How to Cite this Article: Ahmed, M., Yaqoob, N., Ayoub, B., Zubair, M., & Ghani, S. (2026). A Study to Explore the Effectiveness of Information and Communication Technology (ICT) Integration in Science Classrooms at Public Secondary Schools of District Panjgur. *The Knowledge, 5*(1), 34-52. https://doi.org/10.55737/tk/v5i1.51121

RESEARCH ARTICLE THE KNOWLEDGE

Volume 5, Issue 1 (Winter 2026) • Pages: 34 – 52 • DOI: 10.55737/tk/v5i1.51121 • e-ISSN: 3006-869X

A Study to Explore the Effectiveness of Information and Communication Technology (ICT) Integration in Science Classrooms at Public Secondary Schools of District Panjgur

Mehfooz Ahmed [1*] Nazia Yaqoob [2] Basit Ayoub [3] Muhammad Zubair [4] Sadiqa Ghani [5]

Corresponding Author: Mehfooz Ahmed (✉: Mehfoozahmed719@gmail.com)

Abstract

Education quality improvement has become easier with technology integration, particularly in science education. The impact of ICT integration on learning of students, and the challenges of ICT usage while considering specifically the perceptions of teachers, the study analyzed impact of ICT at secondary level science classrooms of public schools in Panjgur District. A quantitative method with a descriptive survey design was utilized. A sample of fifty science teachers at secondary level was drawn to complete a structured questionnaire for collecting data on their perceptions of ICT integration, its impact on students' learning, and its usage barriers. Using 3 as a neutral scale-value, the descriptive statistics and one-sample t-test were utilized. Positive perceptions of teachers concerning integration of ICT is encouraging. It was equally encouraging that teachers felt ICT has positive impact on students' learning in terms of knowledge, engagement, and learning particularly in science. However substantial barriers: lack of resources, deficient training, intermittent & poor Internet, mechanical problems, and lack of support from management, were reported by the teachers regarding ICT integration. For all three variables, mean scores were above the neutral for the public schools, also test results were significant at 0.1% significance level.

Key Words

Information and Communication Technology (ICT), Secondary School Teacher (Science) Teachers' Perceptions, ICT Effectiveness, Public Secondary Schools, Panjgur

Introduction

With the advancement of technology and the advent of the Information and Communication Technology (ICT), the 21st Century has characterized the incorporation of technology in the learning process. ICT supports the transition from the traditional, teacher-centered style of delivery to contemporary, student-centered, and interactive learning. Albirini (2006) emphasized the need for ICT in education and stated that with the use of ICT, students become active participants in the learning process while educators adopt new teaching methodologies that enhance students' understanding, motivation, and overall performance.

[1] M.Phil. Education, Department of Education, Alhamd Islamic University, Quetta, Balochistan, Pakistan. Email: Mehfoozahmed719@gmail.com
[2] PhD Scholar, Department of Education, University of Lahore, Lahore, Punjab, Pakistan. Email: naziayaqoobg@gmail.com
[3] M.Phil. Education, Department of Education, Alhamd Islamic University, Quetta, Balochistan, Pakistan. Email: babaloch96@gmail.com
[4] MS, Department of Educational Research and Developerant, Faculty of Education, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Balochistan, Pakistan. Email: Muhammadzubair129@gmail.com
[5] M.Phil. Education, Department of Education, Alhamd Islamic University, Quetta, Balochistan, Pakistan. Email: Saddiqasaaoli@gmail.com

There are special advantages of using ICT in teaching science. ICT offers a number of teaching tools (simulation, animations, virtual laboratories, multimedia presentation tools) to enable students to gain more understanding and visualization of some complicated scientific concepts. Wang and Wang (2023) claims that ICT enhances the effectiveness and attractiveness of learning to the students because it provides a practical study of abstract scientific phenomena. According to Abel et al. (2022), ICT promotes differentiated learning because it considers the various learning preferences, thus, making scientific concepts to be more effectively learned by students with varying cognitive abilities.

It has been found out that ICT integration enhances student interest, critical thinking, and problem-solving skills (Rizal et al., 2019). ICT integration in Pakistan has also advanced adoption in urban schools, but rural institutions, like the public schools of Panjgur District, do not have access to technology, have weak frameworks, and are not equipped (Bingimlas, 2009). These barriers continue to sustain poor ICT integration and even compromise the learning results of students in particular science subjects.

The process of defining certain issues within the science sphere in public secondary schools of District Panjur is based on the interpretation of the perception on the role of ICT in classroom and its effectiveness and obstacles to its implementation. The improvement potential of ICT in science classroom of unframed, unstructured, when the student comprehension and involvement can be stretched and augmented.

Statement of the Problem

The challenges posed during the teaching and learning of science in public secondary schools within the District Panjgur are pervasive, despite the numerous advantages that come with the use of ICT. The teaching of science within the District Panjgur schools is plagued by the lack of secondary science teachers' access to computers, projectors, and other ICT equipment and tools. In addition to the scarcity of ICT tools, available technology is used ineffectually and, in many instances, is left unutilized (Albirini, 2006).

While previous research suggests teachers may appreciate the transformative role that ICT can play in teaching and learning, their use of it is constrained by inadequate resources, teachers' insufficient digital skills, and lack of support from educational institutions (Wang & Wang, 2023; Abel et al., 2022). Therefore, students might not have the chance to experience interactive, hands-on, and creative learning activities in the field of science.

This study examines the views of science teachers on the use of ICT and its impact on students' learning in the public secondary schools of Panjgur District and the challenges of its application using quantitative methodology and one-sample t-test.

Significance of the Study

This study is significant for several reasons:

1. It sheds light on the perceptions of ICT integration among public secondary school science teachers, which can inform teacher training and professional development initiatives.
2. It assesses the perceived impact of ICT on students' learning in science, which offers evidence for policymakers and school leaders.
3. Recognizing the challenges of ICT use in the context of the study helps to develop initiatives to enhance the rural science education.
4. The study adds to existing body of knowledge about the use of ICT in education, especially in the public schools of marginalized districts in Pakistan.

Objectives of the Study

The aim of this study is:

1. To explore the perceptions of science teachers regarding the integration of ICT in the classrooms of public secondary schools in District Panjgur.
2. To evaluate the perceived effectiveness of ICT integration in science on learners' learning.
3. To examine the key obstacles that impede the successful integration of ICT in science classrooms.

Research Questions

The study attempts to address the following questions:

1. What are the perceptions of science teachers regarding the integration of ICT in public secondary schools of District Panjgur?
2. How do teachers view the effectiveness of ICT integration in the improvement of learners' learning in science?
3. What obstacles are there to the effective application of ICT in science classrooms?

