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EXPLORING THE PEDAGOGICAL VALUE OF ICT IN LIFE SCIENCES TEACHING AND LEARNING

GIFT THAMSANQA LUBISI

PERSON NUMBER: 1914909

A research report submitted to the Wits School of Education, Faculty of Humanities, University of the Witwatersrand in partial fulfilment of the requirements for the degree of Master of Education in Educational Technology by combination of coursework and research.

SUPERVISOR:

DR. NOKULUNGA SITHABILE NDLOVU

CO-SUPERVISOR:

DR. NAJMA AGHERDIEN

DATE:

30 JUNE 2023

DECLARATION

a) Originality

I declare that the work contained in this research proposal is my own and all the sources I have used or quoted have been indicated and acknowledged by means of references. I also declare that I have not previously submitted this research proposal or any part of it to any university in order to obtain a degree.

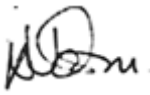


_____ 19 October 2022

Signature Date

b) Supervisors' statement

This dissertation has been submitted with/without my approval.



18 October 2022

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Dr. Nokulunga Sithabile Ndlovu Date



18 October 2022

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Dr. Najma Agherdien Date

ABSTRACT

Life Sciences (LS) is a subject that is mostly based on theoretical and practical ideas that may be difficult to prove in a classroom context. It is thus not easy for some learners to grasp. This study therefore sought to explore the use of Information and Communication Technologies (ICTs) by six LS teachers teaching in three grades (10, 11, and 12) in two public schools located in the Gauteng province in South Africa. It sought to investigate how ICT usage enhances learner understanding of LS concepts. A qualitative research design was used for data collection and analysis. Laurillard's media forms helped to make sense of data from semi-structured interviews and one lesson observed for each of the six teachers. The findings revealed that all participating teachers perceived the effectiveness of ICTs as enabling learners to 'see' LS abstract concepts. Their use of ICTs in the classroom was confined to narrative, interactive, and communicative media forms. There is evidence that suggests that the pedagogical value of the technologies is aligned with the teachers' perceptions as the combination of the three media forms facilitates visualization of abstract concepts—depending on how they are used. Therefore, this research recommends that the use of ICTs (in this case, the smartboards and learner laptops) be extended to the utilization of the adaptive media where learners can be exposed to simulations to help them concretize their understanding of LS. My main argument and findings are that these concepts within the framework will only be effective based on how the teacher views and applies it. I also observed that if learners have access to technologies for learning the subject, potentially better (deeper) learning will be achieved through its use. Moreover, if learners are not given opportunities to apply the learning, engage in a critical way to reveal the importance of ICTs in their lives, pedagogical efforts remain futile. Thus, pedagogical value is key in ICT integration, not only in LS but in all learning.

KEY WORDS

Enhancement of learning, Learning outcomes, Life Sciences, Media forms, Pedagogical value, Teaching with ICTs

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LIST OF ABBREVIATIONS

Abbreviations	Meaning
ICT	Information and Communication Technologies
LS	Life Sciences
LOs	Learning Outcomes
GDE	Gauteng Department of Education
DBE	Department of Basic Education
PDFDL	Professional Development Framework for Digital Learning
CAPS	Curriculum and Assessment Policy Statement
DoE	Department of Education
FET	Further Education and Training
NOS	Nature of Science
NCS	The National Curriculum Statements
MEC	Member of the Executive Council

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION: IMPROVING LIFE SCIENCE TEACHING

The integration of Information and Communication Technologies (ICTs) in education is one of the interventions that can be employed to improve science teaching (Naidoo, 2017). ICT has a wide array of affordances that are believed to enhance teaching and which in turn improves learners' understanding (Simon, 2014). In support of this assertion Mireku (2016) contends that ICT resources can support teaching and learning and improve conceptual understanding. Moreover, Abdullahi (2021) suggests that ICT can enhance science education through teacher ICT literacy and related resources. Learner understanding is central to successful teaching, and this is determined by the teaching methods and tools that teachers use in their practice. This study aims to explore how ICTs can be used by teachers to enhance learning in LS.

Teachers have a responsibility to reflect on their practice and continuously try to implement pedagogies that are relevant to learners of this age. Times have changed and the dynamics of lesson presentation in LS classrooms should also change, and the revolution of teaching strategies should be in line with the 21st-century child (Ziphorah, 2013) who is exposed to modern technology. There is a need to change the methods of instruction to accommodate methods that will increase learner participation in the learning process (Mwanda, Mwanda, Midigo, & Maundu, 2017).

ICT has already penetrated the basic education sector in South Africa (Na-Allah, 2019). How technology was used in the early 1970s has improved in the current age (Ghavifekr & Rosdy, 2015). The uses of technology have moved from an analogous form to a more digital form. The South African Department of Basic Education (DBE) encourages and expects teachers to integrate ICT in their teaching for a more interactive and learner-centred approach (DBE, 2004). In response to these expectations, this study seeks to explore how teachers use ICT to enhance learners' understanding of LS.

1.2 BACKGROUND: LIFE SCIENCES TEACHING IN SOUTH AFRICA

Life Sciences is one of the subjects offered at the Further Education and Training (FET) phase (Grade 10 to 12)—it is the phase that succeeds the Senior phase (Grade 7 to 9) in South Africa. The subject is regarded as one of the crucial subjects in basic education as it is a prerequisite for science qualifications like medicine and pharmacy at the tertiary level (Naidoo, 2017). It is crucial to know the nature of LS and understand its relevance at the schooling level.

Life Sciences is a practical subject that is highly dependent on models, experiments, investigations, and live phenomena to validate the theoretical part of the subject (DoE, 2011). It is the study of living things from a molecular level to their interactions with each other and their environments (DoE, 2011). The creation of the body of knowledge within Life sciences is on an ongoing basis through investigations aimed at answering life's most difficult questions about different phenomena. According to the South African national curriculum statement, the Curriculum Assessment Policy Statement (CAPS) for Life Sciences, some of these questions have not been answered (DoE, 2011). Such gaps in the body of knowledge can motivate learners to seek answers to the questions through investigations. Failure to reach a conclusion may lead to learner dissatisfaction and discouragement due to the lack of tools or mechanisms that they need to make sense of the knowledge they are dealing with.

In light of the above, the subject content, its delivery and ultimately the learning thereof may be compromised. de Villiers (2011) argues that learners tend to find the concepts in Life Sciences complex to understand and irrelevant to their everyday lives. This is exacerbated by the fact that these concepts were coined from languages like Greek and Latin. For example, words like *gibberellins* (plant hormone), *ovovivipary* (reproductive mechanisms) and *cytokinesis* (meiosis) are difficult to grasp (Naidoo, 2017). Failure of learners to understand these concepts becomes a learning barrier—, thus, the use of ICTs in the form of visual representations with animation could help enhance the learning of the subject.

1.3 PROBLEM STATEMENT: TOWARDS IMPROVED LS LEARNING

There is evidence that South African learners are performing poorly in LS. The following table illustrates grade 12 LS results from the year 2014 to 2018 as taken from the Final diagnostic report for the subject (DoE, 2020).

Table 1: Life sciences results from 2014 to 2018 (taken from the Final Diagnostic Report).

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2014	284 298	209 783	73,8	139 109	48,9
2015	348 076	245 164	70,4	160 204	46,0
2016	347 813	245 157	70,5	157 224	45,2
2017	318 474	236 809	74,4	166 071	52,1
2018	310 041	236 584	76,3	160 208	51,7

These results indicate a low level of performance in grade 12 LS examinations, triggering a need to come up with interventions in this regard. Table 2 below shows the full-time candidates' performance at 30% and above in key subjects, from 2016 to 2020 (DBE, 2021, p. 102).

Table 2: Full-time candidates' performance at 30% and above in key subjects, 2016 to 2020.

