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Teachers' Perceptions and Challenges in Integrating Information and Communication Technologies in Life Sciences Practical Work

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Abstract. The school subject of life sciences requires learners to perform practical activities that expose them to content in authentic ways. The subject is taught in environments increasingly influenced by educational technologies. This study was undertaken in the Mahikeng local municipality in South Africa, and the selected schools were in the same vicinity and offered life sciences as a subject. The study aimed to explore teachers' perceptions of and challenges in integrating information and communication technologies (ICTs) into life sciences practical work. To achieve this, data were collected through observations and interviews. The researchers employed thematic analysis to draw themes from the study participants. It was observed that teachers used ICT to facilitate practical work in a limited manner. However, the study participants perceived the use of ICT in life sciences practical work as essential and important for supporting the learners' conceptual understanding, engagement, interactive learning environment, stimulation and experiential learning. Moreover, challenges such as overcrowded classrooms, insufficient in-service training, inadequate resources and teachers' lack of experience with ICTs were identified. The study makes the following recommendations: ICT should be fully integrated in life sciences practical activities because it could assist learners in various topics through simulations to illustrate aspects of life sciences content; all teachers should be trained to implement ICT in practical work with ease, because it would simplify their work. Doing so will help learners adapt to the changing academic landscape.

Keywords: information and communication technology; life sciences; practical work, challenges; teachers' perceptions

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1. Introduction

For life sciences students to successfully fulfil their aspirations in this digital age and acquire the skills required to meet global standards, it is essential that information and communication technology (ICT) be integrated into practical work. By incorporating ICT in classroom activities, teachers can play a crucial role in enhancing students' ICT literacy and preparing them for the digital world (Arnseth & Hatlevik, 2010). Teachers themselves can become proficient ICT users by understanding and resolving issues related to ICT use in teaching and learning (Ramaila & Mavuru, 2023).

The use of computer-based resources in regular classroom instruction is referred to as ICT integration in education. Currently, ICT is increasingly being integrated in life sciences, which involves the study of living organisms; the learning process involves both theory and practical work. According to Kizilaslan et al. (2021), doing practical work in the life sciences is a particularly crucial component of science education because it helps students expand their knowledge and develop practical skills that are essential for their advancement in the field.

The integration of ICTs in classroom practices started in the early 1980s (Elston, 2007). Role players in education welcomed ICT as a significant agent of change for present and future generations (Ghavifekr et al., 2016). Kraft and Rogers (2015) affirm that new technologies have the potential to improve education for all aspects of the curriculum and provide opportunities to make teaching and learning processes more effective in ways that were previously unavailable. The use of ICT is rapidly increasing globally, also in South Africa. The purpose of ICT integration is to improve the quality, accessibility and cost-effectiveness of classroom instruction, especially now, during the Fourth Industrial Revolution (Alsied & Pathan, 2013). Incorporating ICT in the life sciences curriculum (practical work) cannot be a single event but must be an ongoing process involving a series of interventions that fully support teaching and learning and provide access to information resources (Alsied & Pathan, 2013).

The assumption that ICTs can enhance teaching and learning led to the reconstruction of educational systems (Livingstone, 2012). As a result, the use of computers and associated technologies, such as the internet, at school by educators and learners has become the norm, for educational and social reasons. Consequently, we should know what policies support the use of ICT in education in South Africa. The ICT education policy in South Africa includes specific criteria that validate the benefits of successful integration of pedagogical ICT in teaching and learning (Department of Education, 2003).

The policy also highlights that ICT in education encompasses both the use of computers and their availability at schools. Although schools are gradually gaining access to ICT infrastructure, studies in South Africa found that the majority of teachers still do not integrate these technologies into their instruction because of certain challenges inherent in the country. According to Vandeyar (2015), the low adoption of ICT in classroom practical work is caused by a lack of district support and a lack of guidance in education policy on how to apply ICT.

Scholars confirm that these challenges are multifaceted. For instance, Akram et al. (2022) explain that unstable internet, inadequate infrastructure, and insufficient teacher training are hindrances to ICT integration. According to Mathevula and Uwizeyimana (2014), Nettey et al. (2024) and Regli et al. (2026), the challenges facing ICT integration in developing countries and rural schools are compounded by a lack of institutional support, poor leadership, limited technical assistance and insufficient ICT tools. In South Africa, the reports of Gumede and Ngobe (2025) and Mnisi et al. (2024) indicate that, despite ICT policy mandates, teachers still struggle with poor ICT skills, poor infrastructure and, invariably, low classroom implementation. Hence, Mathebula et al. (2025) stress the need for support from education stakeholders to train and provide digital infrastructure in South African classrooms.

Most schools in South Africa struggle to provide virtual learning platforms that would increase the effectiveness of teaching and learning. Bhila and Okwara (2026) reveal that, at most schools, ICT is still not fully integrated into education and life sciences. South African learners, and other learners in developing countries, must be equipped with up-to-date knowledge of ICT, so that they can adapt to a changing world that has become reliant on modern technology. Researchers acknowledge that ICT tools, such as simulations, virtual labs, animations and digital microscopes, can supplement limited physical resources and enable learners to visualise complex processes, such as cell division or ecological interactions, in real time (Alvarez, 2021; Zhang & Liu, 2024). This study therefore explored teachers' perceptions and challenges regarding the integration of ICT into life sciences practical work in South Africa, offering insights into the current situation and highlighting the difficulties of integrating ICT into life sciences.

Specifically, the following research questions guided the study:

1. How do teachers of life sciences perceive the integration of ICT in practical classroom lessons?
2. What are the challenges faced by teachers when they integrate ICT in life sciences practical work?

