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Integrating ICT Tools in Science Learning: A Pedagogical Perspective

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Abstract

This study explores the application of Information and Communication Technology (ICT) tools in the teaching and learning of science at the secondary school level in Nepal. Quantitative and qualitative data were collected through structured questionnaires, checklists, classroom observations, and interviews using a convergent mixed-methods research design. Quantitative data collected from 100 students through a random procedure were analyzed using SPSS (version 25.0), while qualitative insights were gathered from interviews with four purposively selected teachers. The findings revealed that although students and teachers are generally aware of ICT tools, their application in science classrooms remains minimal. Limited access to ICT resources, insufficient training, lack of internet connectivity, and power issues were major challenges. The study concludes that these barriers must be addressed to integrate ICT into science education effectively. It recommends that integrating ICT in classroom learning helps improve infrastructure, professional development, and institutional support in Nepal's secondary science classrooms.

Key Words: ICT, ICT tools, science education, Internet, teaching and learning.

1. Background of the study

Information and Communication Technologies (ICT) represent diverse technological tools and resources used to communicate, create, store, and manage information (Alkamel & Chouthaiwale, 2018). ICT encompasses various digital technologies such as computers, internet services, software applications, mobile devices, and multimedia tools that support transmitting, processing, and sharing information (Aboderin, 2011). As Wallet and Valdez (2014) have noted, ICT is a fundamental requirement for working in the 21st century and has become embedded in all sectors, including education, research, business, and science. Its integration into education has been recognized as a transformative force, shaping new ways of teaching and learning. In recent years, a growing body of literature has recognized the importance of integrating ICT into education. The use of ICT in classrooms is believed to improve pedagogical practices, enhance student engagement, and foster interactive and collaborative learning environments (Ghavifekr & Rosdy, 2015). According to UNESCO (2015b), ICT has the potential to contribute significantly to equitable access, quality learning, teacher development, and efficient educational governance. Furthermore, Imon (2017) argued that integrating ICT may promote a shift from teacher-centred to student-centred learning approaches, encouraging critical thinking and creativity among learners.

Globally, many developed and developing countries have made important efforts to integrate ICT into their education systems. For example, countries are increasingly adopting e-learning platforms, introducing computer-based curricula, and investing in digital infrastructure (Joshi, 2016). In Nepal, the Ministry of Education (MoE) has implemented several national strategies and plans, such as the School Sector Development Plan (2016–2022) and ICT in Education Master Plan (2013–2017), to promote the use of ICT in schools. These initiatives aim to enhance ICT infrastructure, provide digital learning resources, and foster ICT competencies among teachers and students (MoE, 2013). Despite these developments, the practical implementation of ICT in teaching and learning science at the secondary level remains limited in Nepal. Science education, in particular, can benefit greatly from ICT tools, which can enhance students' understanding of abstract scientific concepts through simulations, visualizations, and interactive content (Knezek & Christensen, 2002). However, many teachers still rely on traditional "chalk and talk" methods, and school ICT facilities are often underutilized or lacking. According to Digital and Younus (2022), the COVID-19 pandemic has further exposed the digital divide and highlighted the urgent need to strengthen ICT integration in education systems.

Integrating ICT with science learning aligns closely with Nepal's School Sector Development Plan (SSDP) and school education plan (SEP), which promotes ICT-supported teaching and learning to enhance quality education. The SSDP prioritizes using digital technologies to foster student-centred and inquiry-based learning, particularly in STEM subjects. ICT integration supports the SSDP's equitable access to quality education goals by bridging geographic and resource gaps in science instruction. Study findings also show that digital tools enhance conceptual understanding and critical thinking, directly supporting SSDP's objective of improving learning outcomes. Therefore, incorporating ICT in science education modernizes pedagogy and fulfils national policy mandates for inclusive, technology-enhanced education reform.

This study seeks to address this gap by examining science teachers' current use of ICT tools at the secondary school level in Nepal. It explores how these tools are employed for instructional tasks, the challenges teachers face, and the opportunities for improving ICT-based science education. The study is significant because it provides empirical evidence that may inform policymakers, curriculum designers, and educational stakeholders about effectively integrating ICT in science teaching. Moreover, the findings aim to contribute to the growing knowledge of ICT in education and offer practical recommendations for transforming science pedagogy through digital innovation.

2. Materials and Methods

The study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to understand better the use and integration of ICT tools in science education at the secondary level. Creswell (2012) explains mixed methods as a process combining numerical and narrative data to provide a more complete perspective on research problems, assuming neither method alone can adequately address complex issues. In this study, a QUAN+QUAL convergent was adopted, with the quantitative phase conducted first to explore the extent and frequency of ICT use, types of tools available, and students' and teachers' attitudes toward ICT. Data were collected using structured questionnaires, checklists, and classroom observations and analyzed using SPSS using descriptive statistics such as frequencies and percentages. The subsequent qualitative phase supported and elaborated on the quantitative findings, exploring the deeper challenges and opportunities associated with ICT integration in science education. This phase involved semi-structured interviews with science teachers and was analyzed through thematic techniques. The mixed-method design enabled data triangulation and offered a richer, more comprehensive understanding of the research context (Creswell, 2012).