Hypotheses of the Study

The following null hypotheses will be analyzed employing a one-sample t-test:

H_{01}: There is no statistically significant difference between the mean score of science teachers' perceptions of ICT integration and the neutral score.

H_{11}: There is a statistically significant difference between the mean score of science teachers' perceptions of ICT integration and the neutral score.

H_{02}: There is no statistically significant difference between the mean score of perceived effectiveness of ICT on students' science learning and the neutral score.

H_{12}: The average perception of the effectiveness of ICT in students' learning of science is different from the average neutral perception.

H_{03}: The mean score of perceived barriers to the implementation of ICT does not significantly differ from the average neutral perception.

H_{13}: The mean score of perceived barriers to the implementation of ICT does not equal an average neutral perception.

Limitations of the Study

- Responses are centered on the self-assessments of the teachers and may capture some bias.
- The responses of some schools may be underdeveloped due to lack of access to the ICT resources.
- The available time and resources may not suffice to reach the desired sample size.

Definition of Key Terms

- **Information Communication Technology (ICT):** The various resources and tools (e.g. computers, projectors, software, mobile devices, and other multimedia) used to assist the teaching and learning processes.
- **Integration of ICT:** The process of combining the use of teaching tools and other resources with the aim of improving the results of learning.
- **Perceptions:** The beliefs, opinions, and attitudes that teachers have regarding the use of ICT in the science classroom.
- **Effectiveness:** How understanding, engagement, and performance in the study of science is improved by the integration of ICT.
- **Barriers:** The challenges encountered in the successful application of ICT in science classrooms.

- **Public Secondary Schools:** Secondary (grades 9-10) level government-aided schools in the Panjgur District that provide education to students.

Introduction

Technology has not only enhanced the practice of teaching, but also the practice of learning, especially in the education sector. Rapid development in the field of Information and Communication Technology (ICT) has positively influenced the teaching and learning processes globally. The application of new digital technologies in the teaching and learning processes of education has helped the education sector move away from the traditional method of a teacher monopolizing the class and taking a more learners- interactive and collaborates model with the aid of technology (UNESCO, 2021). Because of the greater dependence on technology as a result of the world educational interruptions, the ICT tools have become vital elements of contemporary educational systems.

In the field of education, ICT is of great importance since science is an abstract and experimental field. ICT tools such as virtual labs, online learning, computer-based simulations, and other multimedia presentations aid students in understanding complex phenomena and fosters their active participation. (Abel et al., 2022; Kozma, 2011) This section is an attempt to analyze the most recent and pertinent literature on the integration of ICT in education, in particular, on the teaching and learning of science at the secondary level.

The Concept of Information and Communication Technology (ICT) in Education

The scope of Information and Communication Technology (ICT) consists of various types of digital instruments and resources which can create, store, process, and transmit information. The resources used in education that fall under the scope of ICT include computers, projectors, interactive whiteboards, cellular devices, internet access, learning management systems, and other multimedia tools (OECD, 2020; UNESCO, 2021).

Studies done in the recent past emphasize that the scope of ICT in education goes beyond the provision of technological instruments to include the intentional and pedagogically sound use of the tools to bring about desirable educational outcomes (Kozma, 2011; Msafiri, et al., 2023). The successful use of ICT in education is the result of the harmonious amalgamation of Technology, Pedagogy, and Content Knowledge (TPACK), and in so doing, it allows educators to develop learning experiences that are meaningful and stimulating.

In the field of science education, ICT assists in appealing to the various types of concretes through which learners can visualize abstract concepts, fosters inquiry-based learning, and provides many tools for simulation (Makransky et al., 2021; Ibrahimi et al., 2024). The appropriate use of ICT in education promotes students' motivation, deep understanding of concepts and retention of scientific knowledge (OECD, 2020; Pamisa & Hinacay, 2025).

Incorporation of Information Communication Technologies in the Teaching and Learning Process

The term 'integration of Information Communication Technologies' (ICT) describes the incorporation of digital devices in teaching and learning processes in a constructive manner. This involves more than the mere substitution of teaching and learning tools of a previous style. It involves a change in construction of the strategies and activities of instruction and the strategies for the assessment (Msambwa, et al., 2024).

Among the several theoretical frameworks available for explaining the integration of educational technologies is the Technological Pedagogical Content Knowledge (TPACK) and the SAMR Model. Each of the frameworks is grounded in a worldview focused on meaning as a purpose of integration. This sentiment describes the integration of technologies focused on the competencies of the teacher in the three domains of technology, pedagogy, and

content. It also focuses on tasks that the teacher designs for the learners and not simply the substitution of the activities that learners perform (Puentedura, 2014).

According to various works done recently, effective integration of ICT improves the extent to which teaching and learning processes facilitate student-centered learning, collaboration, and higher order thinking which include critical thinking and problem solving (OECD, 2020; Msafiri, et al., 2023). In contrast, some studies carried out in developing countries show that because of inadequate teacher training and lack of institutional support, the use of ICT in teaching and learning processes is often restricted to teaching and learning activities that do not include dynamic instruction and is only based on presentations (Hina et al., 2021; Salam et al., 2017).

Integration of Information and Communication Technology in Science Education

The integration of ICT in science education has tremendous potential because of the abstract nature of the processes and the experiential, hands-on activities that characterize science education. Constructivist learning, where students perform scientific processes and engage in self-directed inquiry, is facilitated by many of the ICT tools, including virtual laboratories, data-logging tools, simulations and animations (Abel et al., 2022; Ibrahimi et al., 2024).

Virtual laboratories are even more valuable in institutions with no access to physical laboratories. They allow learners to perform safe, repeated and cost-effective experiments, thereby enhancing their conceptual understanding and scientific reasoning (Makransky et al., 2021; Pamisa & Hinacay, 2025). Resources in multiple formats (text, graphics, animations) also help explain complex topics in the various domains of science: physics, chemistry and biology (Wang & Wang 2023).

Most recent studies indicate that students' engagement, motivation and academic achievement are positively impacted by the integration of ICT in science education (Kozma, 2011; Msambwa, et al., 2024). Despite the consistent positive feedback on the implementation of ICT in science classes, integration of ICT in science education in Pakistan, especially in rural public schools, is hindered due to inadequate infrastructure and insufficient training (Hina et al., 2021; Thannimalai et al., 2022).

Visualisation and Simulation

Consider the case of virtual laboratories, where secondary school pupils are able to conduct remote experiments that would be too expensive, hazardous, or difficult to logistically organize in a regular secondary school. They provide the ability to conduct numerous repetitions, instant feedback, and safe examination of processes at the microscopic and atomic levels (Abel et al., 2022). Such instruments provide assistance for abstract scientific concepts, and inquiry based learning.

