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Utilization of Digital Resources in Grade 10 Life Sciences Teaching and Learning

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ABSTRACT.

This study investigated the utilization of digital resources in the context of grade 10 Life Sciences education across rural, township, and urban schools in South Africa. The research employed a mixed-method approach within an exploratory descriptive survey design, involving 50 purposefully selected participants, including grade 10 Life Sciences teachers and learners. Quantitative data were collected through the distribution of a questionnaire, while qualitative data were gathered through semi-structured interviews. The study's empirical investigation was guided by the Conceptual Framework for the Second Information Technology in Education Study (SITES) as the foundational conceptual framework. The key findings from the study revealed that the effective integration of digital technologies into grade 10 Life Sciences instruction in rural and township schools faced significant challenges primarily due to a widespread lack of resources. Additionally, it was observed that grade 10 Life Sciences teachers in selected rural and township schools exhibited a deficiency in technological pedagogical content knowledge. In contrast, teachers in urban schools demonstrated sufficient technological pedagogical content knowledge (TPACK), which facilitated the meaningful integration of digital technologies into grade 10 Life Sciences teaching and learning. Furthermore, the teachers exhibited a positive attitude towards the educational advantages of employing digital technologies as an innovative approach to achieving predefined educational objectives. The study also discusses the theoretical implications for science teaching and learning.

***Keywords*:** Digital resources; Life Sciences; TPACK; pedagogic innovation; digital transformation

INTRODUCTION

In an era characterized by rapid technological advancements, the education landscape has witnessed a profound transformation, with digital resources playing an increasingly central role in the teaching and learning process. As the world becomes more interconnected and information-driven, educators are faced with the imperative to adapt their pedagogical approaches to effectively engage and empower students. This study delves into the pivotal intersection of education and technology within the realm of Life Sciences education at the grade 10 level. In the contemporary classroom, the availability and integration of digital resources have redefined the traditional boundaries of education while offering teachers novel tools and learners enriched opportunities to explore complex concepts, enhance critical thinking, and cultivate a deeper understanding of scientific phenomena. Grade 10 represents a pivotal juncture in the academic journey of learners, as they

delve into the intricate world of Life Sciences, exploring topics ranging from genetics to ecology and evolution. At this crucial juncture, the thoughtful incorporation of digital resources has the potential to shape the educational experience profoundly.

The emergence of the Fourth Industrial Revolution (4IR) highlights the urgency of enhancing educators' proficiency in information and communication technology (ICT) to adapt to the ever-evolving technological landscape. It is crucial for teachers to wholeheartedly embrace digital transformation in its broadest sense to encourage innovative teaching methods across various educational settings. The gradual realization of this essential strategic goal largely depends on the coherent development of vital skills necessary for meaningful and effective participation in today's digital society. The integration of ICT into education plays a pivotal role in nurturing 21st-century skills like collaboration, problem-solving, decision-making, critical thinking, creativity, and innovation, as noted by Ciroma (2014). However, as argued by Rabah (2015), the successful incorporation of ICT into school teaching and learning still encounters numerous obstacles. This challenging reality underscores the importance of considering the specific contexts, settings, and environments of schools to facilitate the successful integration of ICT. Despite the undeniable advantages ICT integration brings to classrooms, many teachers continue to encounter difficulties when using ICT in their teaching, as observed by Ghavifekr et al. (2016).

A significant proportion of schools in townships face resource limitations in comparison to suburban schools. Nevertheless, due to the widespread COVID-19 pandemic, township schools were compelled to transition to online teaching and learning. This transition was premised on the assumption that both educators and students have access to internet connectivity and possess the necessary digital skills to effectively utilize digital educational materials, as indicated by Lederman (2020. The impact of the COVID-19 pandemic extended across all aspects of life, with particularly pronounced effects on disadvantaged schools and communities, as highlighted by the Organization for Economic Co-operation and Development in 2020. Furthermore, educators had to rapidly adopt innovative teaching methods to support their students remotely, a change described by Kaur and Bhatt (2020).

This study embarked on an exploration of the multifaceted dimensions of digital resource utilization within Grade 10 Life Sciences education. We aim to unravel the implications, challenges, and advantages of integrating digital resources into the curriculum, assess their impact on student engagement and learning outcomes, and gain insights into the perspectives of teachers and learners alike. By doing so, we seek to provide a comprehensive understanding of how technology can be harnessed as a catalyst for enhancing the teaching and learning experience in the field of Life Sciences at the grade 10 level. Through rigorous research and analysis, this study endeavors to offer valuable insights to educators, curriculum developers, policymakers, and researchers, enabling them to make informed decisions about the integration of digital resources into the classroom. By elucidating the potential benefits and challenges, we hope to contribute to the ongoing discourse on the evolution of education in the digital age and, ultimately, empower teachers to nurture the next generation of scientifically

literate and technologically adept citizens.

LITERATURE REVIEW

The importance of integrating ICT into science education cannot be overstated. While the White Paper on e-Education outlines the framework, objectives, funding, resources, and strategies for implementing ICT in education, it lacks clarity regarding the specific categories of technologies that can be employed to support effective curriculum implementation, as stated by the Department of Basic Education in 2004. The Department of Basic Education, in its 2015 Action Plan, has identified key strategies for enhancing ICT in education. These strategies encompass: (i) establishing a clear connection between the use of ICT in the classroom and learning objectives, (ii) comprehending the various types of available technologies, (iii) forging partnerships with stakeholders to promote e-education, and (iv) evaluating the current state of e-education initiatives and their anticipated outcomes.

Numerous studies have illustrated that only a small percentage of teachers can proficiently employ ICT within the classroom, as exemplified by research conducted by Nkula and Krauss (2014) and Padayachee (2017). Similarly, a study by Tamim et al. (2015) identified prevalent misconceptions related to ICT use across various educational contexts. For instance, terms like 'distance learning,' 'distance education,' 'distributed learning,' and 'online learning' are frequently used interchangeably, as noted by Twigg (2001). Furthermore, the discourse on the application of electronic media in distance teaching settings often exhibits confusion between the goals and the means of distance education, as observed by Guri-Rosenblit (2009). The effective integration of ICT into the classroom is hindered by a multitude of factors. These factors encompass constraints such as limited time, as indicated by Assan and Thomas (2012), a lack of clarity regarding the e-Education Policy, as highlighted by Vandeyar (2015), inadequate support in terms of infrastructure and policy, as also noted by Vandeyar (2015), insufficient skills, as mentioned by Msila (2015), and an excessive focus on technical aspects at the expense of pedagogical and theoretical frameworks, as suggested by Tamim et al. (2015). Moreover, at a practical level, it has been acknowledged that the progress of technology-enhanced learning in South Africa has not matched initial expectations, as outlined by the Department of Basic Education in 2015. According to Mooketsi and Chigona (2014), the sluggish advancement of technology-enhanced learning can be partially attributed to the disconnect between government expectations and the actual practices of teachers.

