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Students' Perceptions on Chemistry Education Programme: A Qualitative Inquiry in Faculty of Education

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Abstract

This article examines the efficacy of the Chemistry Education program offered by the Department of Science and Environment Education, Central Department of Education, Tribhuvan University. It also explores students' perceptions and experiences regarding the program, focusing on its strengths and challenges. Using purposive sampling, ten students enrolled in the Science Education program were selected for data collection through face-to-face interviews and conversations. Verbatim and conversational analyses were employed to analyze the data. The findings indicate that the culture of teaching and learning has shifted from traditional, teacher-centered approaches to student-centered pedagogies, with a strong emphasis on research-based and project-oriented learning. Students appreciated the comprehensive coverage of theoretical concepts in the Chemistry Education program. However, they expressed concerns about the limited opportunities for laboratory work, which they felt hindered their ability to fully grasp and apply the concepts learned. Additionally, the study found that while the program integrates theoretical constructs with real-world applications through experiential learning modalities, doubts persist regarding its effectiveness in cultivating skills essential for long-term professional success. It is strongly recommended to elevate the Chemistry Education program by integrating more dynamic and interactive pedagogical approaches to more effectively nurture the skills critical for sustained professional success.

Introduction

The Department of Science and Environment Education is the first program in chemistry education under the Faculty of Education at Tribhuvan University, Nepal. It was established with the purpose of producing qualified and trained human resources in the field of science education. This program has played a vital role in meeting the growing demand for skilled science educators in Nepal, contributing significantly to the development and improvement of science education across the country. The Department of Science and Environment Education, established in 2057 B.S. under the visionary leadership of Prof. Kedar Man Shrestha, marked a significant milestone in the advancement of this programme in Nepal. His dedication and commitment were instrumental in laying the foundation for this program, which has since played a crucial role in shaping the future of science educators in the country. His pioneering efforts and passion for education have not only set a high standard for academic excellence but also inspired students to pursue and contribute to the field with the dedication and integrity. From the start, Prof. Shrestha used a student-centered approach in his teaching. He made learning interactive by using transparent slides on a projector and engaging students in laboratory activities. His dedication to supporting students and maintaining regularity in his work was outstanding during this time.

A comprehensive review of science education programs is crucial to address concerns about its effectiveness and quality. This review enable stakeholders to identify strategic improvements and reaffirm the department's commitment to excellence in education. Although the agency has taken admirable steps, questions have been raised about the effectiveness and caliber of science education programs, which calls for a thorough review of them. To acquire a deeper understanding of the science education program's advantages and shortcomings, a thorough assessment of its effectiveness is essential. Examining a number of areas, such as curriculum design, teacher preparation techniques, pedagogical approaches, and learning outcomes, would be part of such an investigation. Stakeholders can identify strategic actions to improve the quality and effectiveness of science education programs by carrying out a thorough investigation. This proactive approach not only ease existing concerns but also demonstrates the department's unwavering dedication to quality in science education delivery and continuous development. This study explores how science teaching and learning practices have changed in the Department of Science and Environment Education over the last ten years, with a special emphasis on chemistry education. The development of critical thinking abilities was eclipsed by the prevalent reliance on memorizing. Individualized attention from teachers was a noteworthy characteristic, even under the constraints of a dogmatic and stereotypical teaching framework, despite the relatively small class sizes.

As we move forward to the present day, we see a significant change in the science education programme, which is a sign of the move toward student-centered learning strategies. Pedagogical techniques in the field of chemistry education have embraced innovation and diversity (Sanders Johnson, 2021; Stoddard, 2022). A variety of teaching approaches have been developed and used; they include collaborative strategies and flipped learning. Additionally, some faculty members have added project-based learning and group discussions. This shift away from traditional didacticism is part of the department's larger push for a more engaging