Research conducted in Pakistan and other parts of the world has shown that students using simulation tools are able to develop a better understanding of the concepts, and that there are fewer misconceptions. In a recent example, Thannimalai et al. (2022) examined the impact of the use of ICT in the teaching of science in the public schools of Rahim Yar Khan, Pakistan, and reported that it resulted in improved student engagement, critical thinking, and performance.

Data Collection and Analysis

ICT is also able to provide support for authentic and analytical data collection. For example, students are able to employ graphing and modeling software, and use online collaboration to compare results, while using tablets or sensors to collect data from experiments (temperature, pH, motion). This transforms the teaching of science from

a passive activity of reception to an active activity of investigation, which is a hallmark of contemporary science education. Collaboration and Connectivity

Digital tools enable students to participate in collective scientific inquiry beyond immediate classrooms and connect with students in different schools, global data centers, virtual field trips, and video conferences with experts. These activities enhance learning environments and develop students' understanding of real-world scientific contexts, which is often limited in many public schools (Rizal et al., 2019).

Tailored and Flexible Learning

The personalization ICT offers means students control the pace of their learning, and can practice with simulations, review animations, and take online tests that are tailored to their current understanding. This is particularly useful in science education, where students' backgrounds and readiness levels are different. Some students need to practice specific concepts more, and ICT offers that flexibility (Kazakova, 2020).

Evidence of Effectiveness

The use of ICT in science education has led to a combined improvement in academic results. One such example is that of Rizal et al. (2019), where students from virtual labs in Malaysia and Indonesia outperformed their counterparts from traditional teaching methods in assessments that measured understanding of concepts and problem solving.

Likewise, in Pakistan, the "Effectiveness and Assessment of ICT Integration in Primary Education" noted that although ICT Integration in Education has primarily focused on the primary level, schools with more advanced ICT infrastructure and teacher proficiency had better student performance in other subjects and science (Hina et al., 2021).

Challenges unique to Science Education

Even with the above advantages, there are still some challenges when it comes to integrating ICT in science classrooms, which include:

- Licenses' for virtual science labs and specialized science software are not readily available in public schools.
- Teachers may not have training in how to design lessons based on inquiry that use simulations, instead of just showing animations.
- Use of some advanced tools in lab classes may be limited due to infrastructure problems (electricity, connectivity, maintenance).
- There are insufficient resources which means that technology may only be used in a peripheral way rather than being integrated into the everyday teaching of the science curriculum.

Research indicates that public primary schools across Pakistan utilize a science teaching methodology that is primarily textbook driven and instructor-centric, and with minimal integration of ICT. Rural-urban disparities are pronounced. Rural schools, particularly, lack adequate ICT infrastructure and teacher ICT readiness, as noted by Omariba et al. (2015).

Relevance to Panjgur District

The emphasis on public secondary schools in Panjgur District indicates several pertinent considerations. It will be important to ascertain whether ICT resources are available, as well as how they employed in science teaching, the frequency of use, the instructional settings (e.g., simulation, data logging, online collaboration), and the level of

teacher comfort and competence in utilizing the resources. Given the lack of adequate infrastructure and the likely limited ICT resources and teacher training in remote districts, it will be important to evaluate the prevailing contextual constraints (rural infrastructure, electrical supply, and teacher availability).

Teachers' Perceptions Toward ICT Integration

The successful integration of ICT in classrooms depends highly on how teachers view the inclusion of ICT. If teachers have a positive view of the integration process, they will most likely engage in the digital tool adoption process, but if they have a negative attitude, they will most likely engage in limited or ineffective use of ICT (Teo, 2011; Márquez-Baldó et al., 2025).

Using the Technology Acceptance Model (TAM), the two most important factors that influence teachers' adoption of a technology are the perceived usefulness of the technology and how easy the technology is to use (Davis, 1989; Thannimalai et al., 2022). Integration of the technology into the instructional practices is highly likely for the teachers who believe that the use of ICT will make teaching easier and improve the learning of the students (Zamir & Ali, 2023; Bingimlas, 2009).

Access to ICT resources, prior training, and institutional support are aspects that influence Thannimalai et al. (2022)perceptions in rural and public school contexts. When teachers have limited exposure to technology or experience technical difficulties, they often lose confidence in themselves, which negatively impacts their ability to effectively engage in the integration process (Omariba et al., 2015; Msafiri, et al., 2023).

There are several areas that influence teachers' perceptions, and these include the following

1. Technical competence: When teachers are confident in their ability to use digital tools, they tend to use ICT more often and more effectively (Bingimlas, 2009). Incompetence often results in the avoidance of technology and a reliance on traditional teaching methods.
2. Perceived Usefulness: With reference to Thannimalai et al (2022), an application of the Technology Acceptance Model (TAM) suggests that teachers are more inclined to accept the adoption of ICT into their teaching practices if they are convinced that it assists in the teaching process and enhances the learning of students.
3. Attitudes toward Innovation: The adoption of ICT is also a function of the degree of pedagogical innovation to which teachers are willing to embrace. The more resistant or conservative teaching attitudes are, the less the integration of technology.
4. Professional Development Experiences: Albirini (2006) states that ICT training workshops, peer collaborations, and supportive in-service courses are instrumental in changing teachers' perceptions, increasing their level of confidence, and positively reinforcing their level of effectiveness.

There is evidence to support the role of perceptions. For instance, Abel et al. (2022) determined that among science teachers, those who held a positive perception of ICT were more likely to use interactive simulations, virtual laboratories, and multimedia resources. Conversely, teachers who lacked a positive perception of ICT were likely to restrict their use of ICT to only presentation software (e.g., PowerPoint) and not for the purpose of enhancing inquiry or experimentation.

Perceptions are vital in the case of rural and public schools. Given the limited exposure to ICT and associated challenges (e.g. developing infrastructures and lack of policies), technology may be perceived as being secondary and of little use (Salam et al., 2017). Perceptions of teachers in the Panjgur District will shed light on their ICT adoption readiness, the support they need, and offer some avenues to improve the integration of ICT in the teaching of science.

ICT and the Improvement of Student Learning ICT

Impacting student learning has been the focus of many recent studies that show how ICT has positively affected student learning. Interactive learning environments, wireless, or personalized devices; immediate assessment and feedback; and learning collaboratively all promote student achievement (OECD, 2020).

In science, ICT integration has been shown to positively affect students' understanding and achievement as well as their engagement and problem-solving ability (Rizal et al., 2019; Pamisa & Hinacay, 2025). Since 2020, ICT integration, especially in inquiry and constructive teaching, has positively affected students' motivation and participation (Msambwa, et al., 2024; Idowu, 2025).