Inadequate attention has been given to the practical implementation of the e-Education Policy outlined in the Department of Education's Draft White Paper on e-Education, as discussed in Vandeyar's work in 2015 and the Department of Education's report from 2004. A meaningful comprehension of ICT integration can serve as a solution to bridge the gap between theory and practice. Leendertz, Blignaut, Ellis, and Nieuwoud (2015) discovered that establishing an appropriate guideline for the professional development of teachers in utilizing ICT for pedagogical purposes can be an exceptionally challenging and intricate task. Recognizing this challenge, du Plessis and Webb (2012) argue that the current guidelines for teachers' professional development lack sufficient information on how teachers and schools can effectively integrate ICT into teaching and learning within the broader South African context. Research

conducted by Adu (2016), focusing on the utilization of e-learning resources in secondary schools in the Eastern Cape Province of South Africa, revealed that most digital tools such as internet access, web-based learning platforms, email facilities, and multimedia projectors were unavailable in the schools under investigation. There is a pressing need to investigate the discrepancies that exist among different township and suburban schools in the use of ICT tools for teaching and learning in grade 10 Life Sciences. This exploration aims to provide insights into emerging best professional practices that promote technology-enhanced learning.

CONCEPTUAL FRAMEWORK

This study is grounded in the Conceptual Framework for the Second Information Technology in Education Study (SITES) 2006, as presented by Law, Pelgrum, and Plomp (2008). This framework serves as the foundational theoretical basis for the research. Figure 1 below illustrates the SITES 2006 framework, which primarily centers on the activities taking place within the classroom and how ICT is employed within that context. The framework operates on the premise that the pedagogical practices involving ICT are an integral part of a teacher's overall teaching approach. For teachers, the reasons behind and the methods by which they incorporate ICT into their teaching are shaped by their broader pedagogical vision and competence. However, it's important to note that pedagogical practices are not solely determined by individual factors such as teachers' academic qualifications and ICT proficiency; they are also influenced by school- and system-level variables. While the learning outcomes of students can be expected to be affected by the pedagogical practices they encounter, it is essential to recognize that these outcomes, whether perceived or actual, have an impact on the subsequent pedagogical decisions made by teachers. This is because teacher-, school-, and system-level factors often need to adapt or be modified to accommodate the anticipated or observed effects of pedagogical practices on learners.

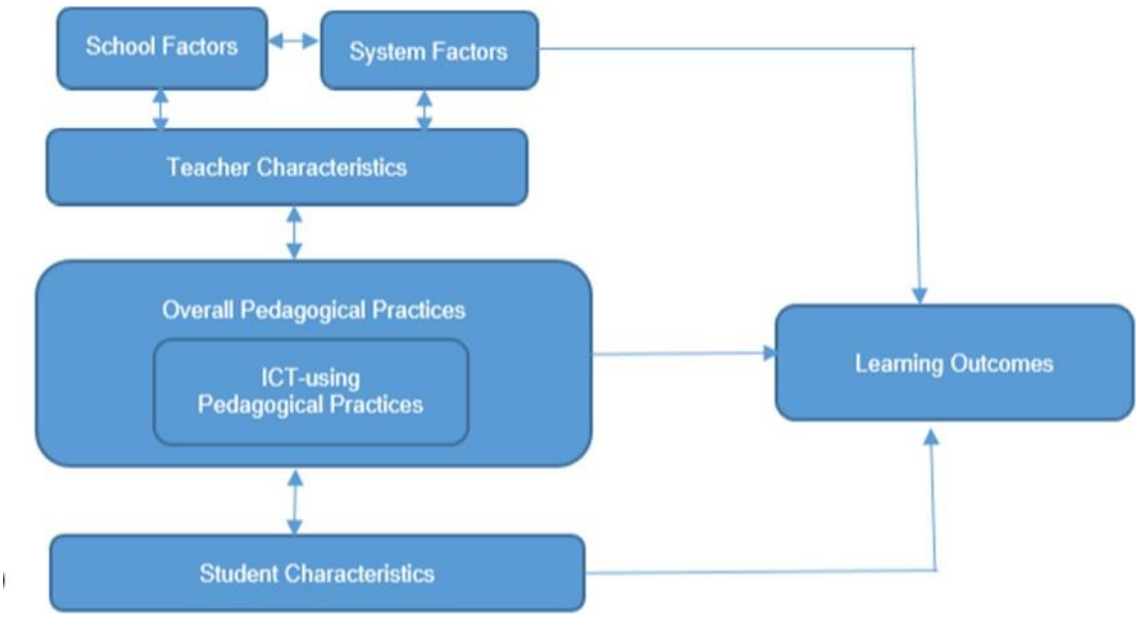

Figure 1: Conceptual Framework for SITES 2006 (Law, Pelgrum, & Plomp, 2008)

THEORETICAL FRAMEWORK

This study is grounded in the Technology Acceptance Model (TAM) as its foundational theoretical framework. TAM has emerged as a prominent scientific framework for exploring the acceptance of educational technology by various stakeholders, including learners and teachers (Davis, 2011). It is a robust model known for its ability to predict the actual utilization of specific technologies (Davis, 1986). TAM posits that a user's motivation can be elucidated by three key factors: perceived ease of use, perceived usefulness, and attitude toward use. According to Davis (1986), it was hypothesized that a user's attitude toward a system plays a significant role in determining whether they will embrace or reject that system. Perceived usefulness refers to the extent to which an individual believes that using a particular system will enhance their job performance, while perceived ease of use is defined as the degree to which a person perceives that using the system will require minimal effort (Davis, 1986). Both perceived ease of use and perceived usefulness have a profound influence on users' acceptance and adoption of technology. This framework is highly pertinent as it provides valuable insights into how teachers perceive the ease of using digital resources and their perceived usefulness in the context of Life Sciences education. The adoption of this framework has been instrumental in developing a comprehensive understanding of the utilization of digital resources in grade 10 Life Sciences teaching and learning. It takes into account both the cognitive and social aspects of the educational process and acknowledges the role of technology in facilitating learning.

METHODS

The research design, selection of participants, data collection and analysis procedures are discussed below.

Research design

In this study, an exploratory descriptive survey design was employed. This design involves the investigation and portrayal of a given situation while also examining how different subgroups perceive a particular issue, as explained by Gay, Mills, and Airasian (2011). According to Burns and Bush (2006), an exploratory research design offers a flexible and unstructured approach to gathering information. It allows researchers to develop a deeper understanding of the research problem. Furthermore, it's important to note that exploratory research design is not constrained by a single paradigm and can encompass either qualitative or quantitative methodologies.