and dynamic learning approach. A pedagogical revival is highlighted by the evolution of teaching approaches, which indicate a shift away from the limitations of traditional teaching practices and toward a more learner-centric and holistic approach. The use of technology, which has transformed education and given students access to a wealth of interactive tools and materials, is essential to this pedagogical growth (Bizami et al., 2023; Tuma, 2021). Technology integration in the classroom has improved student engagement and allowed for a deeper comprehension of difficult scientific ideas (Attard & Holmes, 2020; Bereczki & Kárpáti, 2021; Nkomo et al., 2021). Additionally, a deliberate attempt has been made to develop critical thinking and problem-solving abilities, going beyond simple memory and toward the development of higher-order cognitive skills. The use of differentiated teaching, which aims to meet the various learning requirements of students and provide an inclusive and fair learning environment, reflects this emphasis on skill development.

To enhance flexibility and relevance, a deliberate effort is being made to revise the curriculum to complement these pedagogical advances. This iterative method of developing curricula makes sure that learning opportunities stay in line with the changing needs. Additionally, students are urged to take charge of their education and participate in group inquiry, with a renewed emphasis on creativity and active engagement. Innovation and inclusion have replaced the previous traits of rigidity and uniformity (AlMalki & Durugbo, 2023; Moschko et al., 2023). This renaissance in pedagogy is a reflection of a larger social movement in favor of learner-centric education, which gives students the agency to actively create meaning and knowledge.

Higher education has seen a significant paradigm shift at the Central Department of Education from a traditional teaching-centric approach to a dynamic emphasis on learning. In the past, lecturing and rote memorization were the main methods used in pedagogical practices to spread knowledge one way. However, a shift toward learner-centered approaches has signaled a fundamental reevaluation of educational paradigms in recent years (Gravani et al., 2024; Msonde, 2023; Song et al., 2024).

The adoption of cutting-edge teaching techniques like project-based evaluations, flipped classrooms, and collaborative learning is indicative of this revolutionary progression (Malik & Zhu, 2023; Rahayu & Indriyanti, 2023; Hao et al., 2024). Furthermore, the significance of facilitating students develop their critical thinking, problem-solving, and lifelong learning competencies is becoming increasingly apparent. Because of this, the department is placing a higher priority on technological integration, individualized education, and interactive involvement to improve the learning process. This change represents a move away from passive reception and toward active involvement,providing students the ability to design their own educational path and encouraging a culture of inquiry, investigation, and discovery. A major discovery of the study is how important it is to combine academic ideas with real-world applications in order to strengthen comprehension. Students have a stronger understanding of how abstract concepts appear in real-world situations when they combine the theoretical knowledge they learn in lectures with practical experiences. When students go from being passive users of information to active participants in their learning process, this integration acts as a catalyst for transformative moments (Acosta et al., 2023; Bass, 2023). Through the integration

of hands-on activities like simulations, case studies, and experiments into the curriculum, educators facilitate students' application of theoretical information in a concrete manner.

A culture of ongoing learning and development is fostered by constructive criticism, which raises the standard of the educational process as a whole. Students feel more comfortable asking for help, clarification and guidance when teachers are approachable (Ramey & Stevens, 2023). Positive student-teacher interactions are emphasized as being greatly aided by personalized attention (Javaid et al., 2024; Sørensen, 2023). Teachers can provide a more customized and individualized learning experience for their students by identifying and meeting each student's unique learning requirements, preferences, and skills. A stronger bond and sense of support are fostered by this individualized attention, which shows concern and involvement in students' academic achievement. Building healthy student-teacher relationships seems to revolve around collaboration (Dean & Gibbs, 2023). Working together on assignments, discussions, and research projects fosters a sense of cooperation and shared accountability for the educational process between educators and students. Working together inspires students to investigate various viewpoints, actively interact with the course material (Acharya, 2016), and sharpen their critical thinking abilities in a group environment. Building solid relationships between students and teachers is said to require a foundational element of trust (Payne et al., 2023). Students who have faith in their teachers are more likely to be open to criticism, direction, and assistance. Students are more willing to take intellectual risks, investigate novel concepts, and push themselves intellectually when they feel safe and secure in the classroom (Sun et al., 2023; Çoban et al., 2023).