2. Literature Review

2.1 Use of ICT in Education

The educational system underwent significant change when learning technology was introduced in the late 20th century (Groff, 2019), because ICT can offer a more dynamic, user-friendly and comprehensive teaching and learning environment. Education ministries worldwide have made a range of training facilities available to help their countries integrate cutting-edge technologies in their teaching and learning processes (World Bank, 2020). A number of studies report that ICT integration can improve both teaching and learning, as well as students' performance (Nakayima, 2019). Nonetheless, determining teachers' viewpoints and the methods they use to integrate ICT in life sciences practical work remains a topic to be explored in the South African context (Arnseth & Hatlevik, 2010).

According to Ghavifekr et al. (2016), inadequate accessibility and network connectivity, a lack of technical assistance, inadequate training, a lack of time and a lack of teacher understanding are the main barriers to teachers' and students' overall use of ICT resources. Keane et al. (2016) explain that students must use ICT in the classroom for practical work in order to acquire and apply essential 21st-century skills in this digital age. Teachers can, therefore, become more proficient technology users by investigating issues and difficulties related to the use of ICT in teaching and learning. ICT integration in education is the process of incorporating computer-based communication in regular classroom instruction (Keane et al., 2016). Teachers are regarded as crucial contributors to implementing ICT in their daily lessons and preparing learners for the current digital environment (Arnseth & Hatlevik, 2010), though the contributions of teachers may be limited by challenges that need to be empirically determined to inform and offer solutions, as aimed in this study.

2.2 Life Sciences Practical Activities

Practical activities are an integral part of science education, especially life sciences, because they provide learners with the opportunity to interact directly with natural phenomena and scientific processes. Recent literature continues to affirm the significance of practical work for enhancing learners' understanding of scientific concepts and their engagement in the learning process. According to Rollnick (2021) and Tsakeni (2022), practical work supports learners in constructing scientific knowledge by making abstract content more concrete and accessible to learners from disadvantaged backgrounds.

However, the implementation of practical activities in South African schools is often hindered by systemic challenges. Chuene and Teane (2024) report that many schools, particularly those in rural and under-resourced areas, struggle to provide even the most basic laboratory equipment and materials needed to conduct life sciences experiments. Similarly, Kibirige and Tsamago (2019) found that teachers in the Limpopo province of South Africa face considerable difficulties in conducting practical lessons because of inadequate infrastructure and financial constraints.

Another critical issue is teacher preparedness for using ICT. Effective implementation of practical activities requires that teachers possess content knowledge, practical pedagogical skills and digital skills. Ramnarain et al. (2016) emphasise that many teachers, especially those trained under older curriculum models, often lack the confidence or training to integrate inquiry-based practical work in their teaching. Gumede and Ngobe (2025) also report that teachers still lack adequate ICT skills to effectively use ICT tools in schools; they suggest that ongoing professional development is essential to bridge this gap. Similarly, Almonacid-Fierro et al. (2023) highlight the importance of pedagogical content knowledge for facilitating successful practical lessons; they argue that teacher training programmes should place greater emphasis on practical components of science education. The required pedagogical content knowledge could involve integrating ICT in practical lessons to improve learners' knowledge acquisition.

2.3 Use of ICT in Life Sciences Practicals

Using ICT in education is intended to improve and ultimately boost both learners' learning and educators' teaching abilities. As Zakaria and Khalid (2016) argue, ICT can improve learners' competency so that they meet global demands, through skills-building and knowledge development, and could enhance collaborative learning through a community of practice. The research suggests that collaboration among learners occurs when they are given the opportunity to showcase their activities using projectors, screens and other ICT devices, such as laser pens.

Ghavifekr and Rosdy (2015) note that some schools and learning institutions today offer computer and information technologies, as well as learning resources, to assist learners in gaining knowledge and experience. Learners are more likely to understand educational processes when they are exposed to a variety of teaching approaches, such as watching video tutorials and using animation. Furthermore, if teachers can improve and sustain their learners' interest in the learning process and the subject, learners are more likely to retain more information. Jaiswal (2020) asserts that incorporating ICT in high schools is likely to improve learners' attention span and increase their creative thinking. ICTs are essential for supporting teachers in the life sciences because teachers can use video or slides to illustrate specific concepts or processes, and because seeing and hearing strengthen learning.

2.4 Theoretical Framework

This study was underpinned by the unified theory of acceptance and use of technology (UTAUT), proposed by Venkatesh and Davis (2000). UTAUT incorporates various views on user and innovation acceptability (Williams et al., 2015). The theoretical views of Venkatesh and Davis are based on the model in Figure 1, which depicts four basic constructs that shape the theory: performance expectancy, effort expectancy, social influence and facilitating factors. These variables promote behavioural intention and use behaviour; additionally, gender, age, experience and voluntariness of use moderate the variables (Williams et al., 2015). Figure 1 presents the UTAUT.