Sampling

The research involved the deliberate selection of 50 grade 10 Life Sciences teachers from secondary schools in South Africa, specifically encompassing three rural schools, three urban schools, and four township schools. As Babbie and Mouton (2012) indicate, purposive sampling is employed when the researcher possesses prior knowledge about the target population. The chosen Life Science teachers represented a range of teaching experience levels, and they were joined by their learners in participating in the study. This selection was made because these teachers willingly opted to take part in the study and had demonstrated their exceptional expertise in the field, as evidenced by their records. The inclusion of schools with diverse settings allowed for an exploration of the differences that exist within and among these schools

concerning the utilization of ICT in grade 10 Life Sciences teaching and learning.

Data collection

Quantitative data were gathered by administering the adapted Second Information Technology in Education Study (SITES) Questionnaire, originally developed by Law et al. (2008), to the study participants. The SITES Questionnaire is a versatile tool used for examining various aspects of teachers' pedagogical practices and their utilization of ICT, as well as the relationships between these aspects. In the context of this research, the SITES Questionnaire was specifically utilized to investigate the following constructs:

- Teachers' confidence in their ICT skills (Teachers' ICT self-efficacy)
- The importance teachers place on learning about ICT and coding tasks
- The integration of ICT into classroom activities
- The incorporation of ICT into teaching practices
- The utilization of specific ICT tools within the classroom
- Teachers' perceptions of available ICT resources and collaboration with fellow educators at their school
- Participation in professional development related to ICT
- Teachers' perceptions of the outcomes of using ICT for teaching and learning

Qualitative data, on the other hand, were collected through semi-structured interviews. These interviews were conducted with a smaller, selected subset of the participants. The purpose of these interviews was to provide in-depth insights and explanations regarding the patterns and trends identified in the quantitative data. Essentially, the qualitative interviews were employed to validate and add depth to the key findings that emerged from the quantitative data analysis.

Data analysis

Quantitative data analysis was conducted using Statistical Package for the Social Sciences (SPSS) Version 25, while qualitative data analysis was performed with Atlas.ti. The analysis of qualitative data involved the use of axial coding, which is a qualitative research method that connects and associates data to uncover codes, categories, and subcategories. This approach combines both inductive and deductive reasoning, following the guidelines outlined in the Coding Manual for Qualitative Researchers by Saldana (2009).

FINDINGS EMANATING FROM QUANTITATIVE DATA

The questionnaire items examined various aspects, including teachers' confidence in their ICT abilities, the significance they attach to learning about ICT and coding tasks, their integration of ICT into classroom activities and teaching practices, the utilization of specific ICT tools within the classroom, their perceptions regarding available ICT resources and collaboration with colleagues at the school, their involvement in professional development related to ICT, and their assessments of the outcomes of using ICT for teaching and learning. Table 1 presents the Cronbach's alpha values for the investigated constructs. Table 2 presents the distribution of responses in terms of frequencies regarding teachers' ICT self-efficacy. A significant portion of the teachers (60%) indicated that they could effectively use ICT tools to access teaching materials online. These teachers also expressed their ability to utilize tools like PowerPoint for creating presentations and Microsoft Excel for record-keeping purposes. However, they demonstrated less familiarity with shared

resources like Google Docs and learning management systems such as Blackboard. Furthermore, the teachers noted increasing challenges when it came to using digital resources for assessing student learning. It is imperative to provide training to teachers on the utilization of innovative interactive applications that offer meaningful opportunities for implementing formative assessment techniques in science classrooms. The effective use of digital resources should contribute substantially to the improvement of teaching and learning by providing engaging interactive learning opportunities. Achieving this educational objective necessitates an enhancement of teachers' ICT self-efficacy.

Table 1: Cronbach's alpha values for the constructs investigated

Construct	**Cronbach's alpha**
Teachers' ICT self-efficacy	0.67
Teachers' emphasis on learning of ICT and coding tasks	0.73
Teachers' use of ICT for class activities	0.71
Teachers' use of ICT for teaching practice	0.69
Teachers' use of ICT tools in class	0.78
Teachers' use of ICT for teaching practices	0.76
Teachers' perceptions of ICT resources and teacher collaboration at school	0.79
The level of teachers' involvement in ICT capacity building programme	0.75
How teachers' perceive the outcomes of ICT driven teaching and learning	0.77

Table 2: Teachers' ICT self-efficacy

How well can you do these tasks using ICT?					
	Very poorly	**Poorly**	**Neutral**	**Well**	**Very well**
Find useful teaching resources on the Internet	5	10	5	20	10
Contribute to a discussion forum/user group on the Internet (eg. a wiki or blog)	10	18	7	10	5
Produce presentations (e.g. [PowerPoint® or a similar program]), with simple animation functions	7	8	5	20	10
Use the Internet for online purchases and payments	10	20	10	5	5
Prepare lessons that involve the use of ICT by learners	8	15	5	15	7
Using a spreadsheet program (e.g. [Microsoft Excel ®]) for keeping records or analyzing data	9	12	4	18	7
Assess learning	7	20	8	10	5
Collaborate with others using shared resources such as [Google Docs®], [Padlet]	8	22	4	11	5

Use a learning management system (e.g. [Moodle], [Blackboard], [Edmodo])	9	10	4	17	10

Table 3 displays the distribution of responses in terms of frequencies concerning teachers' emphasis on learning ICT and coding tasks. The teachers placed significant importance on efficient access to information and the ability to present information for various educational purposes, aiming to develop their students' ICT-based skills. They also created opportunities for students to share digital information among themselves. However, assessing the credibility of digital information proved to be a challenging task for these teachers. Furthermore, there were limited opportunities for teachers to explore a wide range of digital resources when searching for information. This limitation can be attributed to teachers' lack of awareness and knowledge regarding the multitude of available digital resources. Teachers also found it increasingly difficult to use digital resources for breaking down complex processes into smaller, manageable steps and for planning tasks by outlining the necessary steps for completion. While teachers did incorporate simulations into Life Sciences teaching and learning, the use of digital resources to facilitate the analysis of real-world data and to revise solutions to problems remained a challenging endeavour. Other areas of concern included using digital resources to create flow diagrams that illustrate various stages of a process and recording and evaluating data to comprehend and address problems effectively

Table 3: Teachers' emphasis on learning of ICT and coding tasks

In your teaching, how much emphasis have you given to developing the following ICT-based capabilities in your learners?					
	No emphasis	**Some emphasis**	**Neutral**	**Little emphasis**	**More emphasis**
To access information efficiently	5	13	7	8	17
To display information for a given audience/purpose	6	14	5	6	19
To evaluate the credibility of digital information	12	13	7	10	8
To share digital information with others	5	10	6	8	21
To use computer software to construct digital work products (e.g. presentations, documents, images and diagrams)	6	9	5	18	12