Subjects	2016			2017			2018			2019			2020		
	Wrote	Achieved 30% & Above	% Achieved	Wrote	Achieved 30% & Above	% Achieved	Wrote	Achieved 30% & Above	% Achieved	Wrote	Achieved 30% & Above	% Achieved	Wrote	Achieved 30% & Above	% Achieved
Accounting	128 853	89 507	69.5	103 427	68 318	**66.1**	90 278	65 481	72.5	80 110	62 796	**78.4**	92 767	70 014	**75.5**
Agricultural Science	106 386	80 184	75.4	98 522	69 360	**70.4**	95 291	66 608	69.9	92 680	69 132	**74.6**	96 155	69 916	**72.7**
Business Studies	234 894	173 195	73.7	204 849	139 386	**68.0**	192 139	124 618	64.9	186 840	132 571	**71.0**	207 045	161 224	**77.9**
Economics	155 908	101 787	65.3	128 796	91 488	**71.0**	115 169	84 395	73.3	107 940	74 796	**69.3**	118 484	81 536	**68.8**
Geography	302 600	231 588	76.5	276 771	212 954	**76.9**	269 621	200 116	74.2	271 807	218 821	**80.5**	287 629	216 467	**75.3**
History	157 594	132 457	84.0	147 668	127 031	**86.0**	154 536	138 570	89.7	164 729	148 271	**90.0**	173 498	159 737	**92.1**
Life Orientation	663 975	661 903	99.7	620 626	619 336	**99.8**	618 726	617 041	99.7	610 234	609 101	**99.8**	589 870	586 360	**99.4**
Life Sciences	347 662	245 070	70.5	318 474	236 809	**74.4**	310 041	236 584	76.3	301 037	217 729	**72.3**	319 228	226 700	**71.0**
Mathematical Literacy	361 865	257 881	71.3	313 030	231 230	**73.9**	294 204	213 225	72.5	298 607	240 816	**80.6**	341 363	275 684	**80.8**
Mathematics	265 810	135 958	51.1	245 103	127 197	**51.9**	233 858	135 638	58.0	222 034	121 179	**54.6**	233 315	125 526	**53.8**
Physical Science	192 618	119 427	62.0	179 561	116 862	**65.1**	172 319	127 919	74.2	164 478	124 237	**75.5**	174 310	114 758	**65.8**

As can be seen in Table 1 and Table 2, the performance in LS was initially increasing; however, it began to decline in 2019. In the year 2016, the overall LS results were 70.5%. In 2017 it increased to 74.4%. In 2018 it increased to 76.3%. In 2019 it dropped to 72.3% and in 2020 it dropped further to 71.0%. It is therefore evident that there is a need for intervention in LS teaching in South Africa if the decline in learners writing LS examinations and passing it (Naidoo, 2017) is to be reduced. If not addressed, the poor learner performance in FET will have long-lasting effects within the field of science. Figure 1 below illustrates the problem, possible causes, and consequences.

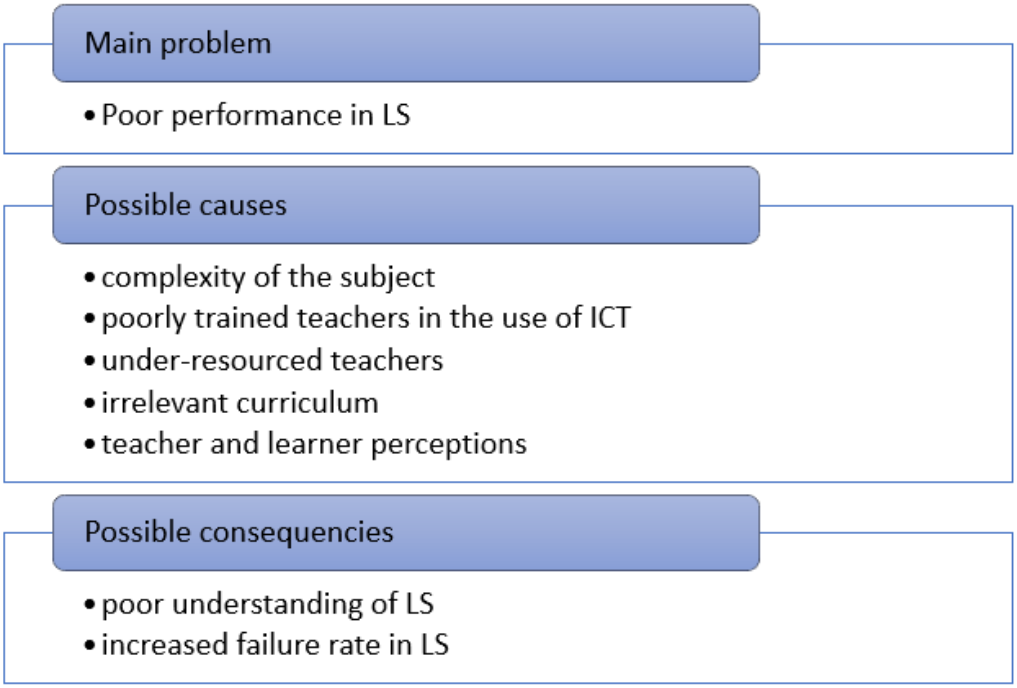


Figure 1: Diagrammatic representation of the problem statement, possible causes, and possible consequences.

The main problem in this study is poor performance in LS. Possible causes can be attributed to several factors as it is illustrated in Figure 1. These relate to the way in which teachers facilitate their lessons in LS to enhance learners' understanding. The use of ICTs for teaching and learning has the potential to address this challenge. Thus, my study aims to explore this problem.

1.4 AIM OF THE STUDY

This study is aimed at exploring how teachers integrate ICTs into the teaching and learning of Life Sciences to enhance learner understanding. It thus seeks to understand what pedagogical value can be assigned to the use of ICTs in LS.

1.5 RESEARCH OBJECTIVES

The research objectives of this study are:

1.5.1 To identify LS teachers' perceptions of the pedagogical value of ICTs.

1.5.2 To explore the pedagogies employed by teachers to integrate ICTs in LS classrooms.

1.5.3 To ascertain how the use of ICTs by teachers enhances learning in LS.

1.6 RESEARCH QUESTIONS

This study seeks to address the following main question:

How does the integration of ICTs by teachers enhance learning in LS (or not)?

The sub-questions that will assist in answering the main question are:

1.6.1 What are the teachers' perceptions regarding the pedagogical value of ICTs in LS teaching?

1.6.2 What are the pedagogies employed by teachers to integrate ICTs in LS classrooms?

1.6.3 How do teachers' use of ICTs enhance the teaching and learning of Life Sciences?

1.7 SIGNIFICANCE OF THE STUDY

According to Majumdar (2006), the literature reveals the effectiveness of ICT in education but there is little that is provided on how teachers can infuse it in their pedagogy. Similarly, Ndlovu (2015) argues that policies do not overtly provide pedagogies that teachers can employ to integrate ICT into their practice. There remains the importance of devising subject-specific pedagogies through the use of ICT. Therefore, how ICTs are used within specific subjects is critical. This research is necessary to explore the use of ICTs in LS classrooms to understand the 'how' part, and explicitly reveal possible subject-specific pedagogies. Moreover, I argue

that the findings should challenge LS teachers to reflect on the way they teach and seek innovative ways to improve their practice in using ICT.

1.8 CONCLUSION

This chapter provided an introduction by outlining the background, problem statement, the aim of the study, research objectives, questions, and significance of the study. Chapter 2 will provide a literature review of previous studies in the same field to gain better insight into this subject. The research design will be presented in Chapter 3, followed by the presentation of findings and analysis in Chapter 4, and Chapter 5 will provide a discussion of the findings. and some recommendations for further studies and the conclusion.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION: LIFE SCIENCES AND ICT INTEGRATION

A literature review can be defined as a compilation of primary, secondary, and tertiary sources on a topic (Mudavanhu, 2017). It is conducted by the researcher to survey and critique the body of knowledge in their area of interest (Mudavanhu, 2017). This is done to enable the researcher to take a stance in their research. The stance taken in this study is based on the premise that pedagogical principles that underpin the use of technology are significant, rather than the technology itself. The purpose of this literature review is to identify similar studies that have been conducted in the past to examine their contributions and identify existing gaps. It is mainly to help understand the concepts that are used in this study to be able to address the research questions. The literature engages with the following subtopics: LS curriculum imperatives, how both teachers and learners perceive LS and ICT integration, and how that affects the performance in the subject, ICT integration into teaching and learning, ICT integration in South Africa, ICT integration challenges in South Africa, media forms, and ICT affordances and its pedagogical value. This literature was drawn mainly to advance the argument that ICT integration does not occur in isolation (Ramorola, 2010) and requires sound pedagogical underpinning. The selection of the literature for this study was motivated by the global spread and uses of ICT in different contexts, locally and internationally. The review also includes the conceptual framework that provides insights into what may enable the successful integration of ICTs.