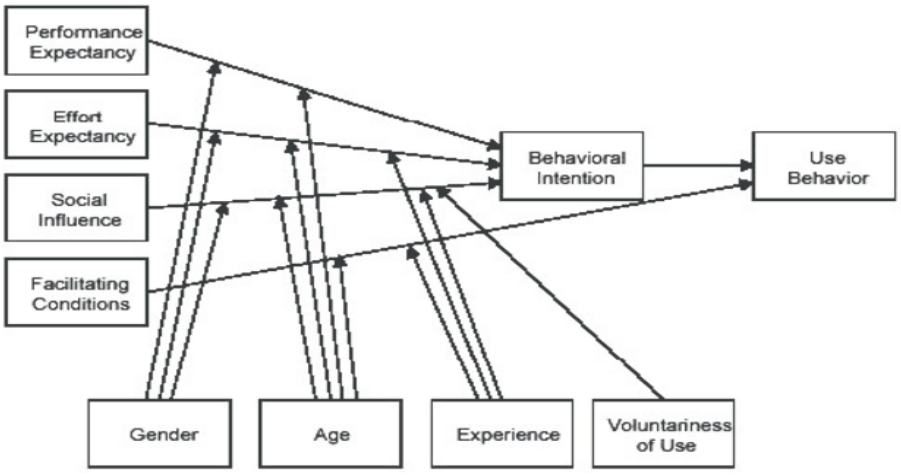

Figure 1: Unified theory of acceptance and use of technology (Williams et al., 2015)

In the framework of this study, the four variables of UTAUT were used, with an emphasis on how teachers perceive the use of ICT. This approach was used because technology adoption and use are driven by the educator, who makes the final decision on how to use a particular technology. Adopting this theory was intended to help explain the goal of using an information system in life sciences practical work, and to expose subsequent ICT user behaviour in practical work. The UTAUT argues that the intention to use technology precedes actual use, which is invariably influenced by the four determinants.

This study, which examined teachers' perspectives and the difficulties they faced in incorporating ICT in practical work in the life sciences, benefited from using this framework. The four main constructs identified by the UTAUT were performance expectancy, effort expectancy from teachers, social influence, and enabling factors that affect the behavioural intention of life sciences teachers to use technology and their actual use behaviour. The attitudes and contextual factors that influenced how and why life sciences teachers used ICT in their hands-on instruction and activities could be directly mapped to these categories.

3. Methodology

A constructivist research paradigm was applied, which ensured interactions with the participants of the study. The study adopted a case study qualitative research approach, which provided extensive insights into the research problems and enabled participants to express themselves. Furthermore, it facilitated an in-depth, multifaceted understanding of a complex issue in its real-life context. A total of four teachers from different schools around Mahikeng participated in the interviews, and they were observed while facilitating ICT classroom practical lessons. The observation was conducted by the researchers through a non-participant, structured classroom observation, with no interference in the teaching process.

From teachers who volunteered to take part in this study, four life sciences teachers with similar characteristics were purposefully selected; hence, the participants were all women, all had master's degrees in teaching, all had 14 years of experience in teaching life sciences, had been using ICT for 16 years and had completed professional development. After obtaining ethical clearance from the General/Human Research Ethics Committee, University of the Free State, South Africa (UFS-HSD2022/0667/22), approval was obtained from the selected schools' principals and teachers.

On an agreed date, participants were interviewed using a structured interview guide that allowed for a semi-structured interview—a two-way conversation—during which the participants were asked questions by the researchers to solicit their ideas, views, opinions and reports of their behaviour (Creswell, 2020). An interview guide enabled the interviewer to maintain the interview flow, thereby enabling new insights and in-depth observations into the phenomena being examined (Gray & Jensen, 2025). The researchers conducted a single interview session with each participant, lasting no more than an hour, to avoid boredom setting in. The interview questions of this study comprised two sections: Section

A collected information on participants' biographical characteristics (Table 1), and Section B listed the interview questions. The interviews provided insights into teachers' perceptions, their understanding of ICT integration, their experiences, and the challenges they faced in integrating ICT in life sciences practical work.

Observational research is a type of qualitative research in which researchers observe participants' actions in natural settings. This process of observation enables the collection of data in a systematic manner (Gray & Jensen, 2025). Observation, with an observation checklist, was used to collect information on the actual practices of teachers when they integrated ICT in life sciences practical lessons. Observation covered the available ICT tools and laboratories, the concepts taught, learners' engagement, and the application of ICT tools to facilitate practical activities.

3.1 Data Analysis

Thematic content analysis was used to analyse the data of this study. Thematic analysis is useful for organising, interpreting and analysing data (Vaismoradi et al., 2016). The data that were collected were transcribed, coded and divided into analytical units, which were evaluated by two professional coders to ensure validity. Coding involves reading transcribed data carefully and dividing it into analytical units (Creswell, 2020). The coded data were categorised, which involved organising and combining related codes into themes or categories. Data were analysed using a narrative analysis approach, in which the researchers related participants' contributions to the literature and to government policies and legislation on the integration of ICT in life sciences practical work. The analytical framework was based on the following themes: teachers' perceptions of educational technologies and the challenges they encountered in integrating ICT in life sciences practical work.

4. Results and Findings

In this study, participants' anonymity was maintained using pseudonyms. Table 1 presents the demographic characteristics of the four participants of this study.

Table 1: Summary of demographic characteristics of participants

Characteristics	Pseudonyms			
	Thabo	Thabiso	Kgomotso	Lebo
Gender	Female	Female	Female	Female
Professional development	Yes	Yes	Yes	Yes
Teaching experience in life sciences	14	14	14	14
Teaching experience using ICT	16	16	16	16
Qualification type	MEd	MEd	MEd	MEd
Teaching subjects	life sciences, natural sciences	life sciences, natural sciences	life sciences, natural sciences	life sciences, natural sciences

4.1 Main Theme 1: Teachers' Perceptions of Integrating ICT in Practical Work in Life Sciences Classroom Lessons

The study evaluated how teachers viewed the integration of ICT in life sciences practical activities, because ICT can be deemed integral and influential in many ways for both teachers and learners. Participants mentioned various benefits of integrating ICT in life sciences practical activities, as reported in the subthemes.