This study is being conducted to explore students' perceptions on the chemistry education program at the Department of Science and Environment Education, FOE, TU. Despite the program's aim to produce skilled and innovative educators, there are concerns about its effectiveness in achieving this goal. By gathering insights from students who have experienced the program from its beginning to the present, the study seeks to assess how well it meets its objectives. Through face-to-face interviews and qualitative analysis, the research examined the changes in teaching and learning practices over the years, particularly the shift from traditional methods to more student-centered, research-based, and project-oriented approaches. The study aims to identify areas for improvement and highlight the importance of creating dynamic and interactive learning environments to enhance the quality and effectiveness of chemistry education in Nepal.

Methodology

The study uses a longitudinal qualitative research methodology with the purpose of examining M.Ed.-level students' opinion. Through the process of gathering and examining student responses, perspectives, and experiences, the study aimed to comprehend how students' learning experiences develop over time. Employing verbatim and conversational analysis methodologies, the research thoroughly examines the student narratives to pinpoint of change in their academic journey. This method enables investigation of students' changing experiences and perspectives in the context of chemistry learning. This longitudinal qualitative study used student responses over ten years, ideas, and experiences, verbatim and conversational analysis, all combined into a qualitative study design. Student reflections and thoughts on these issues spanning this

long period in the Department of Science and Environmental Education.

The population is the students studying from 2071 to 2080 BS. There were about 120 students enrolled in the M.Ed. Chemistry Education program during that time. Only ten students are included in the sample it is designed that mostly one student from each academic year were selected purposively. Interviews were conducted to further investigate the case. The conversational analysis included both formal and casual dialogue, self-reflection over the previous ten years, and conversations in tea shops, under the large tree sheds, and on the campus ground. There was no time limit on conversations, and they were casual. It was casual to elicit detailed experiences and perspectives from the participants. Texts, stories, thoughts, and experiences that provided qualitative data were categorized and examined in accordance with the study's objectives. The study offers a thorough assessment of the long-term experiences and perspectives of students enrolled in the department. Gathering information through systematic observation of students' behaviors, interactions, and engagement in the classroom for observational data gathering. During chemistry education classes, the researcher watched student responses, classroom dynamics, and instructional techniques. By providing contextually rich data that captures students' educational experiences beyond verbal expression, this strategy enhanced data creation strategies. Examining different documents pertaining to chemistry education, including course materials, student assignments, and institutional policies, more reflections were recorded. Verbatim transcripts of students' narratives are meticulously recorded within double inverted commas to maintain their authenticity and ensure accurate representation of participants' voices. Verbatim analysis is employed as a main technique to systematically identify and interpret recurring themes and patterns within the information.

The author has been a teacher in this department for the last twenty years, during this time he has meticulously collected data from one students representing academic sessions. This data, accumulated over an extended period, forms the foundation of this manuscript. Additionally, the author's reflections, enriched by his unique perspective as both a former student and a current teacher in the same department, serve as a valuable data source, adding depth and insight to the study.

Findings

The study highlights a significant shift in the Department's teaching methods, moving from traditional rote learning and teacher-centered approaches to more dynamic, student-centered strategies that prioritize critical thinking and real-world applications. It was found that the Department primarily used traditional rote learning techniques that were teacher-centered and had low student participation. Notes were typically utilized to accompany lectures, creating a passive learning atmosphere that prioritized memorizing over critical thinking. In this line, one of the respondents said:

"I am a student in this department in the fifth batch. I felt that teachers mostly use lectures and provided notes, but they engaged us in practical classes. After years, I realized that it would have been better if teachers had provided us with research-oriented tasks during our time."