To provide digital feedback on the work of others (such as classmates)	5	9	4	19	13
To explore a range of digital resources when searching for information	9	10	8	15	8
To provide references for digital information sources	8	9	8	16	9
To understand the consequences of making information publically available online	7	8	7	20	8
In your teaching, how much emphasis have you given to teaching the following skills?					
	No emphasis	**Some emphasis**	**Neutral**	**Little emphasis**	**More emphasis**
To display information in different ways	7	15	8	10	10
To break a complex process into smaller parts	9	17	6	10	8
To understand diagrams that describe or show real-world problems	8	13	5	6	18
To plan tasks by setting out the steps needed to complete them	7	17	5	8	13
To use tools making diagrams that help solve problems	8	13	6	8	15
To use simulations to help understand or solve real-world problems	10	10	4	19	7
To make flow diagrams to show the different parts of a process	8	8	9	16	9
To record and evaluate data to	13	8	7	17	5

understand and solve a problem					
To use real-world data to review and revise solutions to problems	10	7	5	19	9

Table 4 presents the distribution of responses, depicting frequencies related to teachers' utilization of ICT for class activities. It was noted that 52% of the teachers rarely offered opportunities for students to use ICT tools for engaging in extended projects. Additionally, students were not frequently provided with the chance to employ ICT tools for submitting their completed assignments for assessment. Moreover, there were limited instances where students could work individually with learning materials at their own pace, reflect on their learning experiences, and autonomously plan a sequence of learning activities for themselves. In light of these findings, it is essential for teachers to reconsider their approach to ICT learning and coding tasks. This crucial necessity is significantly dependent on the provision of professional development opportunities for teachers to enhance their competency in effectively utilizing digital resources, thereby promoting meaningful teaching and learning experiences in the field of Life Sciences.

Table 4: Teachers' use of ICT for class activities

How often do learners in your class use ICT for the following activities?					
	Very seldom	**Seldom**	**Neutral**	**Often**	**Very often**
Work on extended projects (i.e. lasting over a week)	10	16	7	10	7
Work on short assignments (i.e. within one week)	11	15	5	11	8
Explain and discuss ideas with other students	12	13	6	10	9
Submit completed work for assessment	10	16	6	11	7
Work individually on learning materials at their own pace	10	11	5	18	10
Undertake open-ended investigations or field work	12	14	6	10	8
Reflect on their learning experiences (e.g. by using a learning log)	13	12	4	13	8
Communicate with students in other schools on projects	10	16	5	11	8

Plan a sequence of learning activities for themselves	11	14	6	12	7
Analyze data	12	16	7	11	4
Evaluate information resulting from a search	13	16	6	12	3
Collect data for a project	10	16	8	10	6
Create visual products or videos	9	15	6	12	5
Share products with other students	9	10	5	16	10

Table 5 illustrates the distribution of responses, outlining frequencies regarding teachers' implementation of ICT in their teaching practices. It was evident that a significant portion of teachers reported infrequent use of digital resources for purposes such as offering individualized remedial or enrichment support to individual learners or small groups, facilitating inquiry-based learning, and supporting whole-class discussions and presentations led by learners themselves. However, there was an increasing trend among teachers to utilize digital resources to encourage collaboration among their learners.

Table 5: Teachers' use of ICT for teaching practices

How often do you use ICT in the following practices when teaching your learners?					
	Very seldom	**Seldom**	**Neutral**	**Often**	**Very often**
The provision of remedial or enrichment support to individual learners or small groups of learners	8	17	7	12	6
The support of learner-led whole-class discussions and presentations	6	13	6	18	7
The assessment of learners' learning through tests	9	18	6	13	4
The provision of feedback to learners on their work	8	19	6	12	8
The reinforcement of learning of skills through repetition of examples	9	17	8	15	7
The support of collaboration among learners	8	10	5	20	9
The mediation of communication between learners and experts or external mentors	9	14	7	12	8

The support of inquiry learning	8	15	8	12	7

Table 6 displays the distribution of responses, highlighting frequencies related to teachers' utilization of ICT tools in their classrooms. It was evident that the teachers exhibited limited familiarity with the use of technological applications such as digital learning games, concept mapping software, modelling software, interactive digital learning resources, and graphing or drawing software. Conversely, the adoption of social media platforms like Facebook and Twitter was notably popular among the teachers. Furthermore, the teachers expressed a high level of comfort and proficiency in using commonly employed ICT tools such as word-processing software (e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), and computer-based information resources (e.g., topic-related websites, wikis, and encyclopaedias)

Table 6: Teachers' use of ICT tools in class

How often do you use the following tools in your teaching?					
	Very seldom	**Seldom**	**Neutral**	**Often**	**Very often**
Practice programs or apps where you ask learners questions	9	14	7	14	6
Digital learning games	7	17	6	12	8
Concept mapping software	8	17	5	13	7
Modelling software	9	16	4	14	7
A learning management system (e.g. [Blackboard])	6	19	7	9	9
Collaborative software (e.g. [Google Docs ®],	7	18	6	13	6
Interactive digital learning resources (e.g. learning objects)	5	22	7	10	6
Graphing or drawing software	6	21	4	14	5
e-portfolios	8	20	5	13	4
Social media (e.g. [Facebook, Twitter])	2	8	2	28	10
How often do you use the following tools in your teaching?					
	Very seldom	**Seldom**	**Neutral**	**Often**	**Very often**
Word-processor software (e.g. [Microsoft Word ®])	6	10	4	20	10
Presentation software (e.g. [Microsoft PowerPoint ®])	5	10	3	18	14
Computer-based information resources (e.g.	3	7	4	24	12

topic-related websites, wikis, encyclopaedia)					
Digital contents linked with textbooks	12	19	3	8	8

Table 7 presents the distribution of responses, demonstrating frequencies related to teachers' perceptions regarding ICT resources and collaboration among teachers at their schools. The teachers conveyed that a significant and fundamental challenge at under-resourced schools was the severe scarcity of digital resources. In the broader South African context, rural and township schools, in particular, grappled with this issue, as they were notably less equipped compared to urban schools. The challenges identified by the teachers encompassed insufficient ICT equipment, limited access to digital learning resources, inadequate opportunities for developing ICT expertise, and a lack of technical support for maintaining ICT resources. This severe shortage of ICT resources seemed to hinder teachers' professional capacity to engage in collaborative efforts on important pedagogical tasks. More specifically, teachers lamented the absence of opportunities to collaborate with their colleagues to enhance the integration of ICT in classroom teaching and to jointly develop ICT-based instructional materials and lessons.