2.2 PEDAGOGIES EXPLAINED

The term pedagogy in this study refers to the strategies that are employed by teachers in classroom teaching (Syfers, 2010). Pedagogy can be defined as a combination of different forms of interaction between the teacher, learners and knowledge (Czemiewicz, Ravjee, & Mlitwa, 2006). There are various pedagogies that teachers can employ to enhance learners' understanding of the subject matter as well as facilitate learning more generally. The use of ICTs can bridge the gap between concepts that are not easy to see and comprehend (Watson, 2001). Science teaching is rooted in two differing approaches, namely deductive and inductive

(Syfers, 2010). These [1]approaches are discussed in section 3.8. It is at the teacher's discretion to understand their context and adapt a suitable pedagogy. The pedagogical value is only realized when the learners' understanding is enhanced. The following section will discuss the curriculum imperatives that can also provide guidelines to inform various pedagogies.

2.3 LIFE SCIENCES CURRICULUM IMPERATIVES

The National Curriculum Statement (NCS)—the CAPS document for LS—focuses on the development of skills, construction of knowledge, and the relationship between science, society, and the environment (DBE, 2004). The nature of the LS curriculum follows a cognitivist, and pragmatic learning approach (DBE, 2004). A pragmatist theory is based on observable practical consequences rather than anything metaphysical (Sharma, Devi, & Kumari, 2018). LS curriculum conforms to the tenants of the nature of science (NOS) based on being tentative, empirical, subjective, involving human inferences, imagination, and creativity (Ramnarain & Padayachee, 2015). LS contributes to many fields pertaining to nature and the well-being of human beings, such as health science, microbiology, nature conservation and other related fields.

Most scientific knowledge is formed from hypothesis testing. This is achieved through different scientific inquiries that follow specific procedures. The intent here is to base their understanding on something observable. Learners should not just receive knowledge passively, but actively engage in social activity to learn (Moll, 2010). Their involvement in practical activities is aligned with pragmatist approaches because of the physical evidence through active participation. Moreover, when learners engage in practical activities, they stimulate their mental processes to comprehend what they are doing. This process is explained by cognitive learning theory.

Cognitivist theory of learning is based on the mental processes during learning, such as attention, memory, concept formation and information processes (Yilmaz, 2011). Cognitive models explain how information is conveyed in three stages: sensory memory, short-term memory, and long-term memory (Moll, 2010). These skills are in line with the three specific

[1] Inductive and deductive approach guides the formation of the body of knowledge

aims contained in the LS curriculum statement (DoE, 2004). The three specific aims that guide the planning and conducting of lessons are:

- Specific Aim 1: Knowing Life Sciences (cognitive skill)
- Specific Aim 2: Investigating Phenomena in Life Sciences (practical skill)
- Specific Aim 3: Appreciating and Understanding the History, Importance, and Applications of Life Sciences in Society (cognitive and practical skill)

Furthermore, to briefly explain the specific aims, the DBE Life Sciences CAPS document (DBE, 2004, p. 14), asserts that learners should acquire these cognitive and practical skills as follows:

1) "In the process of acquiring knowledge learners must: access information from a variety of sources, select key ideas, recall facts; and describe concepts, processes, phenomena, mechanisms, principles, theories, laws, and models in Life Sciences.
2) In the process of making meaning and achieving understanding learners must: build a conceptual framework of science ideas. Organize or reorganize knowledge to derive new meaning. Write summaries through charts and diagrams.
3) Apply Knowledge on Life Sciences in New and Unfamiliar Contexts Learners must be able to: use information in a new way; and apply knowledge to new and unfamiliar contexts.
4) Analyze, Evaluate and Synthesize Scientific Knowledge, Concepts and Ideas in the process of learning science, learners must be able to analyze information/data."

These skills align with Bloom's Taxonomy as stipulated in the LS curriculum (De Beer, Gravett, & Du Plessis, 2015). The taxonomy comprises the following six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation (Mahmud, Yaacob, Ching, Ismail, & Ramachandiran, 2019). These skills promote the development of learning that happens when learning is successful. Teaching and learning are not automatic and independent. There are factors in play that determine the effectiveness of these processes in theory and in practical learning. These factors affect the majority of learners who achieve 30% in the LS results and will be discussed in the section that follows.

2.4 CHALLENGES WITH TEACHING AND LEARNING LIFE SCIENCES

Several factors contribute to the poor performance in LS (Naidoo, 2017). One of the factors that contributes to the poor performance in LS is the beliefs that LS teachers have towards how they teach the subject. This affects the teachers' motivation and ultimately the learners' impetus to learn the subject. In a study by Naidoo (2017), the learners' responses from the interviews highlighted that LS constantly failed to excite and attract students to choose the subject because it was taught often as rote memorization of complex and meaningless facts. In the same study, the learners suggested that the content be embedded in a meaningful context as seen from their points of view (Naidoo, 2017).

Learning that is not meaningful has a high possibility of rote memory and being inapplicable in life contexts. In this case, learners are forced to memorize the content without any practical implications considered. This results in the contradiction of the nature of the subject as mentioned in the previous section. The grade 12 LS syllabus contains various topics, and some might be controversial. One of the controversial topics is 'Evolution'. Studies have revealed that some teachers and learners find it hard to accept evolution because of their religious beliefs (Chinsamy & Plagányi, 2008; Sanders, 2010). In the study by Naidoo (2017), 'evolution' had the highest non-relevance frequency. It is the teacher's responsibility to be neutral (or at the very least convey a nuanced understanding) when teaching such topics to the learners. Other topics like mitosis, plant hormones, and reproductive mechanism in animals were found boring by learners to learn (Naidoo, 2017). Learners find LS uninteresting if they perceive the subject matter to be boring (DeWet & Osborne, 2008). Teachers will then struggle to teach learners in this context.

Some schools do not have access to a working laboratory for scientific experiments. However, the use of videos that can be projected in class for the learners can make up for the unavailability of laboratory resources. For example, in one of the schools that participated in an ICT integration study, a physical sciences teacher wanted to use a projector in a laboratory; but there was light entering the class through the windows because of the absence of blinds (Ndlovu, 2015). Consequently, the process of effective teaching and learning was disturbed. Moreover, the pedagogy used by participating teachers followed a particular sequence and was perceived as a challenge to the learners (Naidoo, 2017). This study focuses on the pedagogy that integrates ICT into LS teaching as an attempt to enhance learners'

understanding of the subject. I argue that when integrating ICTs in the teaching and learning of LS, pedagogical considerations must drive the use of the technologies. The next section discusses teachers' perceptions of LS.

2.5 TEACHERS' PERCEPTIONS TOWARDS LS AND ICT INTEGRATION

Teacher perception is another important factor to consider in the teaching and learning of LS. Merriam-Webster (2023) online dictionary defines perception as the way in which people think or are aware of someone or something. Perception can be regarded as an internal factor (Fu, 2013). The way in which teachers perceive LS creates a foundation that determines the learners' understanding. The research findings from the study conducted by Naidoo (2017) revealed that teachers experience challenges that impede the successful implementation of the Life Sciences curriculum. Consequently, teachers' attitude towards the subject was filled with negativity. Teachers' pedagogical beliefs about the subject teaching and learner needs, may influence their teaching of the subject with ICTs, amidst other institutional barriers (Ndlovu, 2015). Research findings by Cleaves (2005) also revealed that there is a link between finding the subject boring and perceiving it to be difficult and teacher perceptions play a role in both how it is presented by teachers and taken up by learners.

There is a concern that curriculum developers design the curriculum without consulting or involving teachers (Naidoo, 2017). The same teachers who are not considered in the planning are expected to implement the curriculum at the ground level as learning area specialists. Teachers carry a significant role in curriculum development and collaboration is thus key. However, teachers are given little attention, if any, in curriculum development (Carl, 2005). It becomes a challenge for teachers to implement a curriculum that they do not fully understand and relate to. Research findings show that problems regarding the credibility of curriculum implementation could arise if teachers perceive the curricula to be imposed upon them by the authorities as "top-down" by those who are not well informed (Naidoo, 2017, p. 195).

In addition, a lack of confidence discourages teachers from trying new tools that can enhance learning (Ndlovu & Lawrence, 2012). Similarly, Chien, Wu and Hsu (2014) as cited in Ghavifekr and Rosdy (2015) found that barriers to ICT integration in the classroom include confidence, competence and attitudes of teachers. In LS for instance, a tool like Vell – Virtual Cell

Modelling & Analysis Software would need teachers to familiarize themselves with how the tool works before introducing it to learners (Vcell, 2021). These are tools that can be used by teachers for interactive digital teaching and learning. Moreover, software that can be used by teachers in an ICT classroom also includes 'Kahoot' for interactive assessment (Kahoot, 2021). The knowledge of how to use these tools to enhance learning in LS is dependent on how the teachers perceive the subject. Again, it is the pedagogical considerations that should drive the use of the tool.