The research site was the Vyas Municipality of Gandaki province, selected for its accessibility and the presence of ICT-integrated schools. The study population included all secondary-level science teachers and Grade 10 students in the municipality, from which a multistage sampling technique was used to select ten schools. Ten science teachers and 10 students were purposively selected for the qualitative sample, and 100 randomly selected students were taken for the quantitative sample. Four teachers from this sample were later interviewed for qualitative insights. Data collection tools included structured questionnaires, checklists, interviews, and observation guides. The tools' validity and reliability were ensured through expert feedback, pilot testing, and reference to existing literature and previous research instruments (Pandey & Pandey, 2015; Odhiambo, 2013). Quantitative data were statistically analyzed using SPSS and Excel, while qualitative responses were transcribed, coded, and thematically analyzed. Ethical considerations were upheld by obtaining informed consent, protecting respondent confidentiality, and seeking approval from school authorities before data collection (Kabir, 2018).

Theoretical/ Conceptual Framework

Integrating Information and Communication Technology (ICT) in science education is grounded in the constructivist learning theory, which emphasizes learner-centered, interactive, and knowledge-building environments (Vygotsky, 1978). Constructivism supports the idea that students learn best through active

participation and collaboration, which ICT tools can facilitate through simulations, virtual labs, and interactive multimedia resources (Jonassen, 1999). ICT also aligns with the Technology Acceptance Model (TAM), which explains how perceived usefulness and ease of use influence teachers' willingness to adopt technology in the classroom (Davis, 1989). According to this model, teachers are more likely to integrate ICT when they believe it enhances their instructional effectiveness.

The conceptual framework of this study assumes that ICT tools (e.g., computers, projectors, mobile apps, internet resources) can enhance the quality of science education by promoting engagement, visualization of abstract concepts, and real-time access to scientific information (Ghavifekr & Rosdy, 2015). The successful use of ICT in science teaching depends on four key factors: teacher competence, availability of resources, institutional support, and student readiness (UNESCO, 2015). These elements interact to shape the actual use of ICT in classrooms and ultimately impact learning outcomes. In the context of Nepal, where traditional lecture-based methods dominate, ICT tools offer opportunities to modernize science education by fostering inquiry-based and exploratory learning (Joshi, 2016). However, challenges such as lack of infrastructure, inadequate training, and limited access must be addressed to realize these benefits (Digal & Younus, 2022). This framework, therefore, explores how integrating ICT tools can transform science teaching practices and improve student learning outcomes in secondary schools.

3. Result and Discussion

The quantitative data was statistically analyzed using the Statistical Package for the Social Sciences (SPSS), version 25. The analysis includes descriptive analysis. The researcher used descriptive analysis to determine and analyze the data's mean, standard deviation, frequency, and percentage. For qualitative data analysis, the data from the semi-structured interviews were transcribed. It involved identifying themes and patterns through coding and categorizing the data. The responses from the participants were arranged, organized, transcribed, and coded, and themes were generated based on the data that were collected. The data analysis and interpretation have been summarised under the following headings.

Availability and Access to ICT Tools

A checklist was used to record the data on ICT tools and facilities available in the schools. To get an analysis of ICT resource usage, the ICT resources available in the school and their purpose for the application of these resources are given in Table 1.

Table 1. Availability and application of ICT resources at school

ICT tools	Availability	Application		
		Instructional purpose	Administrative purpose	Others
Computer	100%	100%	100%	-
Internet	100%	70%	30%	-
Digital Projector	80%	100%	-	50%
Television	40%	-	-	100%
Scanner	100%	-	100%	-
Printer	100%	-	100%	-
Digital board	40%	100%	-	-

Table 1 shows that all the schools had a range of ICT tools available, including computers, internet access, digital projector, television, scanner, printer, and digital board. 100% of the selected schools were reported to have computers, internet facilities, scanners, and printers. However, only computers were used for instructional purposes in 100% of the schools, and they were also used for administrative purposes by all the schools. Internet facilities were used for instructional purposes in 70% of the schools, while 30% used them for administrative purposes. Similarly, 100% of the schools used scanners and printers for administrative purposes only. On the other hand, the projector was available in 80% of the schools and was used for instructional purposes in some schools and for other purposes. Only 40% of schools reported having a TV, but it was used for different purposes, like engaging kids in pre-primary grades. A few schools indicated that the digital board was available and used for instructional purposes only. Overall, these results suggested that all the selected schools had access to a range of resources that could be used to support science teaching-learning activities. The availability of these resources can facilitate the use of ICT tools in science classrooms and provide students and teachers with access to a wealth of information and resources. However, it is essential to note that the availability of these resources does not necessarily translate into their effective use in the science classroom, as the results also suggested that most of these resources were used for other purposes rather than for instructional purposes.