The effect of technology in classrooms depend greatly on its integration. Factors such as poor pedagogy, teacher inexperience, and lack of consistent use can diminish the potential impact of technology on learning outcomes (Kozma, 2011; Kazakova, 2020).

Some of the notable impacts of the use of technology in learning include

1. Improved interactivity in learning: Certain tools such as virtual labs, multimedia presentations and learning simulations provide students and opportunity to receive immediate feedback on their actions (Rizal et al., 2019).
2. Increased student interest in learning: Compared to traditional classes, classes where the use of technology is emphasized, tend to capture student interest more. By incorporating interactive modules such as quizzes and discussions, students are able to focus on the activity for extended periods of time (Wang & Wang (2023).
3. Increased opportunities for the development of critical scientific reasoning. In working on various projects within a group, students are encouraged to think diversely, critique their work, develop and structure their processes (Bingimlas, 2009).
4. The potential for greater personalization and individualization within the learning environment. Because technology driven instruction allows students to work at their own pace, to go back and review difficult materials, and to choose from a wider array of materials and activities (Kazakova, 2020).

Data shows measurable improvement in outcomes. One study regarding the use of virtual labs in science education conducted in Indonesia and Malaysia (Rizal et al., 2019) shows that students taught using virtual labs scored higher on science assessments and had better problem solving skills than peers taught using traditional methods. Hina et al. (2021) conducted research in Pakistan and shows that students in schools with successful ICT integration demonstrated higher levels of engagement and better academic outcomes in science.

There must be some level of pedagogical design, interactivity, and use frequency for the ICT tools to be of value. Even with advanced tools, poor pedagogical design, lack of interactivity, or infrequent use can limit benefits. For public secondary schools in Panjgur, the problem is to ensure that ICT tools, if available, are employed for educational purposes and not merely used to demonstrate the school\'s level of technological resources.

Barriers to ICT Integration in Classrooms

There are recognized benefits to using ICT in the classroom, but the barriers that impede its integration still exist. They include inadequate infrastructure, lack of teacher training, poor internet support, insufficient technical support, and limited budget (Opre, 2022; Omariba et al., 2015).

Research from developing countries shows that rural schools have less successful integration of ICT due to fewer resources and limited access to ongoing professional development (Hina et al., 2021; Thannimalai et al., 2022). Each of these factors, and the resulting fear of the unknown, and the reluctance to adopt new practices, affect the use of ICT in the classroom (Msafiri, et al., 2023).

To remove these barriers, strategic administrative educational policy support is needed, including the improvement of ICT infrastructure, the provision of teacher education programs, and the development of educational policies that support ICT use (Ertmer & Ottenbreit-Leftwich, 2010; Msambwa, et al., 2024).

To plan for enhanced ICT adoption, the following barriers provide a framework for focused educational policy improvement:

1. **Restricted access to needed ICT resources**: Resources such as computers, projectors, smart boards, and consistent electricity are still lacking in rural public schools (Omariba et al., 2015).
2. **Lack of teacher training:** Under-utilization of ICT resources can occur due to a lack of integration of sufficient technical or pedagogical teaching strategies (Abel et al., 2022).
3. **Limited support from educational institutions:** Educational institutions fail to provide support, permanently integrating the ICT, and provide ongoing support, including technical assistance, and rewards for teaching innovation.
4. **Attitudinal barriers:** Change resistance, lack of trust in the use of technology, and the complexity of digital tools, undermine the use of ICT (Bingimlas, 2009).
5. **Socio-economic factors:** Students' digital literacy, access to learning resources, and availability of ICT outside of school, determine how effective the integration of ICT is.

Research indicates that when barriers are removed via training, teacher infrastructure, and policy supportive of teacher integration of ICT, positive student outcomes are achieved (Rizal et al., 2019; Thannimalai et al., 2022). For Panjgur District, local context will provide guide the development of ICT integration in public secondary schools to be more practical.

Empirical Studies Related to ICT Integration in Pakistan and Abroad

There is ample evidence of ICT integration in science classrooms, both in Pakistan and other countries:

Pakistan

- Hina et al. (2021) studied ICT integration in primary schools, finding that the digital competence of teachers and access to school infrastructure the school, directly affected student learning outcomes.
- Thannimalai et al. (2022) noted that in rural areas, where ICT tools were available, teacher confidence and poor maintenance were the main factors that limited effective use of the tools.

International

- Rizal et al. (2019) studied secondary science education in Indonesia and Malaysia and found that the use of virtual laboratories and simulations enhanced the ability to understand concepts and improved problem solving skills.
- In Bingimlas (2009) study on mobile learning in science classrooms, mobile-based simulations improved student engagement and performance on tests.
- In Abel et al. (2022) study of rural science classrooms, positive perceptions and training were identified as critical factors of successful ICT integration.

The integration of ICT in these studies improved the outcomes of science learning. However, the success of ICT in these studies has been attributed to the positive perceptions and competencies of the teachers, the available ICT infrastructure, and the effective instructional design.

Theoretical Framework

There are two theories that will be utilized in this study:

1. **Technology Acceptance Model (TAM):** The TAM model explains ICT integration in classrooms as a function of the perceived usefulness and ease of use. When teachers perceive that a given technology will improve their teaching and their student learning, they will use that technology (Thannimalai et al., 2022).
2. **Constructivist Learning Theory:** This theory focuses on the active involvement of the learner and emphasizes learning as a process of problem-solving and knowledge building. The ICT tools that provide simulations, virtual laboratories, and collaboration spaces are consistent with the principles of constructivism because they provide opportunities for learners to investigate, manipulate, and apply knowledge in real-world situations (Rizal et al., 2019).

These two theories provide an explanation for the adoption of ICT by teachers and student learning outcomes in science classrooms.

Research Design

The purpose of this study was to analyze the effectiveness of the integration of ICT in the science classrooms of public secondary schools of Panjgur District. Hence, a quantitative research design was adopted. Measuring teachers ' perceptions of the effectiveness of ICT on student learning, the barriers of the ICT integration, and the ICT integration in secondary science classrooms was aimed to achieve through quantitative research.

A descriptive survey design which involves the collection of teachers' perceptions, attitudes, beliefs, and experiences of ICT merger was applied (Creswell, 2018). As for the analytical descriptive statistics, a one-sample t-test was the appropriate use to capture the difference between the teachers' responses and the neutral midpoint in a five-point Likert scale.