In a study that was conducted by Okwara (2016) based on Life Sciences teachers, it was found that negative beliefs and perceptions of the teachers towards the changing of the curriculum, inadequate content knowledge, ambiguous curriculum language, non-adherence to curriculum policy on assessment and planning, will negatively influence the teachers' attitudes towards curriculum change and their classroom practices. Factors such as adequate content knowledge, curriculum materials that are easy to comprehend and interpret as well as curriculum content pertaining to the learners' everyday lives will positively influence the teachers' attitudes and practices (Okwara, 2016, pp. 74-85). Na-Allah (2019) posited that teachers believe that ICT is beneficial to teaching because it is flexible, enhances teaching and learning, saves time, and is interactive. This is an indication that teachers' perceptions play an important role that influences how learners view LS and can affect how they perform. These perceptions also influence the way teachers integrate ICTs into teaching (Ertmer, 1999).

2.6 ICT INTEGRATION INTO TEACHING AND LEARNING

According to Ghavifekr and Rosdy (2015), ICT integration refers to the use of computer-based devices that can be incorporated into the classroom instruction process. ICT can be integrated across all school subjects depending on the teacher's preference for the teaching methods and resources. The use of ICT in education is one way through which learner achievement can be enhanced (Mwanda, Mwanda, Midigo, & Maundu, 2017).

ICT has been adopted internationally by other countries with the belief that it will augment the effectiveness of science teaching and learning (Simon, 2014). In the Netherlands, ICT is ubiquitous, making it easily accessible for familiarity and effective use (Law & Chow, 2006). ICT integration is a potential aid to the teaching and learning process for improvement,

provided that good, sound pedagogical principles are used. However, if the nature and potential of ICTs are not understood by teachers, the whole initiative leads to a fruitless outcome.

In a comparative study conducted by Howie and Blignaut (2009) based on the methods used to prepare teachers for ICT integration, it was found that teachers in Thailand relied more on professional journals for information than other sources. These case studies revealed the factors that determine the success or failure of ICT integration in education at an international level. In Slovenia, it was found that many teachers still do not use ICT in their lessons, and there is little evidence about teachers who claim to use ICT in their science classrooms (Ferk Savec, 2017), especially in developing countries.

The integration of ICT is not at the same level in third-world countries due to various reasons. In Namibia ICT integration in classrooms remains limited (Simon, 2014). Studies have also revealed that the teaching of science with ICT in Namibia has been a challenge (Simon, 2014). The country came up with initiatives to capacitate teachers with ICT skills and integration skills. However, some challenges were encountered because lecturers at the Teacher Training Colleges were not being trained in ICT and thus lacked the expertise to train the teachers (Simon, 2014). In Zimbabwe, ICT integration in 2013 was still segmented into public schools and private schools (Ndawi, Thomas, & Nyaruwata, 2013). The division brought about inequalities in terms of ICT resources, resulting in private schools having access to ICT resources while public schools are disadvantaged (Ndawi et al., 2013). However, teachers in private schools had a clear sense of direction on how to use ICTs to enhance teaching and learning (Ndawi et al., 2013) as is the case in South Africa. This reveals that ICT integration is at different levels in South Africa and some of the neighbouring countries. These inequalities have direct implications for ICT integration.

2.7 ICT INTEGRATION AND CHALLENGES IN SOUTH AFRICA

The Department of Basic Education in South Africa acknowledges the importance of ICT in education. According to the then Minister of the Department of Education, Naledi Pandor, in the White Paper 7 (DBE, 2004, p.6), “Digital media has revolutionised the information society and advances in ICTs have dramatically changed the learning and teaching process”. She

further alluded that "…many schools are exploiting the benefits of ICTs to enhance the quality of teaching and learning" (DBE, 2004, p.6).

The Department of Education has initiatives that are in place to capacitate educators with the necessary basic ICT knowledge and skills (Ndlovu, 2015). There is indeed a need for teachers to develop the necessary skills that can enable them to design learning activities that will enhance learning abilities with the new teaching tools and have the appropriate knowledge to integrate them into their teaching (Ndlovu & Lawrence, 2012). The initiatives involve training workshops on the use of ICT.

The Professional Development Framework for Digital Learning (PDFDL) is also an initiative that is aimed at: "describing the professional development for digital learning in an education system that seeks to improve access, quality, equity, redress and efficiency" (DoE, 2020). The framework addresses strategies that are in place and teacher competencies needed for the implementation of ICT in South African schools. This framework follows a directive in the White Paper 7 to train both in-service and pre-service teachers' ICT uses to address legal and ethical issues, evaluation of software, and the use of ICTs to address learners who experience barriers to learning (DBE, 2004).

The Gauteng Department of Education Member of the Executive Council (MEC), Panyaza Lesufi initiated the notion that all schools should have connectivity, e-learning solutions, and information and communication technology (ICT) in 2015 and moving forward (Bangani, 2021). This project is still in progress to ensure that there is proper ICT infrastructure in schools. The infrastructure supports ICT integration and makes it possible to experience its affordances. However, there are some other factors that can pose challenges to ICT integration besides the infrastructure.

While the implementation is still in progress, evidence from the literature has proven that certain schools in South African townships still experience ICT integration at a lower level (Ndlovu, 2015). There are challenges that are faced by teachers regarding the implementation of ICT in the classroom. The main challenge that is at the centre of teaching and learning is the pedagogy that can be used in the implementation of ICT that is not addressed by the

education policies (Ndlovu, 2015). It is important for teachers to have knowledge of how to integrate ICT in the area of specialization. Research findings show that the initiative for teacher ICT training and basic computer skills is inadequate (Ndlovu & Lawrence, 2012). This is deduced from the fact that teachers cannot go beyond the basic administrative utilization of computers, i.e., typing lesson plans, question papers, and other tasks (Ndlovu & Lawrence, 2012). Jamalahdin (2017) as cited in Khalo (2020) argues that equipping LS teachers with ICT-related skills and affirming the use of these tools can enhance the learners' academic performance in LS. The effectiveness of ICT teacher training initiatives can be challenged if it fails to capacitate teachers with adequate ICT skills that can help them improve their practice.

Infrastructure has also proven to be a hindrance to the implementation of ICT in some South African township schools (Khalo, 2020). The unavailability of laboratory resources can be compensated by videos which can be projected in class for the learners (Ndlovu, 2015). The example cited earlier about the importance of blinds or consideration of light entering the room, is key. Hence there is a need for proper infrastructure to ensure the successful implementation of ICTs. Otherwise, the use of PowerPoint presentations without blinds to cover the light is pointless.

Even after upskilling the educators on the integration of ICT in teaching Mathematics and Sciences, the results revealed that 50 (86.2%) of the teachers did not use ICTs (Mofokeng & Mji, 2010). Even though there can be ICTs available, they are as good as the teacher that uses them (Ndlovu, 2015), as well as the pedagogy that underpins them. As schools face these challenges the process of effective teaching and learning is disturbed to the detriment of learner performance in LS. The following section discusses ICT affordances.

2.8 ICT AFFORDANCES

The term affordance in this context refers to the abilities and benefits that lie within the use of ICT. ICT refers to modern smart digital technologies like computers and smartphones which can improve lives in various ways (Na-Allah, 2019). It is crucial to note that there is a wide array of ICTs that can be used to enhance the teaching and learning process. ICT use can enable lessons that are effective, relevant, authentic, and practical for learners, while it can also improve communication in learning (Na-Allah, 2019). Ndlovu and Lawrence (2012)

denote that quality use of ICTs is what promotes the development of cognitive levels and that leads to the enhancement of learning, and this compliments the specific aims stipulated in the LS CAPS document. Conole and Dayke (2004) developed a taxonomy of ICT affordances, which includes: accessibility, speed of change, diversity, communication, and collaboration reflections, multimodal and non-linear, risk fragility and uncertainty, immediacy, monopolization, and surveillance. These proposed taxonomies of ICT affordances can be used in a number of ways (Conole & Dyke, 2004). The affordances will depend on the ICTs which is selected by the teachers. It is at the teacher's discretion to understand the affordance that lies within each one of these ICTs before using it in the classroom. Ndlovu (2015) denotes that education policies do not overtly disclose how ICT affordances should be used to bring value to the teaching and learning process, and this is the challenge that teachers are faced with. This assertion is supported by Majumdar (2006) with these words; "*While literature provides some evidence of the effectiveness of using ICT in technical considerations, little is known about which learning strategies and pedagogical framework should be used for education and training"* (Majumdar, 2006, p. 1). Therefore, this study seeks to reveal how ICTs can be used in the classroom to enhance learners' understanding of LS. The next section discusses Laurillard's media forms.