Table 7: Teachers' perceptions of ICT resources and teacher collaboration at school

To what extent do you agree or disagree with the following statements about using ICT in teaching at your school?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
My school has sufficient ICT equipment (e.g. computers).	20	13	2	8	7
The computer equipment in our school is up-to-date.	22	10	3	9	6
My school has access to sufficient digital learning resources (e.g. learning software or [apps]).	21	13	2	10	4
My school has good connectivity to the Internet.	15	13	3	10	9
There is enough time to prepare lessons that incorporate ICT.	7	21	3	10	6
There is sufficient opportunity for me to develop expertise in ICT.	12	15	5	10	8

There is sufficient technical support to maintain ICT resources.	14	16	3	11	6
To what extent do you agree or disagree with the following statements about your use of ICT in teaching and learning at your school?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
I work together with other teachers on improving the use of ICT in classroom teaching.	13	12	7	10	8
I collaborate with colleagues to develop ICT-based lessons.	18	14	6	10	2
I observe how other teachers use ICT in teaching.	15	12	5	10	8
I discuss with other teachers how to use ICT in teaching topics	16	12	7	13	2
I share ICT-based resources with other teachers in my school.	10	15	6	11	8

Table 8 displays the distribution of responses, indicating the frequency of teachers' engagement in ICT-related professional learning. The insufficiency of teachers' expertise in utilizing digital tools stems from a lack of opportunities to participate in ICT-related professional development, as revealed by the data in Table 8. Specifically, teachers expressed their frustration over the absence of chances to attend training sessions covering ICT applications, webinars focusing on the integration of ICT in teaching and learning, subject-specific digital teaching and learning resource training, and courses on harnessing ICT for personalized learner support. This challenging situation impedes teachers' capacity to engage in ICT-driven discussions or educational forums, collaborate with peers in sharing digital teaching and learning resources through collaborative platforms, and employ these collaborative spaces for collectively evaluating learners' work.

Table 8: Teachers' participation in ICT-related professional learning

How often have you participated in any of the following professional learning activities in the past two years?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
A course on ICT applications (e.g. word processing,	10	15	6	11	8

presentations, internet use, spreadsheets, databases)					
A course or webinar on integrating ICT into teaching and learning	12	17	6	10	5
Training on subject-specific digital teaching and learning resources	12	16	6	10	6
A course on use of ICT for learners with special needs or specific learning difficulties	16	14	4	12	4
A course on how to use ICT to support personalized learning by learners	12	17	6	10	5
How often do you use the following tools in your teaching?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Observations of other teachers using ICT in teaching	8	13	6	13	10
An ICT-mediated discussion or forum on teaching and learning	12	14	5	14	5
The sharing of digital teaching and learning resources with others through a collaborative workspace	13	15	4	13	5
Use of a collaborative workspace to jointly evaluate learners' work	11	15	7	12	5

Table 9 presents the distribution of responses, showcasing teachers' viewpoints regarding the outcomes of integrating ICT into teaching and learning. The teachers exhibited a favorable attitude toward the effectiveness of ICT tools as an innovative method to achieve specified educational objectives. They conveyed that ICT usage holds the potential to enhance learners' academic performance. Furthermore, employing ICT allows learners to tailor their learning experience to their individual needs and grants them access to superior information sources. The teachers expressed a profound recognition of ICT's importance in the realm of Life Sciences education and passionately asserted that the utilization of digital resources does not hinder the meaningful teaching and learning of science.

Table 9: Teachers' perceptions of outcomes of using ICT for teaching and learning

To what extent do you agree or disagree with the following practices and principles in relation to the use of ICT in teaching and learning?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Helps learners to work at a level appropriate to their learning needs.	4	11	5	21	9
Helps learners develop greater interest in learning.	7	8	4	16	15
Helps learners develop problem solving skills.	5	9	5	15	16
Enables learners to collaborate more effectively.	4	8	3	22	13
Helps learners develop skills in planning and self-regulation of their work.	6	9	5	19	11
Improves academic performance of learners	9	6	3	20	12
Enables learners to access better sources of information	5	3	5	22	15
To what extent do you agree or disagree with the following practices and principles in relation to the use of ICT in teaching and learning?					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Impedes concept formation by students	17	16	2	8	7
Results in learners copying material from Internet sources.	12	17	3	10	8
Distracts learners from learning	15	18	4	7	6
Results in poorer written expression among learners	12	16	3	12	7
Results in poorer calculation and estimation skills among learners	11	18	3	11	7
Limits the amount of personal communication among learners	15	19	4	7	5

FINDINGS EMANATING FROM SEMI-STRUCTURED INTERVIEWS

The results derived from semi-structured interviews have been organized into thematic categories based on patterns that emerged during the data analysis process. These themes encompass the following areas: teachers' comprehension and awareness of ICT, teachers' convictions regarding the role of ICT in Life Sciences education, the incorporation of ICT into Life Sciences instructional sessions, the pedagogical methods employed by Life Sciences teachers when integrating ICT into teaching and learning, the utilization of ICT in specific educational contexts, situational factors influencing diverse teaching approaches and ICT utilization, and the discrepancies observed within and across rural, township, and urban schools concerning the integration of ICT in Life Sciences teaching and learning.

Theme 1: Teachers' knowledge and awareness of ICT

Although the teachers acknowledged their awareness of ICT tools, they expressed dissatisfaction with their insufficient understanding of how to incorporate these tools effectively into Life Sciences teaching and learning. The teachers pointed out that the Fourth Industrial Revolution and the COVID-19 pandemic created openings for embracing digital transformation. However, they felt that there were limited opportunities for teachers to undergo professional development specifically focused on integrating ICT into the teaching and learning of Life Sciences. This situation does not bode well for fostering a positive shift in teachers' professional attitudes towards integrating ICT into their teaching practices. These sentiments are summarized in the following passage.

Yes, ICT integration plays a greater part in education but there are a lot of hindrances towards the implementation of ICT. ICT integration will be the new culture in the education sector because of the changes that come with the 4IR. For an educators to implement ICT integration in their Life Sciences classroom, they must know what it is. The teacher's attitude plays a big role on whether or not they integrate ICT in their classroom.

The teachers also acknowledged that learners were aware of the existence of ICT tools as the following excerpt demonstrates.

This generation that we teach is somewhat connected to technology, they know so much about technology that when it is integrated into life science lessons, they enjoy, they relate, they concentrate, and they understand.

Theme 2: Teachers' beliefs about the role of ICT in Life Sciences teaching and learning

The teachers held the belief that the use of ICT tools plays a pivotal role in Life Sciences teaching and learning. However, lack of professional training on the integration of ICT tools in Life Sciences teaching and learning was identified as a major barrier as the following excerpt illustrates.

For teachers to implement ICT in their classroom, they have to believe it enhances teaching and learning. ICT is the new tradition in education. Teachers have to learn how to use technological tools to reach out to learners and continue with lessons.