Delimitations of the Study

The study was confined to:

- Science teachers (SST Science) teaching in grade 9 and 10.
- Secondary public schools only, which include boys and girls schools in District Panjgur.
- The area of science classrooms in relation to ICT integration, and no other subject area.
- The ICT integration in secondary science classrooms. The perceptions of teachers, the effectiveness of ICT, and the barriers of the ICT integration as captured in the questionnaire.

Research Method

The data for this study was collected using the quantitative survey technique on all the science educators within the district. This provided a framework in gauging the levels of perception and experience as regards the integration of ICT and also provided data that was sufficient for statistical analysis.

Population and Sample

The research focused on all public secondary school SST Science educators in District Panjgur. 22 public secondary schools were sampled for this research. 50 secondary school (science) teachers were sampled across the 22 schools, and they were from both the boys' and girls' schools.

Due to the manageable size of the population, a census approach was undertaken, whereby all secondary school (science) teachers were included. This ensured that the study presents the full range of views from the population and also eliminated any sampling errors.

Data Instrument

The primary tool for data collection was a structured questionnaire. This questionnaire was made up of 35 items that were organized into three distinct sections:

1. **Section A - Teachers' Perceptions of ICT Integration (12 items):** This was aimed at assessing the teachers' feelings, levels of confidence, and beliefs pertaining to the employment of ICT in science classrooms.
2. **Section B - Effectiveness of ICT in Science Learning (13 items):** This examined the views of the teachers regarding the influence of ICT on the students' understanding, participation, and learning outcomes.
3. **Section C - Barriers to ICT Integration (10 items)**: This tackled barriers such as shortage of resources, training, and support from administration.

Participants rated each statement on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), providing answers that could be quantified and analyzed. The instrument was based on a number of previous studies that have undergone validation (Abel et al., 2022; Thannimalai et al., 2022) and adapted to the context of science education in Panjgur.

Pilot Study

A pilot study was carried out amongst 10 science teachers from neighboring districts, who have similar characteristics to Panjgur. This was to ensure the questionnaire's clarity, relevance as well as the questionnaire's reliability. Teachers in the pilot study suggested, and in some cases, a few of the items appeared to be ambiguous and/or unclear which some of which were revised before the administration of the main study.

Validity and Reliability

- **Validity:** The questionnaire was reviewed by a total of three senior science teachers plus two ICT integration faculty members from a university. The reviewer's suggestions for some minor modifications were accepted in order to improve the clarity of the items, the focus on the objectives where they were misaligned and a few items that were inappropriate.
- **Reliability:** The data from the pilot study was analyzed using the Cronbach's alpha method and the obtained coefficients were 0.72. This result in pilot study is considered satisfactory and thus, the main study is expected to have a similar internal consistency (Abel et al., 2022).

Data Collection Procedure

The data collection spanned four stages:

1. **Permission and Coordination:** The first step includes obtaining formal permission from the District Education Office, Panjgur. Subsequently, school principals are briefed about the study.
2. **Distribution of Questionnaires:** Questionnaires were administered to all science teachers across 22 schools.
3. **Collection of Completed Questionnaires:** Teachers were allotted one week to complete the questionnaires, which were subsequently collected and reviewed for completeness.
4. **Data Organization:** In preparation for analysis, responses were coded and entered into SPSS (version 25). To ensure confidentiality, each teacher was assigned a unique identifier.

Data Analysis

- **Descriptive Statistics:** Mean, standard deviation, and frequency distribution were used to summarize the teachers' perceptions about the effectiveness of ICT and the barriers to it.
- **Inferential Statistics:** A one-sample t-test was used to check if any of the means differed significantly from a pre-defined neutral value (3). The test was used for:

1. Teachers' perceptions of ICT integration
2. The effectiveness of ICT in enhancing students' science learning
3. The barriers to ICT integration

The hypotheses set in were tested using the one-sample t-test to determine whether teachers' perspectives were positive, negative, or neutral.

Ethical Considerations

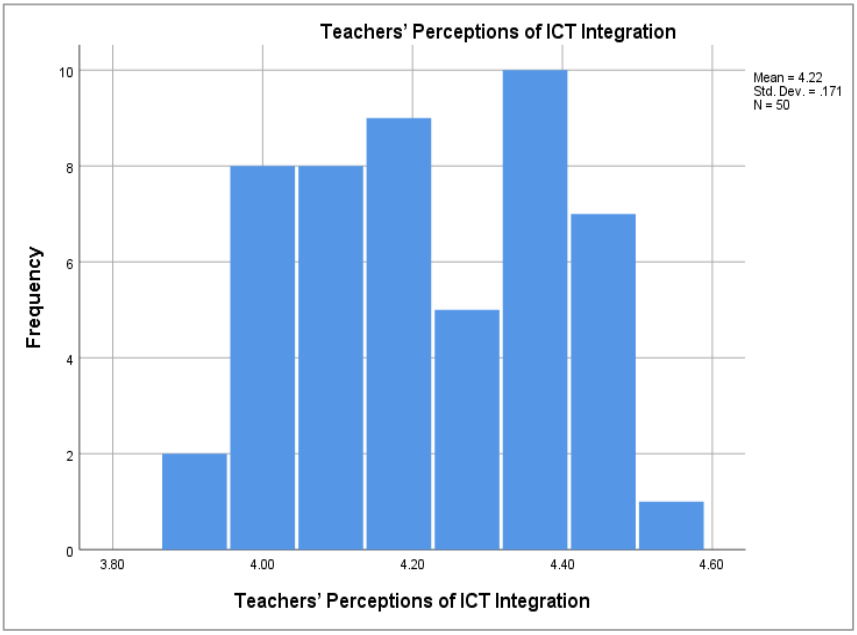
The study adhered to the following ethical principles:

- **Informed Consent:** The purpose of the study was communicated to the teachers, and they provided written consent.
- **Confidentiality:** The identity of the teachers was kept anonymous, and all information was used strictly for research.
- **Voluntary Participation**: There were no penalties for teachers who decided to leave the study.
- **Non-Maleficence:** The process of data collection did not involve any harm or discomfort.
- **Data Security:** Both the physical and digital data were protected, and the researcher was the only person with access.