Access of Teachers and Students to ICT Tools

Availability implies the presence of ICT resources, and accessibility means the degree to which these ICT resources are easily accessible to as many people as possible. The students' responses regarding ICT tools available in their schools that were used in their classrooms were noted. The data showed that the schools used ICT tools in classrooms, with the most common tool being a projector. However, digital boards were also frequently used in the schools where they were available, while others lacked them. The data also indicated that science teachers used the above ICT tools in science teaching. Most students agreed with the statement, while a few had different opinions.

Table 2: Access of teachers and students to ICT tools

SN.		Yes %	No %	Total %
1	Students response	92	8	100
2	**Teachers response**	**31**	**69**	**100**

Table 2 shows that 92% of the students mentioned that their science teacher used ICT tools such as a projector, laptop, and digital board in science teaching. In comparison, 8% did not agree and had a different opinion. Furthermore, according to the interview data, most teachers were reported to use only a single technology projector in the science classroom. In contrast, few were reported using multiple technologies, including online search engines, projectors, digital boards, and laptops. It suggested that the use of ICT tools in science classrooms could vary among teachers and might also depend on the availability of resources and their level of access to these tools. Although teachers' access to an ICT tool is essential in integrating technology in education, teachers have limited access to these devices. This finding is consistent with the studies of Mathayo (2016), Langat (2015), and Tonui et al. (2016), who pointed out the unavailability of ICT as a key obstacle that impedes teachers from using ICT in teaching. The students were also asked to indicate whether they had the opportunity to use ICT in school for science. The table also shows that 31% of the students stated that they got the chance to use ICT in school for science learning, while 69% indicated that they did not get the opportunity to use ICT for science learning. It implies that most students in the selected schools had limited access and did not get the chance to use ICT by themselves for science learning in school.

Table 3. Students' involvement in using ICT

Response	Frequency	Percentage
Everyday	0	0%
Once a week	10	10%
Once or twice a month	40	40%
Never	50	50%
Total	100	100%

Table 3 reveals that most teachers never involve their students in using available ICT tools in science classrooms. 40 % of the teachers engaged students in using ICT once or twice a month, while 10 % of them involved students once a week. None of the teachers were reported to involve students in using ICT daily. The results indicate that though some students were reported to be able to use ICT tools in science class, not all students could do so due to limited access or other logistical issues. It further suggested that while ICT tools can enhance student learning and engagement, many students do not have regular and reliable access to ICT, which ultimately makes it difficult for teachers to integrate technology into existing lesson plans, as Johnson et al. (2016) stated in their study.

Qualitative Responses Regarding Utilisation of ICT by Science Teachers

The science teachers of almost all the selected schools used ICT tools for teaching-learning activities in their classrooms. Among them, the teachers focused on using multimedia in their classes. They used the projector in the classroom to amplify the images and videos. The data collected from the classroom observations and interviews suggested that science teachers of community schools had more opportunities to use different types of technologies in their classes; on the other hand, teachers of private schools had less chance to use various technologies apart from projectors. School A was observed to have a well-equipped computer laboratory on the school premises. However, teachers usually could not use the computer laboratory for science classes as there was

already a computer course in secondary education, and the lab remained busy with students from different levels. Therefore, a projector was the only primary resource for integrating ICT into the classroom. Hence, teachers needed to cooperate among themselves to distribute the supplies, which affected the frequency of utilization of ICT tools in science classrooms. In this context, teacher A stated that-

Other government and community schools get funding from different sources. They can decorate their whole school with technological devices. But private schools have no other funds without the school budget, which does not allow the institution to cover the cost of getting adequate ICT resources in classes."

The statement from teacher A suggested that government and community schools have access to various funding sources, which makes it possible for them to equip their schools with technological devices such as computers, projectors, and digital boards. However, private schools have limited funding available, which may not be sufficient to cover the cost of acquiring adequate ICT resources for their classrooms. It highlights the potential disparity in the availability of ICT resources between different types of schools, which may lead to an uneven distribution of technological resources in the education sector. It could potentially create a gap in the quality of education between different types of schools, which is a significant concern in promoting equitable access to education. When asked about the kind of lessons they usually use the available ICT tool for and the frequency of using them, teacher A further added that-

"Our school has only one classroom where we can use a projector to present our digitalized content to the students. So, I cannot use it as often as other teachers do. I usually use it once a month and whenever required based on the units I am teaching, such as most biology units."