4.1.1 Subtheme 1.1: Promote interactive learning environments

a) Encourage the sharing of information and ideas

Using ICT in classrooms can encourage learners to interact with their educators and demonstrate a sense of understanding of the content they are dealing with. Most life sciences content is practical, which requires learners to experience or apply visual teaching methods to see and understand, which sparks the interactive part of the learning environment. This experience was confirmed by Thabo:

> *''I have been including ICT in classroom practices for almost sixteen years, and the integration has been a great success. Learners not only exhibit greater enthusiasm and involvement during practical sessions but also show a stronger knowledge of the material. While using technology, I have been able to make complicated ideas more approachable and engaging for my learners, where learners can participate and share ideas with others, who now learn in a way that is not only efficient but also fun.''*

Thabo's statement suggests that using ICT in classroom practices increases learners' interest, involvement and knowledge and helps them understand complex ideas. During practical tasks, learners were mostly grouped in groups of five or six learners, and they were allowed to engage with the content. Learners were expected to share their challenges and develop solutions together, because their understanding levels were not the same. Learners could also interact positively and develop the courage to ask questions of the teacher, because they were doing so as a group. During the observation, the teacher was focused on the topic of evolution, as shown in Figure 2 and Table 2 below.

TOPIC : EVOLUTION			
TERM	3	**WEEK**	2
DURATION	4 HOURS	**WEIGHTING**	54 marks (36%)
SUB-TOPICS	Theory of Natural selection Examples of Natural selection Evolution in present times		
RELATED CONCEPTS/ TERMS/VOCABULARY	Species, Natural selection, Population, Offspring, Competition		
PRIOR-KNOWLEDGE/ BACKGROUND KNOWLEDGE			
Intraspecific competition			
RESOURCES			
Textbooks, JIT documents, MTG, videos, Power Point slides, past papers			

Figure 2: Plan of a lesson using ICT, showing the topic during observation

Table 2: Observations made during data collection

Question	Learners' responses
Thabo: What is competition?	The learner explained competition as a response to the lack of resources in nature and interacted with the learning video.
Thabiso: How can we explain natural selection?	The learner explained natural selection as selection that is not controlled and also engaged in activities.
Lebo: Presented the lesson to learners using PowerPoint.	Learners were fully engaged.

The observation in Table 2 illustrates how ICT promotes interactive learning in classrooms. The researchers observed that the learners were motivated, responded to questions during lessons, and were ready to interact with the teacher. Using ICT in the classroom appeared to have a positive impact on learner engagement and motivation, as indicated by the way learners reacted to the questions the teachers asked. In terms of learner participation and interaction with ICT, all participants reported that ICT tools enabled learners to pose questions and actively engage with the content being presented.

This indicates that ICT fosters interactivity in the classroom by enabling learners to engage more deeply with the subject matter. This interaction can enhance the learning experience and encourage active participation among learners. When learners share their views, they make a positive contribution to the lesson and doing so improves the learning environment by engaging and visually stimulating learners. Thabiso explained as follows:

> *''I have the skills to incorporate ICT into classroom practical tasks that I learned while attending university. I have been able to deliver more engaging and visually stimulating classes when they are in groups due to the integration of ICT into life sciences, learners learn and interact more when they are in a group.''*

Thabiso's explanation suggests that they possess the necessary ICT skills for ICT integration and that using ICT in the classroom helps teachers increase learners' overall engagement and interaction in the learning process, by enabling them to share information among themselves. When learners share information during their practical task, they can integrate prior knowledge with what is being presented in class. This can be achieved through interactive and collaborative activities such as simulations, discussions and group tasks.

b) Promote the use of learner-centred teaching methods

By using ICT, teachers can introduce learners to new teaching methods. Consequently, after giving the necessary information, the teacher does less and encourages learners to do more, so that they can improve their understanding by performing practical tasks. Usually, in the schools involved in the study, teachers used a green chalkboard and chalk to teach learners. Using ICT instead exposes learners to PowerPoint, overhead projectors, smart TVs and YouTube videos, which enables them to view presentations by online teachers. Thabo said:

> *''I have been able to make complicated ideas more approachable and engaging for my learners, who now learn in a way that is not only efficient but also fun.''*

Thabiso said:

> *''I cannot overstate how crucial for me as a teacher the incorporation of ICT into life science practical work has become. It not only makes my job simpler, but it also improves the level of instruction I can give my learners."*

According to Thabo and Thabiso, learners' participation can be enhanced by using new materials and ICT tools, such as videos and PowerPoint, to make life sciences practical activities more efficient, fun and simpler. Additionally, ICT enhances instruction, making learners curious about how to use it to achieve the stated learning objectives. Every learner is different and, therefore, they learn and understand in different ways, while educators mostly apply the one method that is the most effective for them. However, when the teacher employs a variety of teaching methods, learners with less understanding can grasp more of the content and participate, like other learners.

c) Stimulates experiential learning (virtual labs and interactive simulations)

Advanced ICT tools such as virtual labs and interactive simulations can be used by both rural and urban schools to improve learning and life sciences practical lessons. The more advanced the tools are, the more impactful they can be for the lesson. Lebo explained how important advanced tools were for interaction and meaningful learning.