Data Analysis and Interpretation

Figure 1

Teachers' Perceptions of ICT Integration

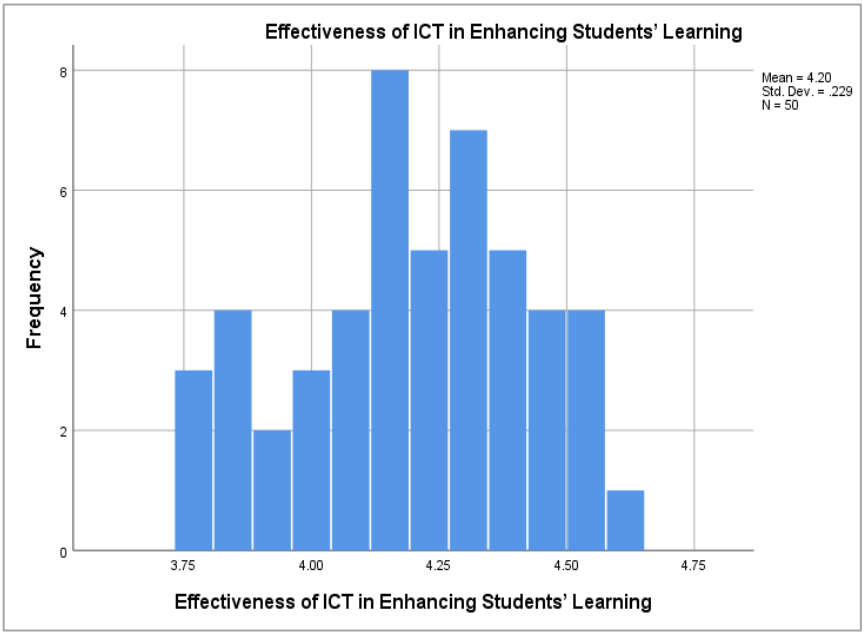


The distribution of mean perception scores of teachers regarding integration of ICT in science classrooms is showcased in Figure 1. The perception of the teachers, in general, is of a positive nature. The mean scores do not range below 3, which is the neutral score, for all scores, thus, all mean scores being in the range of 3.91 to 4.55.

Respondents belong to the higher mean categories in a majority proportion. 20% of teachers mean score of 4.36, 14% mean score of 4.45, 18% mean score of 4.18. When the percentages are summed, 4.36 of the teachers mean score is 84% bottom line which indicates that there is a considerable contribution of mean scores in the integration of ICT. A mean score contribution of 4.55 is reflective of high positive perception and is considerably low, being 2% of the total respondents. The scattered mean in the remaining distribution clearly states the majority of the science teachers are of the positive perception that integration of ICT in the teaching process is vital for the modern science teaching and learning, and to enhance the understanding of the learners. Teachers having mean scores lower than 3 is a consequence of having negative perceptions towards the integration of ICT that is also of a low number.

Figure 2

Effectiveness of ICT in Enhancing Students' Learning



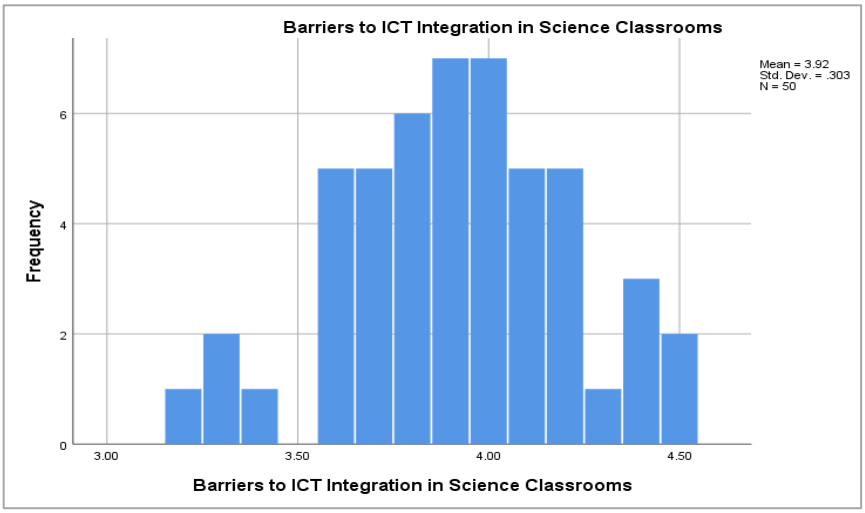
The data depicted in Figure 2 shows how teachers feel about the potential of ICT in enhancing students' learning accomplishments in science. The average scores are between 3.77 and 4.62 which shows that teachers highly agree with the statement that ICT has a positive impact on student learning.

The majority of the respondents are in the mid and higher mean ranges. The highest concentration is at a score of 4.15, with 16% of respondents, followed by 4.31 with 14% and 4.38 with 10%. According to the cumulative data, 72% of teachers' mean scores were 4.31 or less and 98% had a score of 4.54 or less. Notably, only 2% of the teachers gave the greatest mean score of 4.62, which indicates a strong level of agreement.

The teachers, in general, see ICT as a way of enhancing student involvement and comprehension of scientific ideas, active participation and performance at a higher academic level. The data shows that ICT is highly regarded as a teaching aid that can enhance students' overall performance in science.

Figure 3

Barriers to ICT Integration in Science Classrooms



In regard to the barriers of ICT integration, teacher's perspectives are shown in Figure 3. A mean score of 3.20 to 4.50 suggests that the majority of the teachers believed that a variety of barriers hinder the effective use of ICT in the science classrooms.

Mean values that reflected a strong presence of barriers most teachers from the survey. Among the 3.90 mean score, 14% of the respondents, while 10% of the respondents reflected a mean score of 4.10 and 4.20. The mean score collective percentage result showed that 68% of the teachers reported a mean score of 4.00 and below and 100% of the teachers reported a mean score of 4.50 and below.

The result shows that barriers such as insufficient training, inadequate cultivation of ICT resources, tools that are not functioning, internet issues that affects classroom teaching negatively, education budget flaws are perceived as the most significant obstruction that they face. This also shows that, despite the high hopes of ICT integration, many obstacles exist that limits the use of ICT in effective teaching science class, to a great degree.

Table 1

One-Sample t-Test Results

One-Sample Test						
	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Teachers' Perceptions of ICT Integration	50.282	49	.000	1.21818	1.1695	1.2669
Effectiveness of ICT in Enhancing Students' Learning	37.010	49	.000	1.19846	1.1334	1.2635
Barriers to ICT Integration in Science Classrooms	21.356	49	.000	.91600	.8298	1.0022

Table 1 shows that the outcomes of one-sample t-test to determine the mean score differences of teachers' perceptions, and the mean score of ICT effectiveness and barriers to the neutral value of 3.

The mean score of teachers' perceptions is significantly different from the neutral value of 3 ($t = 50.282$, $df = 49$, $p < 0.001$) with a mean difference of 1.218, revealing positive perceptions of teachers, thus, the null hypothesis is rejected.

The mean score of effectiveness of ICT in improving students' learning is $t = 37.010$, $df = 49$, $p < 0.001$, mean difference is 1.198, and thus null hypothesis is rejected; this shows that teachers perceptions of ICT is significantly effective in improving learning outcomes in science.