The above statement suggests that schools face a lack of infrastructural resources. Though the school has a computer lab and projector as the multimedia equipment, it is not enough for the students. As there is only one projector available in the classroom, which the teacher uses to show the presentation, which is made with either pictures, videos, or any other content, there is no opportunity for students to use the technology. Students cannot operate it for science learning in school. Hence, it has been found that though teacher uses a projector in science classes, it is not evident that they use this multimedia facility in every class as they do not have enough classrooms with such services, as Imon (2017) stated in his report.

However, teachers from community schools had a different experience from those at School A. Other NGOs, INGOs, and local-level educational authorities have helped most community schools in the municipality to provide enough resources to implement ICT in every class. School B was also observed to be well-equipped with technological devices in their school. They had computer labs with computers, projectors, digital boards, laptops, printers, router boxes, and other tools. In response to the tools, type of lessons, and the frequency of using such tools for teaching science, teacher B claimed that-

We have a separate room with the digital board to project digital content and integrate ICT in our science teaching-learning. We also have a room with projectors. I take my students to use these tools at least once or twice a week, but the frequency might differ according to my teaching content. I usually use ICT in the content that is difficult to explain, such as circulation system, solar system, etc."

This response from Teacher B further supported Teacher A's statement that the community schools of the municipality had better access to ICT tools and resources than the private schools. As the teacher quoted, the school had a dedicated room with a digital board, a type of interactive whiteboard allowing users to display and manipulate digital content. The school also had projectors for science teaching. The teacher mentioned regularly taking students to the digital boardroom, indicating a commitment to using ICT tools in science education. The frequent use of ICT tools in the classroom can help enhance science teaching and learning by providing students with access to a wide range of resources and information and engaging them in hands-on and interactive activities. It further relates to the theory of constructivism (Pandey S. , 2018) , which suggests that the content, when taught using ICT, becomes interactive, and such activities requiring collaborative work with peers and the provision of support from teachers will enhance learners' social engagement and their level of active participation in learning processes. In addition to determining the extent to which teachers use ICT in their instructional process in the science classroom, the researcher tried to determine how and when they prepare for the lessons or develop a plan to illustrate in the school. Regarding this, teacher A responded as

"I do not get much time to properly plan materials in the school as I have 36 weekly classes. I also do not get much time at home for this because of my other household work, so I usually prepare for the lessons just before going to the classroom. Based on the science content, sometimes I collect pictures and videos from the Internet and demonstrate them in the classroom."

As confirmed by teacher A, in private schools, the teachers must take many classes daily; all are assigned six daily courses. The situation worsens if any of the teachers are absent during the day. Then they must cover all the classes that are absent and don't have much time to prepare for the lessons. The scenario was similar for School B as well. Teacher B said

"As I have to take 26 classes weekly, I cannot make any content during school time. So, I need to give time at home if I want to make digital content for every class, which is not possible regularly. And without digital content development, it would not be possible to use ICT effectively in the classroom."

The above response from both teachers suggested they had a busy schedule and did not have enough time to develop digital content for the science classes during the school day. Though they agreed that creating digital content is necessary for using ICT tools effectively in the classroom, they did not have the time to do so regularly. This finding is similar to research done by Kandasamy and Shah (2013) , which reflected that a lack of time in the school to use ICT was an obstacle faced by teachers in using ICT, as they were burdened with other responsibilities.

Preparing digital content for teaching can be time-consuming. Without sufficient time to develop digital content, teachers may struggle to integrate ICT tools into their lesson plans effectively. They may be less likely to use these tools in the classroom. On the other hand, they would follow or copy others' content instead of developing their own strategy. In this context, teacher B further added-

"Since I do not have much time to create my content, I use help from online search engines such as Google and YouTube to search for content related to my lesson plan for the day. I extract the related contents from there and present them in the classroom."

The above response suggested that teacher B used online search engines and platforms like Google and YouTube to find and access content related to their lesson plans. The teacher then extracted that content and presented it in the classroom. This finding about the use of search engines resonates with the findings of Kabak et al (2010) study in the context of Turkey, that the most preferred search strategy was to resort to search engines, and Google seemed to be the most popular search engine used by teachers. Using ICT tools to access and present information in the classroom could be an effective way to supplement and enrich the teaching and learning of science. Teachers can access various resources and information supporting science teaching and learning through online platforms and search engines. However, despite the teachers trying to incorporate ICT tools and technology in their pedagogical practices, they do not have much time to install them in each class due to the number of courses they take daily. It might be one of the drawbacks that leads the ICT behind the teaching, as Tiwari (2021) concluded in his study. Although the teachers were bound to integrate ICT tools in the classroom frequently, their only objective in using ICT in science classrooms was to make learning effective. Regarding this, teacher C said-

"My main objective in using ICT in a science classroom is to make the learning effective as ICT helps the students to be creative, helps to create systematic involvement of students and makes learning fast, quick and correct."