The teachers also indicated that the role of ICT was accentuated during COVID-19 pandemic. The imposed lockdown compelled teachers and learners to use ICT tools for learning.

These sentiments are reflected in the following excerpt.

Technology was the only hope to save the 2020 academic year during the lockdown when the pandemic began. Teachers were under a lot of stress when the country was shut down due to the outbreak of COVID-19, people were forced to stay indoors and cut all activities including going to school. The only form of communication between teachers and learners was smartphones through WhatsApp. Teachers were forced to teach online through google classroom, zoom meetings and WhatsApp without proper training. That was a turning point for educators, they had to learn how to use technological tools to reach out to learners and continue with lessons and save the academic year. Not all teachers succeeded in this; some couldn't reach out because of the context of their schools and attitudes of learners towards technological learning and mainly because not all parents afforded smartphones for their kids.

Theme 3: ICT integration in Life Sciences lessons

The teachers indicated that they often integrate ICT in Life Sciences lessons without any professional assistance. They always had to deal with technical problems associated with ICT equipment on their own and this was a source of immense frustration as reflected in the following excerpt.

For a teachers to successfully implement ICT, they need full support from their principal and the entire management to help train them to become technologically intelligent teachers.

The ICT tools used by teachers in Life Sciences teaching and learning included laptops, smartphones, applications (WhatsApp, YouTube, Phet Simulations), smart board and tablets. Notwithstanding the challenges encountered when integrating ICT in Life Sciences learners, the teachers acknowledged that ICT integration can serve as an effective catalyst to foster meaningful science teaching and learning.

Theme 4: Pedagogical practices adopted by Life Sciences teachers when integrating ICT in teaching and learning

The teachers adopted a variety of pedagogical strategies when integrating ICT in Life Sciences teaching and learning. These pedagogical strategies included collaborative learning, problem-based learning and cooperative learning. However, the teachers found increasingly challenging to implement inquiry-based learning, project-based learning and self-direct learning when integrating ICT in Life Sciences teaching and learning. These sentiments are encapsulated in the following excerpt.

I normally split the learners into groups to work together. The learners are afforded opportunities to solve problems in groups and to share feedback.

There is a need to professionally empower teachers to meaningfully implement contemporary teaching approaches when integrating ICT in Life Sciences teaching and learning.

Theme 5: The use of ICT in specific situations within the pedagogical practice

The teachers used ICT tools to demystify Life Sciences phenomena such as Mitosis and Meiosis using visual illustrations. The teachers also indicated that the use of ICT tools was effective in explaining the Human Skeleton. These sentiments are encapsulated in the following excerpt.

Explaining Mitosis, Meiosis and the Human Skeleton using visual illustrations was an exciting experience for the learners. This implies that the use of ICT can be effective in developing learners' conceptual understanding of Life Sciences phenomena.

The use of ICT in specific situations within the pedagogical practice ought to be harnessed to foster meaningful science teaching and learning.

Theme 6: Contextual factors associated with different pedagogical approaches and ICT use

The incorporation of ICT into Life Sciences education faced significant obstacles in rural and township schools primarily due to a shortage of resources. In contrast, urban schools, which were well-equipped, found it easier to integrate ICT into their Life Sciences teaching and learning practices. The teachers' insufficient technological pedagogical content knowledge hindered their capacity to implement modern teaching methods, such as inquiry-based learning, when integrating ICT into Life Sciences education. These sentiments are summarized in the following passage.

Our school is located in the township and it is not well-resourced as compared to urban schools. As teachers, we still need professional training on the use of ICT in Life Sciences teaching and learning so that we can embrace pedagogic innovation.

There is a need provide appropriate professional development interventions on the use of ICT tools in Life Sciences teaching and learning to enable teachers to fully embrace pedagogic innovation as an integral part of digital transformation.

Theme 7: Variations existing in and across different rural, township and urban schools on the use of ICT in Life Sciences teaching and learning

In urban schools, Life Sciences teachers exhibited a sufficient grasp of technological pedagogical content knowledge, enabling them to effectively incorporate ICT into their teaching and learning practices. Conversely, in rural and township schools, besides the overall lack of resources, teachers displayed an insufficient level of technological pedagogical content knowledge. This deficiency impeded their capacity to employ modern teaching methods when integrating ICT into the teaching and learning of Life Sciences. These observations are encapsulated in the following passage.

Teachers cannot be left to their own devices when it comes to the use of ICT in science teaching and learning. Teachers need professional training on the use of ICT to enhance their practice. How can teachers embrace pedagogic innovation without ICT resources in township schools?

To address the prevailing socio-economic disparities within the South African basic education system, it is imperative to take steps aimed at establishing a robust foundation for delivering high-quality education. Elevating the overall quality of science education necessitates the allocation of sufficient resources. Many rural and township schools find themselves in resource-limited educational settings that are less than ideal for delivering quality education.

DISCUSSION

Teachers pointed out that a significant and persistent challenge in under-resourced schools is the acute shortage of digital resources. When considering the broader South African context, it becomes evident that rural and township schools, in comparison to their

urban counterparts, often lack adequate resources. The challenges highlighted by teachers encompassed a scarcity of ICT equipment, limited access to digital learning materials, a dearth of opportunities to develop ICT skills, and a lack of technical support for the maintenance of ICT resources. The severe shortage of ICT resources appeared to impede teachers' ability to collaborate effectively on essential pedagogical tasks. Mndzebele (2013) identified widespread issues related to internet accessibility in schools. Moreover, the absence of technical support hinders teachers from effectively using ICT in educational settings (Ghavifekr et al., 2016). According to Rabah (2015), the integration of ICT into education will remain limited to sporadic activities, such as investments or training sessions, unless there is strong leadership and a clear vision for support. The adoption of digital technologies in schools with limited resources remains a substantial challenge (Stantchev et al., 2014). Despite improvements in digital technology access, progress has been slow, and established timelines have not been met (Howard & Mozejko, 2015). Chisango and Marongwe (2021) argue that providing ICT devices like tablets and computers to all students, along with subsidized data, is essential to address the issue of ICT accessibility. Addressing poverty reduction is also crucial in reducing digital exclusion (Mbele, 2020). Reimers and Schleicher (2020) emphasize that learners increasingly find it difficult to learn without access to devices, internet connectivity, and suitable physical learning environments.