Reflecting on teaching and learning, another student said:

"As a student of the fifteenth batch, I remember how, even with small class sizes, the rigid framework of teaching limited the opportunities for teachers to provide personalized attention. The focus was mainly on lectures, with little room for interaction or individualized support. It often felt like we were just going through the motions, memorizing notes without truly understanding the material. However, in recent years, I've observed a significant shift in teaching. There's been a move towards more student-centered approaches, which is a welcome change. Techniques such as project-based learning, group discussions, flipped classrooms, and collaborative methodologies are now being embraced, making the learning experience more engaging and interactive. This evolution in teaching strategies not only encourages critical thinking but also allows students to apply theoretical concepts in practical, real-world contexts."

This change represents a shift away from inflexible didactics and toward dynamic, interactive education. One of the study's main findings is the incorporation of theoretical ideas with real-world applications. Through the use of experiential learning methods like experiments, simulations, and case studies, teachers enable students to comprehend concepts more deeply and have meaningful learning experiences. It is found that opportunities for experiential learning, expose students to real-world problems in a practical setting and develop their critical thinking and problem-solving abilities. Another student said:

"In our classes, the shift towards active participation and collaboration really stood out. Students were no longer just passive listeners; instead, we interacted with the course material and shared ideas in a collaborative atmosphere. This not only made learning more engaging but also led to those transformative moments where everything just clicked."

In the similar line, another student replied:

"The integration of technology into our learning experience was a game-changer. It wasn't just about using computers; it was about having access to interactive tools and resources that made it easier to stay engaged and continue learning both inside and outside of the classroom. The positive relationships with our teachers, built on open communication and mutual respect, also created a strong sense of community, motivating us to be more involved and work together as a team."

Students feel respected and empowered to succeed academically in a supportive learning atmosphere that is further enhanced by personalized attention and constructive criticism. One noteworthy feature of the Department's educational framework is the incorporation of research-based teaching and learning approaches. One of the students said:

"The Department's dedication to promoting a culture of academic inquiry and knowledge dissemination is further demonstrated by its involvement in scholarly publications and its mentoring of students in their research activities. The chemistry education curriculum utilizes a thorough and diverse evaluation structure. Internal assessment measures students' growth and involvement throughout the course of the semester through a variety of tasks like assignments, presentations, and term exams."

The department's dedication to creating transformative learning opportunities and equipping students for success in the field of chemistry is reflected in the emphasis on active involvement, critical thinking, and application of theoretical concepts. The study highlights a significant shift in the methods used in the Department of Science and Environment Education's teaching and learning. One student opinioned:

"Our Department has transformed into a dynamic and inclusive learning environment where critical thinking, lifelong learning, and student engagement are at the forefront. This shift has not only made our education more meaningful but has also prepared us better for the challenges of the modern world."

Another student replied during conversation is:

"By adopting innovative teaching methods, integrating technology, and fostering strong relationships between students and teachers, our Department has truly set a new standard in chemistry education. The focus on research-based teaching and learning practices has created a more engaging and effective learning experience that goes beyond the classroom."

In the transformative gentre, another student said stated:

"The changes in our Department have far-reaching implications for how education is delivered. These findings emphasized the importance of rethinking institutional policies, pedagogical approaches, and curriculum design to improve student learning outcomes. It's about preparing us not just for exams, but for success in the ever-evolving landscape of higher education."

It reveals a significant evolution in the Department's teaching-learning methods, transitioning from traditional, rote learning and teacher-centered approaches to dynamic, student-centered strategies that emphasize critical thinking and practical application. Initially, the Department's reliance on lectures and notes fostered a passive learning environment, with little opportunity for personalized attention and deep understanding. Students from earlier batches reflect on the limitations of this approach, expressing a desire for more research-oriented and interactive learning experiences during their time. However, recent shifts in teaching have embraced project-based learning, group discussions, flipped classrooms, and collaborative methodologies, allowing students to actively engage with the material and apply theoretical concepts in real-world contexts. This transformation has not only enhanced students engagement but has also fostered a more inclusive and interactive educational environment, encouraging meaningful learning experiences through the integration of technology and experiential learning methods.