The mean score of barriers of ICT integration is ($t = 21.356$, $df = 49$, $p < .001$) with a mean difference of 0.916, and thus null hypothesis is rejected, which shows that teachers perceptions barriers that limit the effectiveness of ICT as significantly existing.

The barriers of ICT integration and the other variables give no evidence to state teachers have negative perceptions of the other two variables. Teachers, therefore, state positively ICT is effective in teaching and learning and that barriers exist to integrate it in classrooms.

Discussion, Conclusions, And Recommendations

Discussion of Findings

This section articulates how the study's findings relate to the study's research objectives and the pertinent literature. The discussion follows the three core variables of the study: (i) teachers' perceptions toward the integration of ICT, (ii) the effectiveness of ICT in improving student learning outcomes, and (iii) the barriers of ICT integration in teaching science at the classroom level.

Teachers' Perception of ICT Integration

The study results show that secondary school science teachers in the Panjgur District possess an overwhelmingly positive perception toward ICT integration. The findings of the one sample t-test indicate that the mean value of teachers' perception toward ICT integration and use in the science classroom was significantly greater than the neutral value (3) of the t-test given, suggesting that ICT use in the science classroom was agreed upon.

This finding corroborates the results of earlier studies indicating that the majority of teachers perceive ICT as an instructional resource that increases teaching effectiveness and facilitates the use of innovative teaching methodologies (Abel et al., 2022; Albirini, 2006). Additionally, positive perceptions of teachers indicate an understanding of the role of ICT in enhancing lesson delivery, in the explanation of difficult and abstract scientific concepts, and in promoting active student participation.

The results align with the Technology Acceptance Model (TAM) which proposes that the impact of usefulness is the greatest predictor of acceptance of a technology. Once teachers perceive that the use of ICT is likely to achieve the intended results in teaching and learning, they use it in teaching (Thannimalai et al., 2022). In line with these results, Bingimlas (2009) reported that the use of digital resources in science teaching was strongly predicted by teachers' positive perceptions.

Teachers' Positive Perception of ICT as Effective in Enhancing Students' Learning

Further results indicated that teachers' perceptions of ICT as effective in enhancing students' learning in science is true. The mean perception score for effectiveness was significantly greater than the neutral value, and the one-sample t-test did confirm a significant difference.

The current research findings are also in agreement with the previous studies that support the effectiveness of ICT in teaching the science subjects in enhancing students understanding of the concepts, increasing students

motivation and engagement in active learning (Rizal et al., 2019; Wang & Wang, 2023). Students are able to understand and visualize complex and abstract scientific concepts that traditional face to face teaching is unable to do by the use of ICT resources like, for example, simulations, animations, videos, and virtual laboratories.

Additionally, the results substantiate learning theories that advocate basic constructivism with its emphasis on active participation, questioning, and construction of knowledge. As noted, integrating ICT aids student inquiry learning. ICT helps students explore concepts, conduct remote experimentation, and solve problems collaboratively (Abel et al., 2022). In the context of Pakistan, ICT has been found to positively influence student engagement and academic performance in science (Hina et al., 2021).

Barriers to ICT Integration in Science Classrooms

As much as ICT has been positively perceived, and its effectiveness recognized, the study reiterated that teachers, to the greatest extent, noted the presence of barriers to the integration of ICT. The results of the one-sample t-test indicated that the average barriers to ICT integration score was significantly higher than the average score, thus confirming the extent of the barriers.

Not having enough ICT tools, teachers not being trained enough, unstable internet, technical problems, little support from the management, and budget problems are the most commonly mentioned barriers. These barriers are consistent with previous research in the same context (Bingimlas, 2009; Omariba et al., 2015).

Thannimalai et al. (2022) noticed that, while there were some rural schools equipped with ICT tools, their effective use was hampered due to insufficient training and lack of maintenance. This reinforces the need of additional factors besides positive teacher attitudes for the successful integration of ICT in Abel et al. (2022); the need of backing from the institution and proper facilities.

Conclusions

While looking at the results from the perspective of the relevant literature, it can be noticed that the integration of Information and Communication Technologies (ICTs) within the teaching of science at the public secondary schools of Panjgur District has several important aspects. First, it can be concluded that science educators have, in general, positive views toward the integration of ICT within the teaching of science. They consider the use of ICT in teaching as a contemporary teaching practice and a useful teaching and learning tool that can be used to improve the teaching and learning process. This positive attitude constitutes readiness on the part of the teachers to use ICT in teaching, given that the appropriate conditions and supporting resources are provided. Second, educators regard ICT as a constructive teaching tool to explain the contents of science taught within the curriculum and are likely to improve students' understanding, engagement, and outcomes. They assert that ICT motivates students to be active participants in the learning process and assists in the explanation of complex scientific concepts. This placed ICT as one of the factors that can enhance the practice of good science teaching as it fosters interactive and student-centric learning. Third, the practice of good science teaching as stated above can only be attained if the important factors that are known and in most cases have been documented and, in this case, applicable to the Panjgur District secondary schools are ICT availability, lack of appropriate teacher training, access to the internet, and provision of technical and administrative support (to include resources sufficient to address the barriers).

The aforementioned challenges hinder the frequent and purposeful application of ICT within science classrooms. Fourth, the study states that successful integration of ICT requires more than just access to technological resources. Successful integration has to do with trained educators, dependable resources, ongoing

technical assistance, and a committed administration. Without these factors, the educational advantages of ICT go unachieved". Lastly, the study states that to maximize the educational advantages of ICT within the teaching of science in the public secondary school, the barriers that exist must be alleviated. If these challenges are resolved in an orderly fashion, ICT has the potential to improve the teaching and learning of science.

Recommendations

Recommendations for Educators

The successful integration of ICT in the classrooms places educators at the heart of the changes needed. Therefore, the development ICT related training programs should also include the use of pedagogy, and the teaching of science in the programs scheduled for ongoing professional development. Such training should expand to meaningful integration of ICT in science teaching and not just the use of ICT for presentations. Teachers should also be encouraged to go beyond the use of presentations for teaching ICT. Teachers should also use all of the resources that are available including virtual laboratories, multimedia resources, and digital activities that use inquiry. The effective use of ICT is in the classrooms is also dependent on the peer collaboration and best practice sharing among teachers.

Recommendations for School Administrators

School administration should have proactive strategies for incorporating ICT. School must provide the fundamental components needed for ICT integration, such as computers, projectors, power supplies, and internet services. Even when teachers are willing and trained, without the proper resources, they cannot employ ICT. In addition, schools should have some form of the technical support needed by teachers to address ICT issues as quickly as possible. School leadership should create a more positive and supportive culture that fosters the creativity and initiative to make teaching more technology-oriented. Teachers who incorporate ICT into their teaching should be recognized and rewarded to stimulate others to do the same.