2.9 LAURILLARD'S MEDIA FORMS

The media forms proposed by Laurillard (2002) provide a description of how the combination of media can produce better coverage in a given learning context. The different forms of media are narrative, interactive, adaptive, communicative, and productive (Laurillard, 2002). Each of the media forms is associated with a particular affordance. The actual use of media can be categorized within these media forms according to how and when it is being utilized. Narrative media forms are used when the teacher wants to explain a concept or present subject content (Ndlovu, 2015). The interactive media form can be used to induce learner participation in the lesson (Laurillard, 2002). Adaptive media forms allow suitable change when using ICTs to accommodate the user. To enable platforms for discussing concepts, the communicative media form is suitable for that (Ndlovu, 2015). Productive media forms can be used when learners want to express their conception (Ndlovu, 2015). For instance, if the teacher decides to use a smartboard to teach a particular topic, he or she must know the way in which the use of a smartboard will enhance the learners' understanding of that topic. The

use of ICT in teaching LS involves the use of media forms to enhance the learners' understanding. The media forms will be used in this study as a way of revealing the pedagogical value of ICT in teaching and learning. To illustrate the assumed relationship between understanding the use of ICT and enhancement of learning a conceptual framework will be discussed in the following section.

2.10 CONCEPTUAL FRAMEWORK

The conceptual framework for this study is based on the idea that LS is grounded in cognitivism and pragmatism as discussed in section 2.1. The CAPS-specific aims for LS are cognitively and practically centred. The use of ICTs in LS teaching should strive to fulfil these aims. The premise within this conceptual framework is that the use of ICTs will enhance the learners' understanding of LS. The exploration in this context is to identify how ICTs are used to enhance learning.

The literature that has been explored in this study reveals the following concepts that contribute to the framework, namely: perception, media forms, affordances, and the pedagogical value which is determined by the desired LS curriculum, cognitive and practical skills learners should display as evidence that learning is enhanced (Ertmer, 1999; DoE, 2011; Ndlovu, 2015; Laurillard, 2002). Therefore, having a positive perception and an understanding of the use of ICTs (media forms and their affordance) should reveal its pedagogical value based on how it enhances the learners' cognitive and practical skills. The following diagram illustrates the concepts that will be studied:

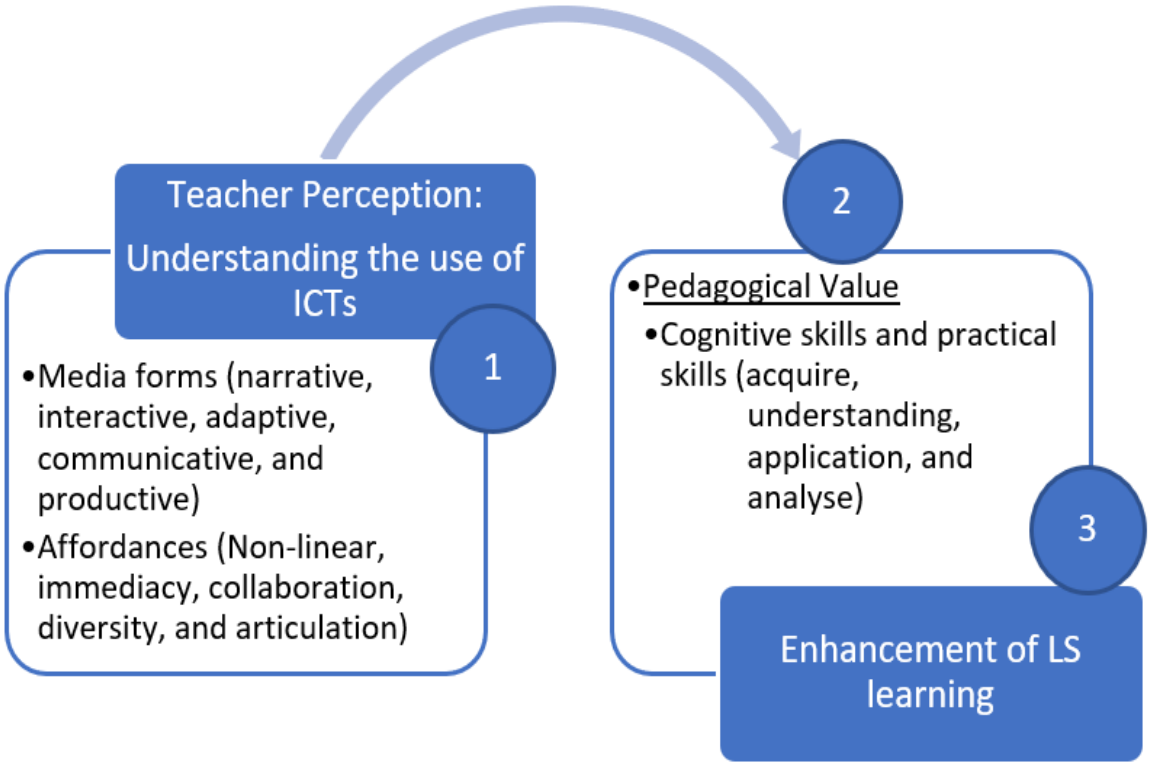


Figure 2: Conceptual framework of the study.

Figure 2 illustrates how these concepts can influence each other to enhance the learners' understanding of LS. This was deduced from previous studies by (Khalo, 2020; Ndlovu & Lawrence, 2012; Silviyanti & Yusuf, 2015), to name a few. For the present study, the identified gap in this research is to explore how ICTs can be used to enhance teaching and learning in LS.

2.11 CONCLUSION

This chapter provided an overview of the literature from previous studies. The literature included different aspects that are related to the research topic. These aspects were selected with the motivation to understand what could affect the use of ICT in LS teaching positively and negatively. Different factors that were discussed provided insight into the research topic. The sub-topics were LS curriculum imperatives, factors causing minimum LS results, learners' perceptions towards LS, teachers' perceptions towards LS and ICT integration, ICT integration into teaching and learning, ICT integration in South Africa, ICT integration challenges in South Africa, ICT affordances, and the conceptual framework for the study.

CHAPTER 3: RESEARCH DESIGN

3.1 INTRODUCTION

The aim of this section was to establish the research design to map out the data collection process. A research design entails aspects that provide the bases and guidance for the data collection process (Merriam, 1998). This section deals with the research design, sample size and site, who the research participants were, how data was collected using instruments, and what data collection looked like under lockdown conditions, amongst others. These aspects and their descriptions are encapsulated in Table 3.

Table 3: Research design.

Aspects	Type
Research paradigm:	Interpretivism
Research design:	Qualitative
Sample:	Targeted sampling method
Sites:	Two ICT integrated schools in Johannesburg north
Participants:	Grade 10, 11, and 12 Life Sciences ICT competent teachers
Data collection instruments:	Teacher Interviews and lesson observation
Data collection under Lockdown restrictions:	Interviews: telephonically or via Microsoft Teams (MS Teams) Lesson observation: Microsoft Teams
Data analysis:	Thematic analysis
Validity and reliability	ICT LS competent teacher Using the same tools and procedure
Research ethics	Consent, anonymity, right to withdraw (Protocol number: H21/07/20)

Sections 3.2 to 3.10 provides detailed accounts of the various research design elements.

3.2 RESEARCH PARADIGM

It is important to establish a research paradigm for the sake of illustrating the researcher's way of thinking. Agherdien, Henning and Van der Westhuizen (2007) argue that a researcher situates a study in a particular paradigm to inform subsequent choices in respect of methodological choices/methods, literature to be drawn from, and research design to be employed. This study used the interpretivist research paradigm. According to Rehman and Alharthi (2016), an interpretivist research paradigm is based on the notion that there are socially constructed multiple realities. In this research paradigm, truth and reality are created and not discovered (Rehman & Alharthi, 2016). In the present study, reality and truth will be created through the pedagogies implemented by the teachers during their lesson presentations. It is worth noting that realities will be created because the curriculum is objective and implemented within a social setting, involving the teachers' perceptions. Therefore, the interpretivist research paradigm is the most appropriate approach for the data collected in this study and the analysis. The next section unpacks the research design employed in this study.