> *''Learners pick up on complex biological processes practically faster because of this interesting teaching method. For learners to better understand and retain the material, advanced simulations are beneficial since they let them interact with and control the processes being studied. With the help of this integration, the classroom has undergone a genuine revolution, becoming a centre for engaging and productive learning.''*

Advanced technology can affect learners when they are performing practical tasks, because it can be a means of improving the learning experience. Advanced technology can aid learners' understanding of concepts. The practical side of the life sciences also requires a variety of apparatus. When more advanced ICT features, such as interactive boards, are available, other materials may not be needed, which could reduce confusion for low-achieving learners. Kgomotso said:

> *''When employing more advanced ICT features, complex ideas can now be represented visually and given life in a way that old approaches were unable to do with the help of simulations and digital tools.''*

Integrating ICT in education can also facilitate collaborative learning among learners and foster their critical thinking skills. Kgomotso added that they used various ICT tools, such as simulations, animations, videos, podcasts and online quizzes, to enrich life sciences practical work for learners.

d) Promotes reflective dialogue among learners (collaborative reflections)
Reflective dialogue among learners is a dynamic, interactive process during which individuals engage in thoughtful conversation to explore and deepen their understanding of a particular topic, concept or experience. When learners apply ICT in their practical lessons, they engage in collaborative reflection during practical tasks, because they must bring their ideas together through groupwork to develop solid understanding. Thabiso explained:

> *''When learners are participating in dialogues, they turn to share necessary ideas that are useful in practical, and this gives those who have less knowledge about the practical more information and improves their participation attitude, which can also be influenced by the use of ICT.''*

Reflective dialogue reduced educators' workload by providing feedback to learners involved in the life sciences practical task.

4.1.2 Subtheme 1.2: Improve methods of conducting practical work through simulations

a) Stimulate learning through imitation in lessons
The integration of ICT in life sciences practical work was perceived as learning through imitation. An educational strategy known as learning through imitation uses physical or interactive computer models to simulate real-world situations and actions. It offers learners a dynamic and hands-on setting in which they could explore, experiment and develop a deeper knowledge of difficult ideas, systems or phenomena. Lebo stated:

> *''I use computers, interactive boards, and overhead projectors to teach the learners. The integration of ICT into life science practices, particularly the use of simulations as an educational tool, has revolutionised the way educators teach and has significantly aided the learning process.''*

Kgomotso said:

> *''Simulations provide a safe and controlled environment for learners to conduct experiments and make observations without the need for physical laboratory equipment. This is especially valuable when dealing with potentially hazardous or expensive experiments.''*

The views above acknowledge the important role of ICT tools and simulation in life sciences practical work. This implies that ICT is not used as a supplementary tool but as an essential alternative to the physical laboratory to undertake practical activities. Hence, ICT has the potential to improve limited facilities. This finding affirms that integrating ICT in life sciences practicals refers to teaching using simulations. The application of simulation in teaching significantly enhanced learners' comprehension and retention of complex concepts and played a pivotal role in promoting active learning and critical thinking.

b) Stimulate learners' critical thinking skills
The participants believed that incorporating ICT in life sciences learning improves learners' critical thinking abilities because it equips them with digital and cognitive skills. Thabiso reported that watching practical lesson videos prompted learners to ask questions and analyse and explain happenings in the environment.

Hence, ICT could enable learners to adapt, think critically and communicate clearly in a technologically enhanced environment. Thabiso said:

> *''Using ICT helps me to think deeply about a concept. For example, when I watch practical lesson videos, it prompts me to ask questions, analyse what I see and explain why things happen the way they do, which develops my critical thinking skills.''*

The roles ICT plays when incorporated in life sciences practical work include assisting with teaching, explaining topics in a simple, easily understandable way, creating an enjoyable learning experience and improving learners' skills.

4.2 Main Theme 2: Challenges Teachers Experience When They Integrate ICT in Practical Work of Life Sciences

When it comes to integrating ICT in lessons, teachers experience a variety of challenges. In this theme, the researchers identified the challenges that teachers who participated in the study experienced. Some of the teachers lacked knowledge of ICT and its integration in life sciences practical lessons.

4.2.1 Subtheme 2.1: Overcrowding in classrooms

a) Learners' inability to concentrate for longer periods

It is important to note that each learner is unique, and what works for one person may not work for another. Experimenting with different strategies and finding what works best for an individual can be a key part of addressing concentration challenges. Difficulty maintaining concentration for an extended period was a common challenge for many learners. Various factors could be contributing to these issues and addressing them may help improve learners' ability to focus. Thabo said:

> *''When I'm teaching, learners do make a lot of noise and unnecessary remarks, which makes it difficult for me to keep the classroom calm and conducive to learning. In addition to impeding my capacity to successfully explain crucial scientific concepts in topics like life sciences, this disruption also disturbs the focus of other learners who are interested in learning.''*

Struggling to concentrate in a science class could be a significant challenge that affects the learning experiences of learners and the effectiveness of teaching. This challenge significantly affected the performance of learners in life sciences. One of the reasons learners found it difficult to concentrate could be because the classroom or laboratory was overcrowded, as shown in Figure 3.

Figure 3: An overcrowded classroom

b) Learners do not participate in practical tasks

Learners not participating in practical tasks emerged as a concern expressed by participating teachers. This feedback is supported by the interview data. Lebo reported:

> *''Some learners struggle with motivation and are extremely lazy when it comes to writing, and overcoming this difficulty frequently calls for a multifaceted strategy.''*

This report suggests that learners' unwillingness to participate may be the result of a lack of motivation and a negative attitude towards practical work, particularly writing. Moreover, during the observation, it was clear that some learners were not actively engaged in practical tasks and relied on their peers for information, while others were busy working in groups. This implies that learners' failure to participate is influenced by both their lack of motivation and group dynamics, and because they do not realise the value or purpose of the task.

c) Inadequate space in classrooms and laboratories to accommodate all learners

Creating an inclusive and accommodating classroom arrangement is essential to support the diverse needs of learners. However, participants reported insufficient space in both classrooms and laboratories, which prevented the use of ICT tools and effective classroom movement. When the classroom arrangement is effective, it is easy to group learners and use ICT tools to perform practical tasks. Thabiso said:

> *''I experience noise making, while some learners do not cope due to a lack of space. Also, the poor classroom background is a challenge that prevents the adequate use of digital resources, which makes them tired, distracted and uninterested in practical works.''*

Thabo said:

> *''I experience overcrowding, lack of space and lack of concentration during practical lessons. The classroom is often full and not properly*

arranged, which makes it difficult for learners to move around freely, interact, and use ICT tools effectively.''