Furthermore, the Department's commitment to research-based teaching and fostering strong student-teacher relationships has set a new standard in chemistry education. The integration of technology has been particularly impactful, providing students with interactive tools that enhance learning both inside and outside the classroom. Positive student feedback highlights the supportive learning atmosphere, characterized by open communication, respect, and collaboration, which has empowered students to succeed academically. The Department's active involvement in scholarly research and mentoring students in their academic inquiries further underscores its dedication to promoting a culture of academic excellence.

These changes have significant implications for institutional policies, pedagogical approaches, and curriculum design, ultimately aiming to improve student learning outcomes and prepare them for success in the evolving landscape of higher education.

Discussion

The notable transition from conventional rote learning techniques to more student-centered methods is indicative of a larger pedagogical renaissance that aims to support students' lifelong learning, critical thinking, and deeper involvement. There has been a fundamental shift in educational philosophy with the shift from teacher-centered to student-centered approaches. This shift is supported by a large body of literature that emphasizes the value of learner autonomy and active learning (Şener & Mede, 2023; Zhou, 2023). The passive character of traditional lecture-based instruction, its poor capacity to foster deep learning, and its incompatibility with contemporary pedagogical ideas have all been criticized (Dean & Gibbs, 2023). Student-centered techniques, on the other hand, place more emphasis on inquiry-based methods, collaborative learning, and active involvement. These strategies have been demonstrated to improve conceptual understanding, motivation, and retention (Gravani et al., 2024). By adopting cutting-edge teaching strategies like project-based learning, flipped learning, and collaborative methods, teachers enable students to take charge of their education, developing a stronger sense of agency and intellectual curiosity (Şener & Mede, 2023).

The findings of this study underscore a notable shift from traditional rote learning and teacher-centered approaches towards more dynamic, student-centered methods in the Department. In the past years, chemistry education in the Department relied heavily on lectures and notes, creating a passive learning environment that emphasized memorization over critical thinking. This approach is consistent with what researcher have criticized as an outdated model of instruction, which often fails to engage students actively to promote deeper understanding (Hao et al., 2024). The student's reflection on the limitations of past practices highlights the need for a more interactive and research-oriented approach, aligning with current pedagogical trends that advocate for a departure from mere content delivery towards fostering critical thinking and problem-solving skills (Acosta et al., 2023).

The Department has embraced student-centered teaching strategies such as project-based learning, group discussions, and flipped classrooms. These methods reflect a broader educational shift towards active learning, which has been shown to enhance student engagement and academic achievement (Bizami et al., 2023; Stoddard, 2022). The experiences of students from the tenth batch, who observed a significant improvement in their learning environment, corroborate findings from literature that suggest such strategies can lead to more meaningful learning experiences by encouraging students to apply theoretical knowledge in practical contexts (Bass et al., 2023). This transition aligns with contemporary educational theories that emphasize the importance of interactive and participatory learning environments in promoting deeper cognitive engagement and skill development (Javaid et al., 2024).

The incorporation of experiential learning methods, such as experiments and simulations, further supports the shift towards a more dynamic educational approach. These methods allow students to confront real-world problems and apply their knowledge

in practical settings, thereby enhancing their critical thinking and problem-solving abilities (Demircioglu et al., 2023). The feedback from students about the increased opportunities for active participation and collaboration reflects the benefits of these innovative pedagogical practices. As educational research increasingly supports the efficacy of such approaches in improving student outcomes, the Department's commitment to integrating technology and fostering strong student-teacher relationships demonstrates its alignment with best practices in modern education (Ma et al., 2023). This evolving framework not only addresses past deficiencies but also prepares students more effectively for the challenges of higher education and professional environments.