3.3 RESEARCH DESIGN: QUALITATIVE

Research design is defined by Leedy (1997) as a plan that shows the framework that was used to collect data. The plan involved research sites, selecting subjects, and data collecting procedures that should assist in answering the research question (MacMillan & Schumacher, 2001). Qualitative research focuses on understanding, describing, explaining human perceptions, behaviour, attitude, actions, and values (Cresswell, 2011). Therefore, using the qualitative method enabled a deeper understanding of the idea pertaining to the use of ICT in LS teaching for the enhancement of learning. Furthermore, this approach is motivated by the curiosity about the affordance of ICT in LS to enhance learners' understanding. The data collection process was guided by a strategy of inquiry that will be discussed in the section that follows.

3.4 SAMPLE SIZE, SITES, AND PARTICIPANTS

In a qualitative study, researchers study few people but delve deeper into the subject to provide explanations of various phenomena (Baker & Edwards, 2012). Thus, depth is valued

and not so much breadth. Due to the qualitative nature of the study, a targeted and purposive sampling method was used. The target was based on the availability and use of ICTs, schools having FET grades 10, 11 and 12, and LS teachers. The sample size was limited to enable qualitative data collection and analysis. The sample was targeted purposively to help address the research questions based on the ICT availability and the usage thereof.

The targeted schools had ICTs and taught LS as an FET subject. The sampling was to allow convenient analysis for the researcher and conclusions based on the usage of ICT. These schools were in the Johannesburg area. The area in which the schools are situated is in a close radius. The proximity of the schools was motivated by convenient access prior to the intensification of the global pandemic Coronavirus. However, the convenience of location did not matter after changing the mode of data collection from physical to virtual sessions.

The study scope was limited to two targeted schools and three FET LS grades (10, 11 and 12). This sampling method assessed how the use of ICTs in LS teaching enhances learners' understanding. The three grades were chosen to understand how teachers use ICTs for the teaching and learning of LS across the three grades. The sampling was limited to three teachers per school. In total, six LS teachers participated in this study. The teachers (the quantity depended on the school's arrangement) were selected for interviews and lesson observation based on the assumption that they possessed the following qualities:

1. Have knowledge of LS content, (having a university or college qualification in LS),
2. Have knowledge of ICTs and be able to integrate it in their teaching, and
3. Narrative competence (to be able to communicate during the interviews)

An inquiry was done through the two schools' principals based on the criteria. The principals confirmed that the teachers met the criteria. The selection of sample size, sites, and participants was purposeful. Therefore, I needed to select according to the relevance to enable the presentation of data that was most likely to address the research question (Neuman, 2000).

3.5 DATA COLLECTION METHODS

The two data collection methods that were used for this study were teacher interviews and lesson observation. The data collection methods were guided by the purpose of the study which was to explore the use of ICT to enhance learning in LS. The semi-structured interviews allowed for limited data to be collected.

3.5.1 INTERVIEWS

The teacher interviews were used to identify the teachers' perceptions towards the use of ICTs and how integration was done. I conducted semi-structured interviews to avoid directed responses but instead allowed open-ended answers. The open-ended responses allowed me to probe for clarity and greater detail from the participants. The disadvantage of using semi-structured interviews led to some responses not being relevant to the research. Semi-structured interviews allowed the teacher participants to express themselves freely by not providing information that was not addressing the questions being asked (Oates, 2006). In theoretical studies, interviews are used to provide the researcher the liberty to produce evidence to support existing information (Van der Merwer, 1996). Conducting each interview took approximately 15 to 30 minutes. The interview questions were adapted from the Professional Development Framework for Digital Learning (PDFDL) (DBE, 2020). The interview questions related to how teachers maintain the curriculum focus, engage learners in higher-order thinking and interactive activities, make best use of digital tools, find and use digital content, facilitate assessment through digital tools, assess learners' skills and ensure better understanding of the subject content. The questions were used prior to the lesson to assess the standard of the planning and after ICT integrated lesson presentation.

3.5.2 LESSON OBSERVATIONS

The lesson observations were conducted to identify the pedagogical value of ICT (sub-question 1) in enhancing learners' understanding of LS in the classroom. The focus during lesson observations was on the teachers' presentation according to ICT affordances. The advantage of lesson observation was to be able to see the actual use of ICT and how it enhances learners' understanding of LS. The tool was adapted by adding the type of ICTs being used, when the ICTs are used in the lesson, and whether learning is enhanced or not according to the LS CAPS objectives and aims. The addition of these elements was done to assist in the organization of the data. Adapting the analytical tool also assisted with the language used for

this study. The language used in this study must align with the main topic and the research questions. The template (see Table 4) is adapted from the analytical tool developed by Ndlovu (2015):

Table 3.5.2.1: Observation tool.

What ICTs are used? (Computers, Laptops, Smartboard, Smartphones, Overhead projector)	Which Media form do they belong to? (Narrative, Interactive, Communicative, Adaptive or Productive)	When are the ICTs used in the lesson? (Lesson introduction, body of the lesson, summary of the lesson)	What are the ICT affordances used? (Non-linear, Immediacy, Collaboration, Diversity, Articulation)	How are the Affordances used? (Multimodality, Immediate feedback, Discussion: class/ group, Reproduction: experiment/ role play, Product: animation/model)	What pedagogical value does it add? (Does it enhance learning)	Is learning enhanced? (Does it achieve the CAPS objectives, evidence)

The original analytical tool is shown in Table 5

Table 3.5.2.2: Analytical tool developed from Laurillard's media forms and Conole and Dyke's taxonomy of affordances.

Media forms	Affordances	Evidence	What pedagogical value does it add?
Narrative	Non-linear	Multimodality	Apprehending structure/connections
Interactive	Immediacy	Immediate feedback	Exploring: misconceptions amended
Communicative	Collaboration	Discussion: class/group	Re-description of concepts
Adaptive	Diversity	Reproduction: experiment	Concretizing theory: practice
Productive	Articulation	Product: animation/model	Knowledge construction

The unpacking of the analytical tool is done in the data analysis section 3.8.

3.6 DATA COLLECTION PROCESS

The collection of data followed an iterative and sequential method to allow a repetitive and constant way of data collection. Figure 3.6.3.1 illustrates the process by which the data was collected:

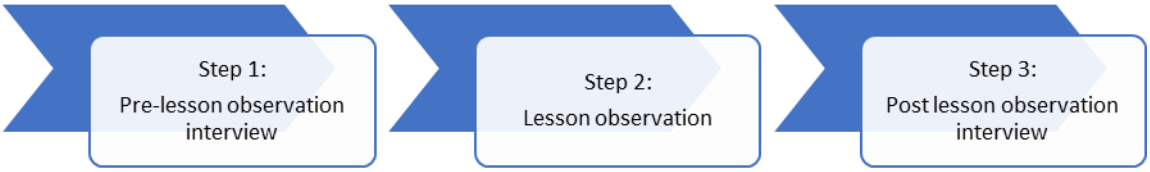


Figure 3: Data collection process used in this study.

Step 1: Pre-lesson observation interviews were conducted with the individual teachers. With the teachers' consent, the interviews were audio-recorded to avoid distortion of information and to allow convenient data analysis. This was necessary to guide the researcher on what plans were in place for the lesson presentation. For instance, this entails the media that will be used for lesson presentation, how it will be used and why.

Step 2: Lessons presented by the selected teachers were observed and video recorded in Microsoft Teams (MS Teams). The observation assisted in exploring the teachers' effective use of ICTs, the learners' participation and understanding of the content presented. Consent to video record the lessons was obtained from the teachers, parents, and the learners.

Step 3: Finally, a post-lesson interview was conducted with the teachers to reflect on what worked and what did not work, why, and how it could be improved for future lessons.

3.7 DATA COLLECTION AND CHALLENGES UNDER LOCKDOWN RESTRICTIONS

The global health crisis of COVID-19 or Coronavirus has brought several restrictions. To adhere to the COVID-19 regulation, data collection was achieved through the use of cell phones and computers for teacher interviews. Lesson observations were conducted through video calls using MS Teams. The actual lesson took place in class with the teachers and learners, and I was observing through the MS Teams video call. It is important to consider the health and

safety of the participants during the duration of the study. There were challenges in the way data was collected through this platform. These challenges will be discussed in Chapter 5 under the limitations of the study.