The response of teacher D on this was also similar, as she added-

"I use ICT in the science classroom to clarify the subject matter and make sustainable content, as it helps the students relate to the content, making learning more effective."

The above responses from both teachers suggested that the teacher's primary objective in using ICT tools in the science classroom was to enhance the effectiveness of the learning experience for students. They believed that ICT tools could support students' innovation, facilitate a more systematic and interactive learning experience, help clarify and enhance the subject matter, and make the content more sustainable and relevant. Using ICT tools was seen as a way to make learning more effective by helping the students better understand and relate to the material. This situation parallels Ghavifekr and Rosdy's study (2015), which showed that teachers view the use of ICT in the teaching and learning process as something positive, where ICT is the aid needed to ensure the effectiveness of both the teaching and learning process. However, it is essential to note that these objectives can be fulfilled only when ICT tools are effective in education. For that, it may be necessary to provide teachers with training and support to use these tools effectively in the classroom. So, the teachers were asked whether they had benefited from any training in ICT use. To this, teacher C responded as

"I got the training opportunity to use technology in the school itself. The school had conducted 4 4-day programs about the use of technology, where the school administration invited our trainer."

As confirmed by teacher C, school C had conducted training on using technology in their school. This training was conducted by an external trainer and lasted for four days. It was likely that the school administration invited the trainer to provide this training to the teachers. However, teacher C did not mention the core theme of the training or the type of technology mentioned in the training. When asked by teacher D regarding the same, she said-

"I got teacher's professional development training. Education Training Center had conducted the training, and the main aim of the training was improvement in teaching learning skills."

Teacher D participated in a teacher's professional development (TPD) training program focused on improving teaching and learning skills. However, teacher D did not specify that the training theme was related to the use of ICT in any way. The availability of training and support for teachers in using ICT tools can be an essential factor in successfully using these tools in the classroom. By providing teachers with the knowledge and skills they need to use ICT tools effectively, schools can help promote the use of these tools and realize the potential benefits of using ICT tools in education. However, none of the teachers specified that they benefitted from the training as the program was either for a short period or did not include ICT as the core theme. Without adequate training and support, teachers may struggle to effectively integrate ICT tools into their teaching practice, which can hinder the benefits of using ICT tools in education. It agrees with the report by Anao (2003) in the context of Nigeria, which states that most secondary school teachers lack the skills to utilize technology implementation fully; hence, the traditional chalk and duster approach still dominates secondary school pedagogy.

Utilization of ICT Tools by Students: A Quantitative Response

The students agreed they had limited ICT access in the science classroom. However, the study also found that though students had little access to ICT tools in school, they all had ICT access at home through one or the other media, such as cell phone, television, computer, laptop, Internet, etc. The study reported that the students used ICT tools most frequently for doing assignments and for entertainment. The students are highly focused on the Internet and search engines for their science assignments. They preferred search engines like e-books, Google, websites, YouTube, etc. ICT tools for completing assignments can give students access to various resources and information supporting their learning. It supports the finding of Lam and Lawrence's (2002) study, which argued that it helps the learning process and access information with a broad vision. The selected students agreed that using ICT makes it easy to learn something.

They were further asked to specify their other purpose of using these tools. The data derived from the students is presented in Table 4.

Table 4. Purpose of using ICT tools

Purpose	**Frequency**	**Percentage**
Entertainment (games, social media, movies, etc.)	53	53%
Instruction (for study, assignment, learning, etc.)	37	37%
News	10	10%

Table 4 shows that the majority of students, i.e., 53%, use ICT at home for entertainment purposes, including playing games, watching movies, and using social media. However, a significant number of students (37%) use ICT for learning purposes at home, such as studying, completing assignments, and learning new things. A few of them use ICT for news. Students had more access to ICT tools at home than at school. However, these tools were not commonly used for instruction but mainly for entertainment (Mishra, 2020).

Students' Skills, Knowledge, and Experience in Using ICT Tools.

The students' skills and knowledge of ICT tools, whether they know how to use them or not, were noted. Their responses are presented in table 7.

Table 5: students' knowledge of ICT tools and comfort in using ICT

SN.		Yes %	No %	Total %
1	Students' knowledge of using ICT tools	94	6	100
2	**Students' level of comfort in using ICT**	**71**	**29**	**100**

Table 5 indicated that 94% of the students knew how to use ICT tools, while only 6% were students who did not realize ICT tools. It implies that most students are familiar with using ICT tools. The student's comfort level and experience in using ICT tools were also recorded. It also indicated that 71% of the students were found to be somewhat comfortable using the ICT, while 29% of the students were very comfortable using ICT. It suggests that while most of the students were comfortable with using ICT tools, a significant percentage were not as comfortable with them.

Table 6. Student's experience with ICT.

