information and Communication Technology (ICT) emerged as a pivotal factor in enhancing instructional quality and student engagement. Certainly, ICT can enrich learning experiences of students regardless of subjects. Integrating ICT tools into this method will certainly help in accelerating students' learning process and give students a unique feel in class. The comparatively higher ICT adoption in Ganesh Secondary School illustrates how digital tools can mitigate infrastructural and pedagogical challenges when supported by motivated educators and adequate resources.

For sustainable improvement, policy interventions must prioritize teacher training, gender-sensitive strategies, and active community engagement. Bridging the digital divide through expanded ICT infrastructure and support will be essential to equip rural students with skills aligned to contemporary scientific and technological demands. Ultimately, a coordinated approach involving educators, families, and policymakers is crucial to transform rural science education in Nepal into a model of inclusive, effective, and future-ready learning.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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