3.8 DATA ANALYSIS

Data analysis can be defined as the process of systematically searching and arranging the observation notes, interview transcripts, or other non-textual materials that the researcher gathered to increase the comprehension of the research topic (Wong, 2021). The analysis process began at the end of the data collection phase. An inductive thematic analysis was used to analyze the data collected in this research (Cresswell, 2011). Inductive analysis is defined as moving from a specific idea to a more general idea (Trochim, 2022). Contrary to that, deductive analysis can be defined as moving from general to more specific (Trochim, 2022). The analysis was inductive because of the strategy of inquiry that was adopted for this study. The end results were not known, and it was moving from specific to general, enabling the researcher to explore. Thematic analysis method detects ideas from the data collected in a qualitative manner through themes (Guest, Bunce & Johnson, 2006).

The process of identifying themes involved transcribing both the interviews and the lesson presentation as a start. A theme is defined as a result of coding, categorization, or analytic reflection (Billups, 2021). Therefore, the next action was to establish a criterion for the process of coding and grouping from the interview and lesson transcripts. Coding can be seen as an important link between data collection and their explanation of meaning (Charmaz, 2001). Billups (2021) denotes that coding should be understood as a transitional process between data collection and further analysis. The criterion for coding for this study was taken from the analytical tool that was adapted for this study. This criterion from the analytical tool involved the media forms, affordances, and cognitive levels. The possible media forms were narrative, interactive, communicative, adaptive, and productive. The cognitive levels were understanding, acquiring, application, and analysis. Different colours were used to code the data according to the criterion. The colours were allocated in this way, acquire=yellow, understanding=green, application=blue, and analysis=grey. The media forms were noted based on the usage of ICTs to realize its affordance and achieve cognitive skills. This categorization and organization enabled the researcher to identify the themes from the

interview transcripts and the observation transcript in relation to the recorded lessons as it was stated at the beginning of this section. These themes were identified based on intensity across the teacher participants and their relevance to the research topic.

The results were presented in the following manner:

a. Data from the interviews

The first step was to group the teachers' responses according to the questions that relates to the main question and the sub-questions, namely.

- What are the teachers' perceptions regarding the pedagogical value of ICTs in LS teaching?
- What are the pedagogies employed by teachers to integrate ICTs in LS classrooms?
- How does the integration of ICTs by teachers enhance learning in LS?

The interview questions were not asking these questions directly. However, these questions were selected on the basis that they relate to the research questions. According to the nature of this study, this was done to allow me to share my own interpretation of the responses. The framework from which the interview questions were adapted is concerned with professional development of digital learning in the education system and this complements the aim of this study.

The second step was to identify the common responses across the teachers and formulate the themes. The themes were further discussed after the presentation of the research findings. The factor that was considered from the teacher's responses from the transcripts was consistency. The teachers' consistency during the interviews—before and after the lesson presentation—provided insight into their perceptions of the value of ICT in their teaching. Furthermore, this practice was done to understand the outcome of the exploration and provide possible answers to the research questions.

b. Data from the lesson observation

As a reminder, the analytical tool was adapted from Ndlovu (2015) based on Laurillard's (2002) media forms, and ICT affordances by Conole and Dyke (2004) was used in conjunction with the interview questions. The tool comprises four categories: i.e., Media forms,

Affordances, Evidence, and the pedagogical value added (Ndlovu & Moll, 2016). Each of the categories consists of possible descriptions.

During the lesson observation, the four categories were noted with possible descriptions. The four categories and possible description are elucidated to allow convenient analysis. Media forms consist of the following descriptions: narrative, interactive, communicative, adaptive, and productive. The term *Media forms* were discussed in section 2.10. However, the possible descriptions were not discussed, hence it will be unpacked next. Narrative media forms were used to present content in different forms namely, verbal or written that was in a series to illustrate the connection of events for learners. Interactive media forms enable an exchange of information between two or more parties, for example, a laptop and a learner. Communicative media forms enable information to be conveyed. Adaptive media forms allow information to fit and be used in new contexts. Productive media forms allow for the creation of new information (Ndlovu, 2015). Each of these descriptions may characterize different media forms and enable different affordances.

Affordances have been discussed in the literature review under section 2.8, but the evidence and the pedagogical value that they bring will be discussed next. According to the analytical tool as illustrated in *Table 3.5.2.2*, there is a relationship between the media forms, affordances, evidence, and pedagogical value. For example, if the affordance is non-linear, the evidence will be multimodal, and the pedagogical value will be able to apprehend structure or make connections. The relationship between these categories was analyzed in relation to the specific aims stipulated in the CAPS document. It is this relationship between categories that gives rise to themes or what Agherdien et al. (2007, p74) refers to as “mini-findings” or trends.

This approach was to align these media categories with what is regarded as learning according to the LS curriculum. Section 2.1 discussed the specific aims and skills for LS which serve as evidence for learning. The alignment of the CAPS-specific aims with the analytical tool is what distinguishes its adaptation from the original framework. The legitimacy of the pedagogical value of ICT can be aligned to the CAPS document. Table 3.8.1 below presents an example of

the different media forms, when they can be used in conjunction with the specific aim 1, and its affordances:

Table 3.8.1 shows when the different media forms can be used, affordances, and skills under specific aim 1.

Media forms	**Affordances**	**How (ICT) and When (cognitive skills) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear				
Interactive	Immediacy				
Communicative	Collaboration				
Adaptive	Diversity				
Productive	Articulation				

Furthermore, Table 3.8.2 explains when the media forms can be used, and the associated affordances taken from Ndlovu (2015).

Table 3.8.2: The explanation of when the media forms can be used.

Media forms	**When can it be used**	**Affordances**
Narrative	Explain new concepts while interacting with learners and apprehending structure/connections	Non-linear
Interactive	When learners interact with technology or their teacher, and exploring misconceptions, and information	Immediacy
Communicative	When using ICT sending text messages and redescriptions of concepts	Collaboration
Adaptive	When offering formative intrinsic feedback to the user and concretizing theory: practice	Diversity
Productive	When learners create their own products to represent concepts of the world and knowledge construction	Articulation

In Chapter 2, under curriculum imperatives, it was discussed that the specific aims are directed at inculcating various learner skills. For example, specific aim 1 focuses on the following skills: acquiring, understanding, applying and analyzing. Table 3.8.3 illustrates how these skills are described in the CAPS document.

Table 3.8.3: The description of the skills under specific aim 1.

ACQUIRE	UNDERSTANDING	APPLICATION	ANALYSE
Access information from a variety of sources (teachers, reference books, textbooks, internet, experts, peers, parents, etc.); **select** key ideas; **recall** facts; and **describe** concepts, processes, phenomena, mechanisms, principles, theories, laws and models in Life Sciences.	Build a conceptual framework of science **ideas**; **organise** or **reorganise** knowledge to derive new meaning; write summaries; **develop** flow charts, diagrams and mind maps; and **recognise** patterns and trends	Use **information** in a new way; and **apply** knowledge to **new** and unfamiliar contexts	**Analyse** information/data; recognise relationships between existing knowledge and new ideas; **critically** evaluate scientific information; identify assumptions; and categorise information.

Data collected from the lesson observations were thematically grouped under the media forms, skills and affordances as per Table 3.8.1 (Guest, Bunce, & Johnson, 2006). The affordances are dependent on what the media forms can do given a particular activity. The evidence is witnessed from the practical observation of the use of ICT during teaching and learning. The pedagogical value was manifested from the benefits of using digital and non-digital tools for effective teaching and learning (Ndlovu & Moll, 2016). The enhancement of

learning was determined through the learners' ability to demonstrate the cognitive and practical skills as stipulated in the LS CAPS document.

c. Summary of the process

The data collected were analyzed to understand how the teachers' perceptions (sub-question 2) contribute to the way they integrate ICTs in LS teaching (sub-question 3), and how that affects the learners' understanding. The overall analysis was tabulated to identify the prevalent themes gathered from the pre-lesson interview, lesson observation and post-lesson interview data. This data analysis assisted in addressing the main research question and sub-questions.

The summary of how the data was presented is shown Table below:

Table 3.8.4: The steps that were used to present the data.