SN.	Experience	Percentages
1	Somewhat experience	52
2	Very limited	40
3	Extensive	5
4	Quite a lot	2
5	None	1
Total		100

Table 6 indicates that 52% of the students were somewhat experienced with ICT, 40% of their experience with ICT was very limited, and 5% had extensive experience with ICT. In contrast, 2%-1% had quite a lot and none of the experience with ICT, respectively.

The fact that a large percentage of students knew how to use ICT tools, along with being comfortable and experienced with them, is encouraging, as it suggests that they can take advantage of the benefits of using these tools in the science classroom.

However, it is essential to note that knowledge and experience with ICT tools are only one aspect of effectively using them in the classroom. Other factors, such as integrating ICT tools into the science curriculum and lesson plans and teacher training and support, also play a role in the successful use of ICT tools in science teaching-learning activities. It is consistent with the study of Salehi and Salehi (2012), who concluded that effective use of ICT can be applied in teaching and learning by providing appropriate and sufficient support for the teachers integrating ICT into the curriculum.

Teacher's Skills and Experience in Using ICT Tools

The selected science teachers were asked to rate their expertise in using ICT on a five-point Likert-type scale ranging from Very Good (5), Good (4), Average (3), Weak (2), and Poor (1).

Table 1. Teacher's perceived ICT skills

Variables	VG %	G %	A %	W %	P %	Mean
Use of spreadsheet packages (e.g., MS Excel)	0	30	50	20	0	3.10
Use of search engines (e.g., Google, Opera mini, Chrome)	70	30	0	0	0	4.70
Use of word processors (e.g., Microsoft Word)	0	50	30	20	0	3.30
Use of communication (e.g., Email)	0	70	30	0	0	3.70
Use of presentation packages (e.g., PowerPoint)	0	60	40	0	0	3.60
Using and producing video for classroom presentation	0	30	50	20	0	3.10
Use of the Internet for teaching and learning	70	30	0	0	0	4.70

Table 7 reveals that most science teachers were very good at using the Internet for teaching and learning, as shown by the highest mean of 4.70. Similarly, most teachers were also found to be very good at using search engines like Google, Chrome, etc., with a sharing mean of 4.70. This situation shows that science teachers exhibited high competence in using the Internet and search engines for teaching and learning activities, suggesting they possess the necessary digital skills to effectively incorporate these tools in their instructional practices. Likewise, most science teachers perceived good ICT skills in using communication media like email and presentation packages like PowerPoint, as evidenced by the 3.70 and 3.60 means, respectively. Besides, the teachers were found to have perceived their skills in using MS Word and Excel as average, with mean scores of 3.30 and 3.10, respectively. They also had average skills in using and producing videos for classroom presentations. It suggests that the science teachers have some proficiency in using different ICT tools, which can contribute to creating a dynamic and interactive learning environment in the science classroom. However, the data also suggests that their digital skills can be improved and enhanced through future training or support. It agrees with the findings of Lubuva et al. (2022), which suggest that teachers need more hands-on training in applying ICT pedagogical competencies in their classroom practice. Teachers were also asked to indicate their experience in using ICT. Their responses are shown in Table 8.

Table 8. Teacher's experience in using ICT

SN.	Experience	Percentages
1	Somewhat experience	40
2	Very limited	30
3	Extensive	0
4	Quite a lot	30
5	None	0
Total		100

Table 8 indicates that the majority of the teachers (40%) were somewhat experienced with ICT; 30% had a lot of experience with ICT, while the rest 30 % had minimal experience with ICT. It suggests that a considerable proportion of the teachers in the study had some level of familiarity and exposure to ICT. However, it is essential to note that a significant portion of the teachers still had limited experience in working with ICT tools. These insights highlight the importance of teachers developing familiarity with ICT because, as Mann (2014) concluded, teachers' confidence increases with their familiarity with a new technology.

Students' Attitudes Towards Using ICT Tools

The students were asked to indicate on a five-point Likert scale ranging from strongly agree (5) to strongly disagree (1) their attitude towards using ICT tools in science teaching and learning.

Table 9. An attitude of students towards the use of ICT tools

Variables	**N**	**Min.**	**Max.**	**Mean**	**Std. Deviation**
I enjoy lessons presented using ICT tools.	100	4	5	4.52	0.504
I think that ICT tools are challenging to use.	100	1	5	2.79	0.871
I want to use ICT tools in the science classroom.	100	4	5	4.52	0.504
I think that my science learning can be improved by using ICT tools.	100	3	5	4.68	0.536
I believe that it is essential for me to learn how to use ICT tools.	100	3	5	4.50	0.621
I learn more from ICT tools than from books.	100	3	5	3.90	0.564
I enjoy doing my science assignments using ICT tools.	100	2	5	4.06	0.903
Using ICT tools will be a frustrating experience.	100	1	4	2.11	0.851
ICT tools would stimulate creativity in me.	100	3	5	4.19	0.623