Thabo's statement suggests that overcrowded classrooms and limited space significantly hinder effective teaching and learning in ICT-integrated practical work. From a researcher's perspective, this implies that the physical classroom environment is a critical factor in successful ICT integration. Suboptimal classroom arrangements not only reduce learner participation but also negatively affect learners' concentration and engagement. This claim was confirmed by the researchers' observations, which showed classrooms that were not conducive to learning and were overcrowded, as indicated in Figure 3.

4.2.2 Subtheme 2: Limited experience of ICTs

a) Inability to use the right ICT tools for various life science concepts

Teachers were unable to effectively select and integrate the right technology for most life science concepts. The practice of choosing the right technology based on concepts to be taught is a pedagogically sound approach that ensures the use of educational technology. However, teachers face the challenge of selecting the best ICT tools for specific concepts. This suggests that teachers lack the experience to choose and incorporate technological resources and tools that are compatible with the topic or subject matter they are teaching. Kgomotso said:

''I find it difficult to choose the right technology based on the concept I want to teach. Although this strategy will help me to carefully match the precise content and learning goals for each concept, I do not have the needed skills to implement it in my classroom lessons.''

The failure of teachers to use and apply the right ICT tools to various life sciences concepts has far-reaching consequences for learners' academic and personal development. Only by working together can teachers and learners create a dynamic, enriching educational experience that prepares learners for success in the modern era. During the observation, the researchers found that some of the teachers and learners were unable to effectively use appropriate ICT tools to engage in the activities relevant to some life sciences concepts, because they had limited ICT experience and were unfamiliar with these tools.

b) Lack of in-service training in ICT

The lack of in-service training in ICT for teachers could pose several challenges in today's rapidly evolving technological landscape, according to participants. They reported experiencing difficulty in effectively using newer ICT tools, decreased productivity because they did not know how to operate the ICT, and hesitation to adopt new technologies. Lebo said:

''The Department of Education does not support us as teachers when it comes to training teachers in introducing ICT in school and also providing the necessary materials to make it easy to use.''

Thabiso said:

> *''The schools lack resources that can support the initiative of introducing ICT in schools. Learners are also not well informed when it comes to the use of ICT materials in our school.''*

To address the challenges caused by a lack of training, the Department of Education should prioritise in-service ICT training programmes. Continuous development is essential for the effective use of technology and ensuring that individuals remain competitive in the digital world.

4.2.3 Subtheme 2.3. Lack of influence on the school setting that hinders integration of ICT in life sciences practical work

a) Inadequate school infrastructure

The findings reveal inadequate school infrastructure as a challenge hindering ICT integration in life sciences practical work. The participants reported inadequate ICT tools, poor internet connectivity, limited access to ICT tools, and an unconducive learning environment as factors that affect ICT integration. Hence, the key strategies suggested by the participants to enhance school infrastructure and promote learner participation include ensuring internet connectivity and providing ICT tools in laboratories and classrooms. Thabo said:

> *''We really need to improve the standards of the laboratories, get more projectors, televisions, and laptops for the teachers and learners. At the moment, the resources are not adequate, and the laboratories are not well-equipped to support teaching with technology.''*

Thabiso said:

> *''I suggest that we get computers in all the classrooms, tablets for learners, and projectors in all the classrooms and laboratories. For now, only a few classrooms have these facilities, and that limits how I use technology in teaching, especially during practical work.''*

Kgomotso said:

> *''I want to see that the network connectivity is improved. Also, learners need more access to computers, as we lack computers that students can use at my school. This makes me group the students, which can limit some of them from fully participating in the life sciences practical lessons.''*

This feedback implies that effective ICT integration is undermined by inadequate infrastructure. Therefore, ICT integration depends not only on teachers' willingness and competence, but also on the availability and accessibility of ICT resources at schools. By addressing the requirements for improving the use of ICT in schools, schools could create an environment that supports the effective integration of ICT in teaching and learning and prepares learners for the digital age. Regular assessments and feedback from teachers, learners and IT staff can help refine and improve the school's ICT infrastructure over time.

b) Shortages of necessary resources (ICT tools, cost of data)

Finding ICT resources that align with the curriculum and are suitable for specific subjects, such as life sciences, could be challenging. Thabiso highlighted that the

lack of sound equipment is a technical challenge that hindered the pace of ICT implementation in life sciences:

> *''One of the challenges facing the incorporation of ICT into life sciences practices is the lack of ICT equipment to facilitate learning. We need recent and modern technologies to ensure that our learners will move on with the trend.''*

Thabiso pointed out that their school lacked the equipment needed to facilitate ICT in classrooms. This scarcity of ICT equipment can be a significant barrier to incorporating technology in teaching and learning processes. The information gathered from the observation is given in Table 3. It shows that the laboratory setting was not conducive to teaching and learning and that learners were not appropriately engaged because they had too few computers: many students were grouped together to use one computer.