Teachers expressed their frustration over the lack of opportunities to collaborate with peers in enhancing the utilization of ICT in classroom instruction and developing ICT-based lessons collectively. They specifically lamented the absence of chances to partake in training sessions covering various aspects of ICT, such as ICT applications, webinars on integrating ICT into teaching and learning, training on subject-specific digital teaching and learning resources, and courses on utilizing ICT to support personalized learning for learners. Bocconi et al. (2013) suggested a connection between learners' use of digital learning resources during lessons and teachers' confidence in their digital competencies. Furthermore, numerous studies have indicated that various demographic factors of teachers, including age, experience, and gender, can influence the extent to which they incorporate digital technologies into their teaching methodologies (e.g., Merc, 2015). The teachers displayed a positive attitude towards the effectiveness of integrating ICT as an innovative approach to achieve educational objectives. They pointed out that the utilization of ICT tools has the potential to enhance learners' academic performance. In this context, Shaikh and Khoja (2011) argued that ICT tools can positively impact teaching and learning styles by shifting the focus from a teacher-centred to a learner-centred classroom. This shift provides valuable opportunities to enhance reasoning skills, foster critical thinking and creativity, and develop problem-solving abilities. The use of ICT tools also empowers learners to explore new information in non-linear sequences and enhance their comprehension through visualization tools (Song & Kang, 2012).

The teachers firmly believed that the utilization of ICT tools holds a crucial role in the context of Life Sciences teaching and learning. However, a significant hindrance they identified was the absence of proper professional training concerning the integration of ICT tools into Life Sciences education. These findings align with a study conducted by Galvis (2012), which

demonstrated that individual attitudes and perspectives are closely intertwined with professional beliefs and practices, thus influencing teachers' actions. An individual teacher's beliefs about digital technologies, both in general and for learning purposes, also exert a substantial impact on ICT integration (Petko, 2012). Prensky (2005) further asserts that teachers' stances, beliefs, and attitudes toward digital technology inevitably shape its usage and determine the level of implementation. The teachers employed a range of pedagogical strategies when incorporating ICT into Life Sciences teaching and learning. These strategies encompassed collaborative learning, problem-based learning, and cooperative learning. Nevertheless, the teachers encountered increasing challenges when attempting to implement inquiry-based learning, project-based learning, and self-directed learning in the context of ICT integration into Life Sciences education. Fullan (2013) notes that new pedagogical approaches underpinned by digital technology and constructivist principles are not universally well-understood among teachers and learners. The teachers noted that they often integrated ICT into their Life Sciences lessons without professional guidance. They frequently had to address technical issues related to ICT equipment independently, leading to considerable frustration. While the teachers acknowledged their awareness of the existence of ICT tools, they lamented their inadequate knowledge concerning the effective integration of these tools into Life Sciences teaching and learning. In addition to the overarching lack of resources, teachers in rural and township schools exhibited insufficient technological pedagogical content knowledge, which impeded their ability to implement contemporary teaching methodologies when incorporating ICT into Life Sciences education.

The incorporation of ICT into Life Sciences education encounters significant obstacles in rural and township schools primarily due to a pervasive lack of resources. In contrast, urban schools enjoy ample resources, which greatly facilitate the integration of ICT into Life Sciences teaching and learning. Dzansi and Amedzo (2014) argue that the adoption and implementation of digital technologies in South Africa face hindrances stemming from inadequate infrastructure. Furthermore, Ndlovu and Lawrence (2012) contend that despite legislative provisions, policy implementation at the local school level, particularly in disadvantaged areas, has been notably deficient. These disparities in access to and implementation of ICT tools between urban and rural schools contribute to the perpetuation of the digital divide. Supporting these viewpoints, Ndlovu and Lawrence (2012) assert that the challenges surrounding the inadequate implementation and adoption of digital technologies in South Africa are not solely attributable to a scarcity of resources but are also influenced by teachers' capacity to effectively utilize the available digital educational tools at their disposal. As Fullan (2013) stipulates, digitally proficient teachers play a crucial role in offering guidance, strategic support, and assistance to learners with diverse needs, enabling them to take on increasing responsibilities in their learning journey.

Teachers in urban schools exhibited a strong grasp of technological pedagogical content knowledge, which facilitated the effective integration of ICT into their Life Sciences teaching and learning practices. However, a significant obstacle is the lack of knowledge regarding how technology can be optimally utilized to benefit students across various subject areas (Kurt, 2019). To enable teachers to

meaningfully integrate technology into their teaching and learning processes, it is essential to provide them with guidance based on the Technological Pedagogical Content Knowledge (TPACK) framework proposed by Mishra and Koehler (2006). This framework encompasses three domains: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) (Batiibwe, Bukkabulindi & Mango, 2016). As emphasized by Laabidi and Laabidi (2016), there exists a critical necessity to bolster teachers' professional confidence through skills training, ensuring that learners are adequately prepared for a technologically driven society. Teachers who lack confidence in applying technology in their profession may seek to avoid such roles altogether (Laabidi & Laabidi, 2016). An essential step in enhancing the quality of teaching and learning involves identifying potential challenges or barriers that teachers encounter when integrating digital technologies into schools (Ghaviferkr et al., 2016).

INTERPRETATION OF KEY FINDINGS IN TERMS OF THE ADOPTED CONCEPTUAL FRAMEWORK

As previously mentioned, this study was guided by the Conceptual Framework for the Second Information Technology in Education Study (SITES) (Law, Pelgrum, & Plomp, 2008) as its foundational conceptual framework. This framework primarily centres on the dynamics occurring within the classroom and the utilization of ICT within that classroom environment. It underscores the notion that pedagogical practices involving ICT are integral components of a teacher's broader pedagogical approach. In the case of teachers, the motivations behind their use of ICT in the classroom and the methods they employ are deeply rooted in their overall pedagogical vision and competence. However, it's important to recognize that pedagogical practices are not solely determined by the individual characteristics of teachers, such as their academic qualifications and ICT proficiency. They are also influenced by factors at the school and system levels. While it's reasonable to expect that learning outcomes will be impacted by the pedagogical practices learners encounter, it's crucial to acknowledge that these outcomes, whether perceived or actual, can also shape teachers' subsequent pedagogical choices. This is because adjustments often need to be made at the teacher, school, and system levels to accommodate the anticipated or observed impact of pedagogical practices on learners.

A prevalent absence of digital resources in rural and township schools posed a significant obstacle to the effective integration of ICT into grade 10 Life Sciences teaching and learning within the context of this study. Insufficient technical support necessary for incorporating ICT into teaching and learning continued to be a primary challenge faced by teachers. Both the general shortage of digital resources and the deficiency in the required technical support for ICT integration represented school-related factors that had a detrimental impact on ICT integration, particularly in rural and township schools. The existing socio-economic disparities within the basic education system, which can be categorized as systemic factors, demand immediate attention to lay the foundation for providing high-quality education aligned with the imperatives associated with the Fourth Industrial Revolution. Teachers in rural and township schools exhibited a lack of adequate technological pedagogical content knowledge, a characteristic of teachers that impeded their ability to effectively incorporate

technology into Life Sciences teaching and learning. Despite teachers' utilization of various pedagogical strategies when integrating technology into Life Sciences instruction, achieving consistent implementation of contemporary teaching approaches such as inquiry-based learning and self-directed learning remained a formidable challenge in their pedagogical practices. Learners, for their part, displayed considerable enthusiasm when exposed to the use of digital resources in Life Sciences teaching and learning. However, the aforementioned challenges complicated the coherent attainment of learning objectives for teachers.