Table 9 presents the five-point Likert scale, which is treated as an interval scale, where the mean indicates varying levels of agreement. A recent study (Aynalem, 2020) revealed that students generally have a positive attitude

toward ICT tools in science education. The mean score of 4.68 indicates that most students strongly believe these tools improve their learning experiences. Additionally, students expressed enjoyment in lessons that utilized ICT, with a mean of 4.52, highlighting their enthusiasm for using these tools in the classroom. Students also rated the importance of learning ICT skills highly, with a mean of 4.50, reflecting their understanding of the need for digital literacy in today's tech-driven world. They perceive ICT as a valuable resource for enhancing creativity and expressed enjoyment in using these tools for assignments, scoring a mean of 4.06. However, while they agreed they learn more from ICT than from books (mean of 3.90), their views on the ease of use were neutral (mean of 2.79), indicating variability in comfort levels with technology. Most students disagreed with the notion that using ICT is frustrating, scoring 2.11. Despite differences in access to ICT tools across schools, students recognize their usefulness and are comfortable using them, suggesting that integrating ICT into science education can enhance engagement and learning. Nonetheless, some may find these tools challenging, echoing findings from Odhiambo (2013), which showed that while attitudes towards ICT are generally positive, the lack of essential skills persists.

Teacher's Attitude Towards Using ICT Tools

The science teachers were asked to indicate their views on the transformative role of ICT in their teaching and learning situations with a five-point scale ranging from strongly agree (5) to disagree (1). Their responses are presented in Table 10.

Table 10. An attitude of science teachers towards the use of ICT tools

Variables	N	Min.	Max.	Mean	Std. Deviation
ICT can improve science teaching and learning processes.	10	3	5	4.20	0.789
ICT can enhance students' critical thinking skills.	10	3	4	3.50	0.527
ICT can enhance student participation and feedback to teachers.	10	3	5	3.60	0.699
ICT can enhance collaboration among students.	10	4	5	4.40	0.516
ICT can enhance teacher and student interaction.	10	4	5	4.40	0.516
The Internet can offer opportunities to teachers to obtain science-related course content.	10	3	5	4.30	0.675
ICT tends to increase students learning motivation.	10	3	5	4.20	0.789

Table 10 shows that most science teachers strongly believe ICT enhances student collaboration and teacher-student interaction, with a mean score of 4.40. They acknowledge the Internet as a valuable resource for obtaining science-related content, scoring 4.30, and recognize ICT's potential to improve teaching and increase student motivation with a mean of 4.20. Teachers also agreed that ICT enhances student participation and feedback (mean of 3.60) and critical thinking skills (mean of 3.50). Overall, the findings indicate that most science teachers positively perceive ICT in teaching science, valuing its role in promoting engagement and critical thinking. However, a noted discrepancy exists between their positive beliefs and the low frequency of ICT usage in classrooms, aligning with Odhiambo's (2013) study on the inconsistency between beliefs and practice.

Challenges Faced in Using ICT Tools

The challenges in using ICT tools that the teachers and students face when they try to implement ICTs in teaching and learning science were reported in the study. Relevant responses from the teachers' and student's questionnaires were sought and analyzed. Students from selected schools were given a list of potential challenges in using ICTs in enhancing science teaching-learning activities and asked to indicate whether they considered each obstacle not a challenge, a minor challenge, or a major challenge. The data has been presented in the table below:

Table 11. Challenges faced in using ICT tools

Potential challenges	Not a challenge	A minor challenge	A major challenge
Insufficient ICT tools	5%	47%	48%
Lack of Internet facilities in school	56%	28%	16%
Teachers are not adequately prepared to use ICT tools for presentation in science	19%	61%	20%

classroom			
Frequent power failure	38%	41%	21%

The responses from students regarding insufficient ICT tools indicated that 48% considered it a major challenge to ICT implementation, aligning with the E-learning Nordic (2006) study that identified limited equipment as a major barrier. In contrast, 56% of students felt that the lack of internet facilities was not a challenge. In comparison, only 16% viewed it as a major issue, suggesting increased access to ICT tools for a more engaging science education. Additionally, 20% of students cited teachers' inadequate preparation to use ICT in the classroom as a major challenge, with 61% seeing it as a minor issue. It highlights the need for better training and support for teachers, as emphasized by Johnson et al. (2016). Regarding power failures, 21% of students identified it as a major challenge. In comparison, 41% marked it as minor, impacting their ability to effectively utilize ICT, which aligns with Khadka's (2021) findings on the challenges of frequent power outages.

Qualitative Responses Regarding Challenges

In order to find in-depth information about these challenges, interviews were also conducted to get the opinions of sampled science teachers on the challenges. Teacher A, concerning the challenge of using ICT tools, stated.