According to Demircioglu et al., (2023) fostering positive relationships between students and teachers is crucial to establishing a supportive learning environment that promotes academic performance and personal development. Effective teacher-student relationships are characterized by open communication, mutual respect, and approachability, which promote trust, rapport, and a sense of community (Bizami et al., 2023). Furthermore, a supportive learning environment where students feel appreciated, encouraged, and empowered to realize their full potential is facilitated by individualized attention, constructive criticism, and active participation (Izquierdo-Acebes & Taber, 2024). Teachers established a favorable learning environment that fosters academic engagement, social-emotional growth, and general well-being by placing a high priority on strong student-teacher relations (Strat et al., 2024). Research projects prepare students for success in academic and professional pursuits by encouraging critical thinking, problem-solving techniques, and intellectual curiosity (Izquierdo-Acebes & Taber, 2024). Additionally, encouraging interdisciplinary collaboration and expanding the boundaries of knowledge in the field, mentoring students in their research endeavors fosters a culture of academic excellence and innovation (Moreira et al., 2023). Teachers can design engaging learning environments that encourage students' critical thinking, deep learning, and scholarly engagement by using research-based teaching and learning techniques (Strat et al., 2024).

The integration of technology into the learning experience has been pivotal in transforming educational practices within the Department, as evidenced by student feedback highlighting its role in enhancing engagement and facilitating learning both inside and outside the classroom. This shift aligns with recent literature, which emphasizes that technology, when used effectively, can significantly enrich the learning environment by providing interactive tools and resources that support active learning and continuous engagement (Nkomo et al., 2021). The positive impact of technology on student motivation and participation is well-documented, with studies indicating that interactive tools and digital resources can make learning more dynamic and accessible, thus fostering a more engaging educational experience (Gautam & Acharya, 2023). Additionally, the development of strong teacher-student relationships through open communication and mutual respect further supports the notion that a collaborative and supportive learning atmosphere enhances student involvement and teamwork (Haag et al., 2023).

The Department's focus on research-based teaching and learning approaches represents a commitment to advancing academic inquiry and fostering a culture of continuous improvement. This dedication is supported by

literature that underscores the importance of integrating research into educational practice to enhance teaching effectiveness and student outcomes (Wagle et al., 2023). The involvement of faculty members in scholarly research and their role in mentoring students aligns with best practices in education that advocate for a research-informed approach to teaching, which can lead to more effective and evidence-based instructional strategies (Acharya, 2024). The diverse evaluation structure employed by the Department, including various assessment methods such as assignments, presentations, and exams, further reflects a comprehensive approach to measuring student progress and supporting their academic development (Gautam & Acharya, 2023). This transformation is consistent with contemporary educational research that highlights the benefits of student-centered learning environments in promoting deeper understanding and lifelong learning (Dean & Gibbs, 2023). The findings suggest that rethinking institutional policies, pedagogical approaches, and curriculum design is crucial for improving educational outcomes and equipping students with the skills needed to thrive in higher education and beyond (Bizami et al., 2023). Assignments, term examinations, and presentations are examples of internal assessments that provide insightful information about students' involvement and progress throughout the semester. This information helps teachers make decisions about their instruction and carry out focused interventions (Moreira et al., 2023). Furthermore, a thorough assessment of students' learning outcomes is provided by the alignment of internal and external assessments, which guarantees the validity and reliability of evaluation measures (Tuma, 2021). Internal assessments support the development of critical thinking, active participation, and the application of theoretical concepts all of which are critical for success in the chemical field (Attard & Holmes, 2020).

It is imperative to comprehend the transforming moments that university students encounter in the field of chemistry education in order to improve pedagogical methods and advance successful learning outcomes. In order to find important insights and patterns across time, this literature review concentrates on longitudinal qualitative assessments of the body of research on this subject. Students' comprehension of scientific concepts and their capacity to apply them in practical settings are significantly shaped by their chemistry education (Bizami et al., 2023). Deep learning and conceptual understanding are greatly aided by transformative moments, which are characterized as crucial events or experiences that cause significant changes in students' perspectives, attitudes, and behaviors (Koirala, 2023). The transition from rote memory to conceptual comprehension is a crucial component of transformative moments in chemistry education (Parajuli & Subedi, 2023). Teachers can track the development of students' understanding and pinpoint certain events and treatments that spur this change by using longitudinal qualitative analysis.