INTERPRETATION OF KEY FINDINGS IN TERMS OF THE ADOPTED THEORETICAL FRAMEWORK

Interpreting the findings of a study on the through the lens of the Technology Acceptance Model (TAM) provided insights into how teachers and learners perceive and accept these digital resources. The TAM posits that perceived ease of use and perceived usefulness influence users' acceptance and adoption of technology. The study found that the majority of teachers reported that they found the digital resources in grade 10 Life Sciences easy to use. High ratings of perceived ease of use suggest that the digital resources employed in the study were user-friendly and accessible. This may indicate that the design and interface of these resources were well-received and did not pose significant usability barriers. The study revealed that both learners and teachers perceived the digital resources as highly valuable for enhancing their understanding of Life Sciences concepts. The positive perception of usefulness aligns with TAM's expectations. It implies that the digital resources were seen as effective tools for supporting teaching and learning in grade 10 Life Sciences. Teachers may have found them valuable for facilitating instruction, while learners may have appreciated their role in improving their grasp of complex topics. The study shows that a significant percentage of participants expressed a strong intention to continue using digital resources in their Life Sciences education. This finding suggests that the positive perceptions of ease of use and usefulness have a direct impact on the participants' intention to incorporate these resources into their teaching or learning routines. It aligns with TAM's prediction that favorable attitudes lead to actual technology adoption.

The study indicates that the frequency of actual use of digital resources varied among participants, with some integrating them regularly into their teaching and learning practices, while others used them less frequently. While the TAM primarily focuses on intention to use, the study's findings on actual use highlight the complexity of technology adoption. Factors beyond perceived ease of use and usefulness, such as institutional support or individual preferences, may influence the extent to which digital resources are integrated into teaching and learning. Based on the TAM framework, the study recommend strategies to further enhance perceived ease of use and perceived usefulness. This could include providing additional training, technical support, or improving the design of digital resources. The study also suggests initiatives to foster a positive attitude and intention to use digital resources, such as demonstrating their effectiveness in improving academic performance. In summary, interpreting the findings through the TAM framework helps explain why learners and teachers are accepting or resisting the integration of digital resources in grade 10 Life Sciences teaching and learning. By identifying

factors related to perceived ease of use and perceived usefulness, the study offers insights for improving the design and implementation of these resources to enhance their adoption in educational settings.

IMPLICATIONS OF RESEARCH FINDINGS FOR SCIENCE TEACHING AND LEARNING

The key findings from the study strongly indicate that the incorporation of digital technologies into science teaching and learning in schools holds significant potential benefits. However, its effectiveness is impeded by a range of factors, both inherent and external in nature. Furthermore, the results reveal that the embrace of digital technologies varies from one school to another. These variations are primarily influenced by the digital competence, attitudes, and beliefs of both teachers and learners. This underscores the importance of thoroughly examining the contextual conditions, as they play a crucial role in the integration of digital technology into various educational activities. The Department of Basic Education faces the critical task of implementing targeted professional development programs to enhance teachers' technological pedagogical content knowledge. Additionally, the presence of adequate technological infrastructure, teachers' proficiency in technological pedagogical content knowledge, teacher training, and a supportive learning environment are all factors that determine the successful adoption of digital technologies in education. Ultimately, the utilization of digital resources carries significant implications for enhancing meaningful science teaching and learning within the broader South African educational landscape.

CONCLUSION

In conclusion, the study on the utilization of digital resources in Grade 10 Life Sciences teaching and learning has shed light on the transformative potential of technology in education. Our findings underscore the importance of incorporating digital resources into the classroom to enhance engagement, understanding, and retention of complex scientific concepts. Through the integration of multimedia, interactive simulations, and online platforms, teachers can create dynamic and immersive learning experiences that cater to diverse learning styles. Furthermore, this research highlights the need for ongoing professional development for teachers to effectively harness the power of digital resources. It is crucial for teachers to continuously adapt to evolving technologies and pedagogical approaches to ensure that learners receive the most up-to-date and effective educational experiences. As we move forward, it is clear that the integration of digital resources into education is not a mere trend but a necessity in preparing learners for the challenges of the 21st century. This study serves as a foundation for further exploration and refinement of digital resource utilization in education, ultimately contributing to the improvement of teaching and learning in the field of Life Sciences and beyond. By embracing the potential of technology in education, we can foster a more engaging and effective learning environment that equips students with the knowledge and skills they need to succeed in an increasingly digital and interconnected world.

RECOMMENDATIONS

Based on the findings of the study on the utilization of digital resources in Grade 10 Life Sciences teaching and learning, several recommendations are outlined to enhance the effectiveness of digital resource integration in the classroom:

Teacher Training and Professional Development: Provide ongoing training and professional development opportunities for teachers to ensure they are proficient in using digital resources effectively. Workshops, webinars, and online courses can help teachers stay up-to-date with the latest technologies and pedagogical approaches.

Curriculum Integration: Collaborate with curriculum developers and educational experts to align digital resources with the curriculum standards and learning objectives. Ensure that digital content enhances and supplements the existing curriculum, rather than replacing it.

Diverse Digital Resources: Encourage the use of a wide range of digital resources, including interactive simulations, virtual labs, video lectures, and online textbooks. Diverse content can cater to different learning styles and preferences among learners.

Accessibility and Equity: Address issues of access and equity by providing equal access to digital resources for all learners, regardless of their socioeconomic background. Schools should work to bridge the digital divide and ensure that every learner has access to the necessary technology.

Assessment Strategies: Develop innovative assessment methods that align with digital learning resources. Traditional forms of assessment may not fully capture the benefits of digital learning. Consider incorporating e-portfolios, peer assessments, and interactive quizzes into the evaluation process.

Feedback and Continuous Improvement: Establish mechanisms for collecting feedback from both teachers and learners regarding the use of digital resources. Use this feedback to continuously improve the quality and effectiveness of digital content and instructional strategies.

Flexibility and Adaptability: Recognize that technology is constantly evolving. Schools should be flexible and adaptable in their approach to digital resource integration, allowing for experimentation and adjustment based on changing technologies and educational needs.

Incorporating these recommendations can help educational institutions create a more effective and inclusive learning environment in Grade 10 Life Sciences and beyond, where digital resources play a crucial role in enhancing the quality of education.

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