By providing the necessary tools and resources, schools can create environments where ICT is readily available, foster a technology-rich learning experience for learners, and support teachers in their instructional practices. Regular assessments of and updates to the ICT plan will help ensure that resources remain current and aligned with the educational goals of subjects.

Table 3: Laboratory setting

Question	Observations
How is the laboratory/classroom setting? 1. Is it conducive for the practical lesson to take place? 2. Learner engagement	Thabo: No, not really engaged because of distractions. Thabiso: No, though learners were not fully engaged. Kgomotso: Distracted because of many learners using one computer. Lebo: The apparatus was set up, and learners were able to watch and perform the practical.

Kgomotso echoed the need for their school to be equipped with ICT resources. This shortage of resources can impede the school's ability to effectively integrate technology in education. However, Kgomotso indicated that the school supports the integration of ICT in classrooms by providing the needed equipment, though more equipment is needed. Figure 4 shows how a large number of learners have to share one laptop, indicating that, even in a supportive school environment, there may be room for improvement and further investment in ICT resources.

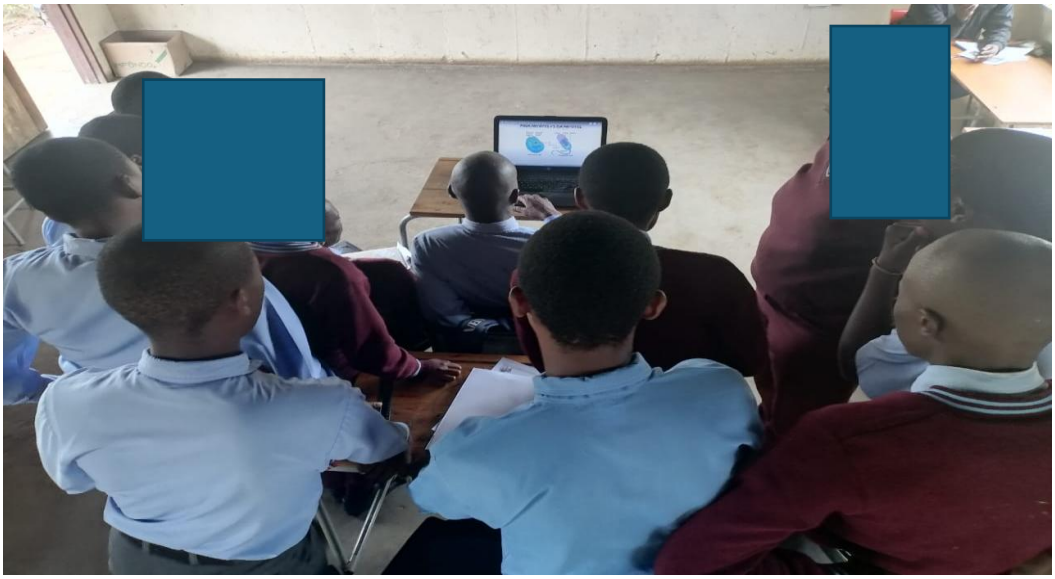

Figure 4: Learners sharing a laptop

c) Inability to enable learners to use computers in a way that is beneficial for their development

Participants believed that empowering learners to use computers in ways that benefit their development would foster digital literacy and promote responsible, effective use of technology. However, this is not possible, because they reported that their schools had too few computers and did not maintain the ones they had. Kgomotso said:

> *''We have a computer lab in our school, but there are only a few computers which are in good condition and can be used by learners because they are not well-maintained by the school or the department. The computers are not enough to cover all learners within the school, which makes it difficult to allow learners to use them.''*

Educators can create an environment in which learners use computers not only as tools for information consumption but also as means for active learning, collaboration and creativity. The challenges reported by Kgomotso can be mitigated if learners can be encouraged to use their personal devices, if learners share available computers in groups, and by practising rotational access across different classes. Moreover, in South Africa, reports of the Department of Basic Education (2025) report that the government and the private sector companies, such as mobile network operators, are partnering to provide schools with tablets, broadband connectivity and mobile computer labs to enhance schools' access to ICT resources.

However, these efforts are insufficient and unevenly implemented and are not sufficient in semi-urban and rural schools. The goal of effective ICT use in schools is to develop well-rounded digital citizens who can navigate the digital landscape responsibly and leverage technology for their educational and personal development.

5. Discussion

The study found that life sciences teachers view the integration of ICT in life sciences practical activities as integral and influential for both teachers and learners in several ways. The teachers identified various positive aspects of integrating ICT in life sciences practical work, including enhancing learners' engagement and critical thinking skills, improving their understanding of complex concepts, promoting an interactive learning environment, and using learner-centred teaching methods that involve stimulation, repetition, experiential learning, reflective dialogue, groupwork and inquiry-based learning. The researchers' observations confirm that teachers that use ICT tools create an interactive learning environment in classrooms, increase learner motivation and enable learners to pose questions and actively engage deeply with the subject matter.

These findings align with those of Zakaria and Khalid (2016), who found that incorporating multimedia elements, such as simulations, animations and virtual labs, can make abstract biological concepts more tangible and engaging for learners. These technologies can capture learners' attention and make learning more interactive and enjoyable. However, they stress that teacher perceptions of ICT remain an important aspect of its integration, because teachers influence learners' proclivity to be friendly or hostile towards the use of cutting-edge technology in education.

Similarly, Msila (2015) and Louw (2017) affirm that ICT in the classroom helps learners assume active roles in their learning rather than taking the more traditional stance of passive observers and listeners, which involves cramming. Price et al. (2025) had similar findings to those of this study. They demonstrate that learners who used spaced repetition retained information better and had higher knowledge-transfer scores than those who reviewed content in a single session. Hence, there is a need to integrate ICT in the curriculum to enhance practical activities and to support analysis, inference, idea development, theorising, simulation and hypothesis testing.