Researchers can investigate how various instructional strategies affect students' learning trajectories over time by using longitudinal studies (Sztajn et al., 2012). Through the process of recording student experiences and perspectives across several years, teacher’s can pinpoint instructional practices that reliably provide transformative learning results. Moreover, longitudinal qualitative studies shed light on the sociocultural elements influencing students' experiences learning chemistry. According to research, a student's attitudes toward science and learning outcomes can be influenced

by a variety of factors, including gender, ethnicity, socioeconomic background, and previous educational experiences (Haas & Hadjar, 2020). Teachers can investigate how these socio-cultural elements interact with instructional interventions to affect students' transformative learning experiences in chemistry through longitudinal studies. Additionally, there are chances for life-changing educational experiences when technology is included into chemistry learning. Students can conduct experiments in virtual environments and explore chemical processes through interactive technologies such as simulation software, internet resources, and virtual laboratories (Upadhyaya, 2023). Qualitative longitudinal studies can provide insight into how students interact with these tools over time and how much they add to chemistry lessons that are truly transformative.

The study's findings highlight a significant transformation in the Department's teaching methodologies, moving away from traditional, rote learning and teacher-centered approaches towards more dynamic, student-centered strategies. This shift is in line with current educational research that advocates for active learning environments which prioritize critical thinking and practical application over passive absorption of information (Dean & Gibbs, 2023). Initially, the Department's reliance on lectures and notes created a passive learning environment with limited opportunities for personalized engagement and deep understanding. This reflects concerns raised by scholars who argue that traditional methods often fail to foster deeper cognitive engagement and critical thinking (Moreira et al., 2023). The recent adoption of project-based learning, group discussions, and flipped classrooms represents a significant advancement in pedagogical practices. These methods, supported by research, enhance student engagement and learning by promoting active participation and real-world application of theoretical concepts.

Moreover, the Department's commitment to integrating technology and fostering strong student-teacher relationships underscores its dedication to creating an inclusive and supportive learning environment. The positive impact of technology on learning, as highlighted in student feedback, is consistent with literature that emphasizes its role in enhancing student engagement and facilitating continuous learning both inside and outside the classroom (Acharya et al., 2023). The emphasis on research-based teaching and mentorship aligns with best practices in education that advocate for a research-informed approach to teaching, which can significantly improve educational outcomes (Acharya, 2024). The Department's focus on creating a supportive atmosphere characterized by open communication and respect has empowered students to excel academically, reflecting the importance of a collaborative and nurturing educational environment (Acharya et al., 2020). These advancements have profound implications for institutional policies, pedagogical approaches, and curriculum design, aiming to better prepare students for success in the evolving landscape of higher education.

Conclusion and Implication

The findings of this study underscore the transformative impact of innovative teaching and learning strategies implemented by the Department of Science and Environment Education. By moving from traditional, rote learning methods to dynamic, student-centered approaches, the Department has significantly enhanced student engagement and learning outcomes. The integration of technology, emphasis on real-world

applications, and strong student-teacher relationships have collectively fostered a more inclusive and interactive educational environment. This evolution reflects a commitment to adopting best practices in pedagogy and highlights the Department's leadership in advancing chemistry education. The shift towards project-based learning, collaborative methodologies, and research-oriented tasks has not only improved the quality of instruction but also better prepared students for the challenges of higher education and their future careers.

The study's findings have several important implications for educational institutions. First, they suggest a need for policy adjustments that support the integration of innovative teaching methods and technology in the curriculum. Department should consider adopting similar student-centered approaches and fostering strong student-teacher relationships to enhance learning outcomes. Additionally, the emphasis on research-based teaching underscores the importance of continuous professional development and scholarly engagement for educators. Future research should focus on evaluating the long-term effects of these pedagogical innovations on student performance, career readiness, and lifelong learning capabilities. It is also crucial to explore strategies for sustaining and expanding successful practices across diverse educational contexts to maximize their impact on student success.

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