Recommendations for Education Decision Makers and Authorities

Education decision makers and authorities have some of the most significant challenges of ICT implementation at the secondary schools in the most remote and underdeveloped areas, such as the secondary schools in the Panjgur District. These areas need the most attention. There should be a significant budget for the supply, support, and upgrading of ICT tools, the same for the ICT-enabled training of teachers. For a change, the directive ICT policies must be focused on the long-term. It should target Sustainability, professional growth, and curricular integration, instead of merely giving out equipment. To this end, there should be relevant and realistic M&Es to make sure that the use of ICT in teaching and learning is used and that there is a basis for continual improvement.

References

Abel, V. R., Tondeur, J., & Sang, G. (2022). Teacher Perceptions about ICT Integration into Classroom Instruction. *Education Sciences*, *12*(9), 609. https://doi.org/10.3390/educsci12090609

Albirini, A. (2006). Teachers' attitudes toward information and communication technologies: the case of Syrian EFL teachers. *Computers & Education*, *47*(4), 373–398. https://doi.org/10.1016/j.compedu.2004.10.013

Bingimlas, K. A. (2009). Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, *5*(3), 235–245. https://doi.org/10.12973/ejmste/75275

Creswell, J. W. (2018). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (5th ed.)*. Pearson Education.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change. *Journal of Research on Technology in Education*, *42*(3), 255-284. https://doi.org/10.1080/15391523.2010.10782551

Hina, H., & Policy, M. P. EFFECTIVENESS AND ASSESSMENT OF ICT INTEGRATION IN PRIMARY EDUCATION. https://file-thesis.pide.org.pk/pdf/mphil-development-studies-2021-nasreen--effectiveness-and-assessment-of-ict-integration-in-primary-education.pdf

Ibrahimi, E., Miri, F., & Koçiaj, I. (2024). An assessment of the integration of ICTs into teaching processes by science teachers: The case of Albania. *Journal of Technology and Science Education*, *14*(2), 405-417. https://doi.org/10.3926/jotse.2319

Idowu, E. (2025). *The Impact of ICT on Teaching and Learning in Higher Education Institutions*. https://doi.org/10.20944/preprints202504.1600.v1

Kazakova, E. I. (2020). Digital transformation of pedagogical education. *Yaroslavl Pedagogical Bulletin*, *112*(1), 8-14. https://doi.org/10.20323/1813-145x-2020-1-112-8-14 .

Kozma, R. B. (2011). ICT, Education Transformation, and Economic Development: An Analysis of the US National Educational Technology Plan. *E-Learning and Digital Media*, *8*(2), 106–120. https://doi.org/10.2304/elea.2011.8.2.106

Makransky, G., Andreasen, N. K., Baceviciute, S., & Mayer, R. E. (2021). Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. *Journal of Educational Psychology*, *113*(4), 719-735. https://doi.org/10.1037/edu0000473

Márquez-Baldó, L., Orellana, N., Almerich, G., & Jesús, S. (2025). Attitude toward ICT integration for teachers. Validation of a multidimensional scale. *Computers in Human Behavior Reports*, *20*, 100786. https://doi.org/10.1016/j.chbr.2025.100786

Msafiri, M. M., Kangwa, D., & Cai, L. (2023). A systematic literature review of ICT integration in secondary education: What works, what does not, and what next? *Discover Education*, *2*(1). https://doi.org/10.1007/s44217-023-00070-x

Msambwa, M. M., Daniel, K., & Lianyu, C. (2024). Integration of information and communication technology in secondary education for better learning: A systematic literature review. *Social Sciences & Humanities Open*, *10*(1). https://doi.org/10.1016/j.ssaho.2024.101203

OECD. (2020). *Innovating education and educating for innovation: The power of digital technologies and skills*. OECD Publishing. https://www.oecd.org/en/publications/innovating-education-and-educating-for-innovation_9789264265097-en.html

Omariba, A., Ayot, H. O., & Ondigi, S. R. (2015). TEACHERS'PREPAREDNESS IN INTEGRATING INFORMATION COMMUNICATION TECHNOLOGIES IN PUBLIC PRIMARY TEACHER TRAINING

COLLEGES IN KENYA. *Building Capacity Through Quality Teacher Education Nairobi, Kenya July 14-16, 2015*, 333.

Opre, D. (2022). Teachers' pedagogical beliefs and technology integration. *European Proceedings of Educational Sciences*, 112-118. https://doi.org/10.15405/epes.22032.10

Pamisa Jr., A. T., & D. Hinacay, J. J. (2025). Teachers' ICT integration in science teaching and learning outcomes. *INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS*, *08*(09), 5287–5295. https://doi.org/10.47191/ijmra/v8-i09-42

Puentedura, R. R. (2014). *SAMR: A model for educational transformation*. Hippasus.

Rizal, F., Jalinus, N., Syahril, Sukardi, Zaus, M. A., Wulansari, R. E., & Nabawi, R. A. (2019). Comparison of ICT using in learning between Indonesia and Malaysia. *Journal of Physics: Conference Series*, *1387*(1), 012133. https://doi.org/10.1088/1742-6596/1387/1/012133

Salam, S., Jianqiu, Z., Pathan, Z. H., & Lei, W. (2017). Strategic barriers in the effective integration of ICT in the public schools of Pakistan. *Proceedings of the 2017 International Conference on Computer Science and Artificial Intelligence*, 169-172. https://doi.org/10.1145/3168390.3168422

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education*, *57*(4), 2432-2440. https://doi.org/10.1016/j.compedu.2011.06.008

Thannimalai, T., Ponniah, K., Nawastheen, F. M., Jose, F. T., & Jaiseelan, S. (2022). Attitudes and acceptance of information and communication technology (ICT) among urban and rural teachers in teaching and facilitation. *International Journal of ADVANCED AND APPLIED SCIENCES*, *9*(7), 16-23. https://doi.org/10.21833/ijaas.2022.07.003

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. UNESCO Publishing.

Wang, Y., & Wang, Y. (2023). Exploring the relationship between educational ICT resources, student engagement, and academic performance: A multilevel structural equation analysis based on PISA 2018 data. *Studies in Educational Evaluation*, *79*, 101308. https://doi.org/10.1016/j.stueduc.2023.101308

Zamir, S., & Ali, H. (2023). Prospective teachers' perceptions, reliance, and barriers to ICT integration in mathematics learning. *Journal of Education and Educational Development*, *10*(1), 7-25. https://doi.org/10.22555/joeed.v10i1.800