"As we have only a computer lab but not a separate ICT room for science teaching-learning, the major challenge is that we don't always have enough ICT tools to meet the needs of all the students in the classroom. We have one projector, which makes it difficult to engage all the students in the lesson effectively."

It was not the only challenge faced by teachers, as teacher C further added-

"Technology is constantly evolving and improving every day, but we don't always have access to the latest technology or resources, which limits what we can do in the classroom. We may not have access to certain software or tools useful for teaching science. Sometimes, power cuts can be a major obstacle, too. We may have the necessary tools, but without a stable power supply, we can't use them effectively."

Teachers B and D also had similar responses regarding the challenges in using ICT tools that the teachers and students face when implementing ICTs in teaching and learning science. Teacher B said-

"Though we have some kind of ICT tools available in our school, as they are dedicated to computer subjects, we cannot always use them adequately in the science classroom."

Teacher D supported the above statement and added.

"I also find it difficult to operate the ICT tools as I don't have enough training or support to use them in the classroom effectively. Sometimes, we also face problems with the internet connectivity and power supply."

The responses from students and teachers of the selected schools suggested that issues related to the availability of ICT tools, internet connectivity, power supply, training, and support are some challenges they face when trying to implement ICTs in teaching and learning science. It complies with different studies carried out by Dhital (2018), Mathayo (2016), Odhiambo (2013) and so on.

4. Discussion of Findings

The study found that while selected schools had access to various ICT tools, their use in science classrooms was limited and mostly confined to laptops and projectors for visual demonstrations. There were differences in the types of ICT tools available, with some schools having additional resources like digital boards. However, students and teachers reported limited access to these tools for instructional purposes, and many resources were used more for non-academic tasks. Despite limited school access, students had better access to ICT tools at home, often using them for assignments, though entertainment remained the primary use. Teachers tried integrating ICT into their teaching based on content needs. Still, they faced challenges such as a lack of time to create digital content and dependence on online platforms for materials. The study revealed that while most students and teachers had some ICT knowledge and skills, not all felt comfortable or experienced using these tools effectively. Encouragingly, both groups recognized the value of ICT in enhancing science education, with students expressing strong interest and teachers noting its potential for improving engagement and critical thinking. However, challenges such as inadequate ICT tools, poor internet connectivity, lack of training, and frequent power outages significantly hindered effective integration. Due to these persistent barriers, the study highlighted a gap between

ICT availability and its instructional use. Overall, the findings emphasize the need for better infrastructure, training, and support to harness the full potential of ICT in science education.

5. Conclusion

The integration of ICT in teaching and learning science at secondary schools in Nepal has the potential to improve the quality of education and student outcomes significantly. By benefiting from the power of technology, teachers can create more interactive and engaging lessons, while students can benefit from access to a wealth of online resources and learning materials. However, from the above-stated findings of the study, it can be concluded that science teaching-learning activities using ICT are not satisfactory in the Vyas municipality of Tanahun district. The study revealed a gap between the availability of ICT tools and their effective use in science classrooms, echoing challenges addressed in Nepal's School Sector Development Plan (SSDP), which advocates for enhanced teacher training, infrastructure, and equitable ICT access to improve educational quality. Despite students' positive attitudes and familiarity with ICT, reflected in 94% reporting usage knowledge and a mean score of 4.68 for positive perception, teachers struggled due to insufficient tools, inadequate preparation, and lack of support. These findings align with SSDP's call for strengthened ICT integration and capacity-building in teaching practices, particularly in science education. Furthermore, linking these insights to Sustainable Development Goal 4 highlights the global relevance of addressing systemic barriers to quality education through inclusive, ICT-enhanced pedagogies. Bridging these gaps through targeted policy implementation would support national priorities and global education targets, ensuring more effective and equitable science learning experiences.

Implications

Several implications are proposed to enhance the teaching-learning situation of science at the secondary level. The government should ensure that schools have sufficient equipment for effective ICT implementation and establish training centres in each district for science teachers to improve their technological and pedagogical skills. Additionally, regular seminars, workshops, and training programs should be organized for teachers and students on the systematic use of ICT while ensuring access to reliable Internet and necessary school resources. The science curriculum must be revised to incorporate ICT tools, complemented by well-designed course content and trained educators. Emphasis should be placed on integrating ICT into teaching practices, encouraging teachers to conduct ICT-based activities and collaborate on best practices. Student engagement is crucial, and schools should facilitate their active involvement through online resources and digital content creation. Continuous evaluation and feedback should drive improvements in ICT usage in classrooms, alongside recognition and rewards for teachers who successfully implement these technologies. Lastly, further research is recommended to assess the impact of teacher training on ICT effectiveness, factors influencing student attitudes towards ICT, its effects on creativity, and teachers' perceptions across various contexts in Nepal.

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