According to the findings, the challenges of integrating ICT into life sciences practical work include overcrowded classrooms, students being unwilling to participate in practical tasks, inadequate space in school laboratories and classrooms, limited experience in using ICTs, the teacher not having been exposed to in-service training in ICT, a school setting with poor infrastructure and limited ICT resources (ICT tools, expensive data) and limited access to ICT resources. Participant observation at the different schools confirmed that most classrooms were overcrowded and lacked ICT resources, which made it difficult for teachers to personalise learning.

These challenges can impede learners' engagement and the school's ability to effectively integrate technology in education. If a classroom is overcrowded, learners could hide and rely on peers to guide them rather than ask their teachers questions, which could be dangerous for their learning and their marks in practical activities. Teachers' limited experience with ICT presented significant

challenges that affected their teaching practices, life sciences practical lessons, learners' engagement and learning outcomes.

These findings are consistent with those of Ogunjobi et al. (2023), who report that larger classes affect resource availability and make it difficult to ensure that every learner has adequate access to ICT tools in science subjects. In the South African context, large classes are often linked to high enrolment, classroom shortages, teacher distribution issues and infrastructure shortages. These conditions lead to overcrowded classrooms, which present significant challenges for integrating ICT in life sciences practical work. Strategies such as blended learning models, mobile learning, flipped classrooms, collaborative learning, partnerships between the private sector and government and teacher professional development can help mitigate these challenges and enhance the effectiveness of ICT integration.

In large classes, teachers spend more time on classroom management and less on personalised instruction, which negatively affects the quality of ICT-based practical work (Graham et al., 2020). School leadership plays a crucial role in facilitating the use of ICT. Other challenges that affect ICT integration include the absence of administrative support (Ohei et al., 2019), inadequate training opportunities for teachers (Gumede & Ngobe, 2025; Padayachee, 2017) and students with varying levels of computer literacy (Ghavifekr et al., 2016). Similarly, Nettey et al. (2024) and Regli et al. (2026) report that schools in developing countries and rural settings lack institutional support and access to technical assistance and have insufficient ICT tools.

6. Conclusion

Integrating ICT can significantly affect how teachers perceive ICT in life sciences practical lessons, because it can address the diverse challenges learners face. This is because learners learn and adapt to what the teacher provides during practical activities. This study found that ICT was perceived to enhance learners' engagement, improve their understanding of complex concepts, and promote an interactive learning environment in life sciences practical work. However, the information from observations revealed that most classrooms were overcrowded and lacked ICT resources, and, therefore, teachers did not pay attention to each learner. The use of ICT can fill gaps, because it could enable learners who, after a lesson, still did not understand the content, to repeat playback of videos, for instance, in class or on their own.

Theoretically, this study lends credence to the UTAUT, which incorporates various views on user and innovation acceptability (Williams et al., 2015). In the context of life sciences practical work, teachers' perceptions of how ICT enhances the interactive learning environment, experiential learning, critical thinking skills and ease of use of digital tools shape their willingness to integrate technology in their teaching practices. By applying the UTAUT, this study systematically analysed the enablers of and barriers to ICT adoption in life sciences practical work and provides insights that could inform effective strategies to improve technology integration in science education. The theoretical framework is

important because it provides a structured framework to understand the key factors that influence teachers' adoption and use of ICT in science education.

7. Implications and Recommendations

The participants in the study highlighted the need to ensure that ICT use in practical work is not just an add-on but is integrated to support curriculum goals and learning outcomes. According to the findings, the teachers were interested in integrating ICT in their practical activities to improve the teaching and learning of life sciences. However, several factors hindered progress: Most schools lacked sufficient ICT tools and had school settings that were unconducive to using ICT, and most schools were situated in rural areas. This implies that comprehensive strategies, such as providing adequate infrastructure, overcoming resistance to change, managing time constraints, ensuring equity, providing reliable technical support and aligning ICT use with curriculum and assessment standards, are needed to neutralise the factors that stand in the way of ICT integration.

Additionally, assessment methods need to be adapted to evaluate the skills and knowledge gained through ICT-enhanced activities. This is because integrating ICT in life sciences practical work not only offers significant benefits but also presents various challenges. It should be noted that, because of the recent changes in education, learners must be exposed to a variety of teaching methods, which can be achieved if the department trains teachers on how to apply these teaching methods. Therefore, it should be mandatory for teachers to undergo training to improve their digital literacy, so that they can deliver quality education for learners and help them integrate ICT in their life sciences practical activities. Training through professional development programmes will enhance both technical skills and pedagogical strategies of teachers for integrating ICT in practical work.

8. Limitations and Research Gaps for Future Research

Despite the comprehensive findings, this study is limited in that it cannot be generalised to a larger population because of its small sample size. Also, as a qualitative study, the data collection and analysis garnered the perspectives of only four participants, which might have led to the experiences of other life sciences teachers, who were not part of the study, being missed. These limitations highlight the need for further investigation into the broader and more measurable impacts of digital integration in life sciences teaching.

Unexplored areas are available for future research on integrating ICTs in life sciences practical work. Most studies focus mainly on teachers' perceptions but do not assess how ICT use affects learner outcomes. There is little evidence of whether digital tools improve learners' understanding, engagement or performance in practical activities. Another limitation is the short-term nature of this study; hence, longitudinal studies are needed to track changes in teachers' experiences, beliefs, skills, and teaching approaches over time.

Conflict of Interest

The authors declare no conflicts of interest.

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