Data presentation per teacher	Step 1	Step 2	Step 3	Rationale
Data collected from the interviews	√			To identify the teachers' perception towards the pedagogical value of ICTs in their teaching
Data collected from the lesson observation		√		To understand the use of ICTs in LS teaching and learning
Summary of the process			√	To identify the prevalent themes

3.9 CREDIBILITY, TRANFERABILITY, DEPENDABILITY AND CONFIRMABILITY

Dependability in this study focused on the empirical data that was obtained from the results (Korstjens & Moserb, 2018) as provided by the teacher participants The confidence that is placed in the dependability of the results is based on the criteria that were used during the lesson observations and the interviews. The media forms, cognitive and practical skills enabled me to accumulate relevant results. Implementing data triangulation, where data was collected at different times contributed to the credibility of the results (Korstjens & Moserb,

2018). Moreover, the open-ended nature of the interview questions before and after the lesson made it possible for me to probe for clarity from the teacher participants.

The description of the contexts where data was collected contributes to the transferability of the results (Korstjens & Moserb, 2018). Providing information based on the teacher participants' experience with the use of ICTs in their practice and their teaching experience in general forms bases for application in other contexts. Dependability and confirmability are achieved from the audit trail outlining the start of the research until the end when findings were presented (Korstjens & Moserb, 2018). This was also achieved through an objective reality approach (Stahl & King, 2020). This approach promotes that the results can allow flexible interpretations apart from my own.

3.10 RESEARCH ETHICS

Research ethics are moral principles that guide researchers on how to conduct research and report findings while protecting and maintaining the rights, and dignity of participants, members of the society at large, and the environment, whether they are aware or not (Kruger, Ndebele, & Horn, 2014). To ensure that the participants are protected, there was a consent form to be completed by the participants. The consent form explained the nature of the research (involving voice and video recordings of the teachers) and what they were expected to do. Confidentiality and anonymity as the principles of the research ethics were assured to the participant (Strydom & Venter, 2002). The participants were informed about their rights to withdraw at any point during the study. Permission was attained from the relevant stakeholders prior to conducting the research in this order; the University of the Witwatersrand research office (protocol number: H21/07/20), the Gauteng Department of Education (GDE), the school principal, the teachers, and the parents, were necessary. It was important to attain permission before conducting the research from the relevant stakeholders to ensure that participants did not feel compelled to participate. Respect was shown to the participants to ensure that their dignity was maintained throughout the research process.

3.11 CONCLUSION

This chapter gave an overview of the research design outlining the steps that were followed for the data collection process. The next section discusses the findings that were obtained from the use of ICTs to enhance learning in LS.

CHAPTER 4: RESEARCH DATA AND ANALYSIS

4.1 INTRODUCTION

The research data were obtained during the data collection process (Cresswell & Plano Clark, 2007). The gathered data were organized and categorized according to the steps illustrated in Table 3.8.1 in chapter 3. All teachers in this study teach LS in the FET Phase and have teaching experience of between 5 and 10 years. The table below provides a list of the LS teacher participants, the grades they teach and their teaching experience.

Table 10: The teaching experience of the teachers and their grades for schools A and B.

Schools	Teachers	Grade	Teaching experience
School A	R	10	More than 10 years teaching experience (4 years with ICT)
	S	11	Less than 5 years teaching experience (2 years with ICT)
	Q	12	Less than 5 years teaching experience (2 years with ICT)
School B	X	10	Less than 5 years teaching experience (2 years with ICT)
	Y	11	More than 10 years teaching experience (4 years with ICT)
	Z	12	More than 10 years teaching experience (4 years with ICT)

All teachers in this study have 2 – 4 years' experience teaching LS with ICTs. They therefore could provide this study with an understanding of how ICTs could be used to teach LS based on their experiences. Results from teacher interviews and observations are presented by school as follows:

4. 2 INTERVIEWS AND OBSERVATIONS FOR TEACHERS IN SCHOOL A

GRADE 10: TEACHER R

Teacher R is one of the most experienced teachers in School A in teaching LS and using ICTs in his practice. He perceives ICTs as valuable educational tools in the teaching of LS and understands how the technologies he uses enhance teaching and learning. The ICT tool that was used by teacher R was the smartboard.

STEP 1: TEACHER'S RESPONSES FROM THE INTERVIEW BEFORE THE LESSON PRESENTATION

Teacher R believes that learners learn LS better when visual aids are used. Visual aids in his context are the pictures that can be displayed on the smartboard. His conviction on the value of visual aids was demonstrated in his responses where he repeatedly mentioned the word 'see', ten times. In addition, the teacher believes that learners can remember if they have seen a visual representation of the object or concept about which they are learning. The teacher elaborated,

> *… we also prepare pictures, so that they actually see and even the PowerPoint somewhere you have to make sure that they get the information.*

The teacher used multimedia in the PowerPoint presentations and that confirms his use of the technology as a narrative media form. This enriched his explanation of new concepts to the learners while interacting with them as he taught. This use of the media form is in line with the non-linear affordance which the teacher employed by integrating interaction with learners through questions. This is evident from the following response:

> *"Obviously is to interact with them properly so that each and every learner has to participate…"*

In his example of how he uses ICTs, Teacher R said he displays pictures of different diseases associated with the skeletal system on the smartboard so that the learners can grasp the information. In this case, the teacher wanted to create an environment where all learners could participate.

As the teacher and learners interact, there is an affordance of immediacy. The immediate feedback enables the learners to receive answers on time and this promotes learning as their questions are addressed immediately. Moreover, the interactive media form was observed based on the nature of communication between the teacher and the learners. The question-and-answer session was supposed to happen in an interactive manner.

When the narrative media form is used to present knowledge, the skill that is developed is the ability to acquire knowledge as indicated in the LS curriculum (DoE, 2011). It is stipulated in the CAPS document that for learners to acquire knowledge they should access information from a variety of sources (like teachers, digital technology, and different internet resources). Teacher R believed that the choice of media and the approach to deliver the content promotes interaction and participation of all learners to enhance the learners' understanding. For instance, he explained that the smartboard can project information in different representations for the learners. In his emphasis on the suitability of the media, he said,

> *I am hundred percent sure that they will, they will understand it. Because, as I am saying, they gonna see the things. It's not like they think about it, but will see it, they will have to, yah, let me say they experience it.*

The technology used the smartboard affordances enable this visibility of images and written text - the representation of concepts. Beyond benefiting from learning through seeing as indicated earlier, the teacher regarded the use of the smartboard affordance to display pictures as of value for giving them an authentic learning experience. The narrative media form complements how the ICTs were going to be used to equip learners with skills. The analytical skill was noted from the following quote.

> *… asking them questions, asking them ideas, their own ideas. And then by so doing I think it will open up their mind.*

According to the teacher's response, this statement conforms to the description of the communicative media form in the analytical tool because it speaks about sharing ideas and collaboration as evidence. The argument in this context is that if learners are able to demonstrate critical thinking skills that involve sharing ideas about the content, then they would have acquired analytical skills.

The responses given by teacher R from the interview are summarized in Table 11.

Table 11: Teacher R interview responses.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	Learners seeing the information	Learners' interaction and participation increases the likelihood of comprehending the content		Learners being able to think critically and evaluate scientific information
Interactive	Immediacy	Teacher and learners asking questions	Learners asking questions and seeking understanding, bring their ideas, showing interest		Immediate feedback to address any misconceptions and adapt conceptions

STEP 2: LESSON OBSERVATION RESULTS

Topic: Diseases associated with the skeletal system

The affordances that were observed from the media forms are non-linearity and immediacy. For instance, a PowerPoint presentation was used to display images of the various skeletal diseases for the learners to *see* as the teacher alluded earlier in the interview. This was observed as he explained the leg in the following extract:

If you look at this leg here.

That's how you'd look like

…if you check here. I want us to check here

This one is the one that is affected

As you can see.

…you don't see the blood

These quotations indicate that the teacher's aim was to enable the learners to *see* different types of diseases. Teacher R repeatedly invited the learners about eight times to *see* the images on the smartboards as the lesson progressed. The images enabled the learners to *see* what each of the diseases look like. The approach of using the smartboard to display the images was a digital representation that is similar to using a normal paper poster. The advantage, in this case, was that time was saved by changing slides to illustrate the various diseases.

Secondly, the interactive media form was facilitated when the learners were asking questions. This is evident from the following quotation about disease prevention:

Sir, how do you prevent it?

As this type of interaction continued as learners asked questions and teacher R provided answers and vice versa, the analytical skill was at play. Although the immediacy affordance was engaged as the teacher was providing answers to the learners, this was done through the classroom conversation. The learners were able to *see* the difference between affected legs and healthy ones. The image below is a screenshot showing the smartboard and the picture of arthritis.

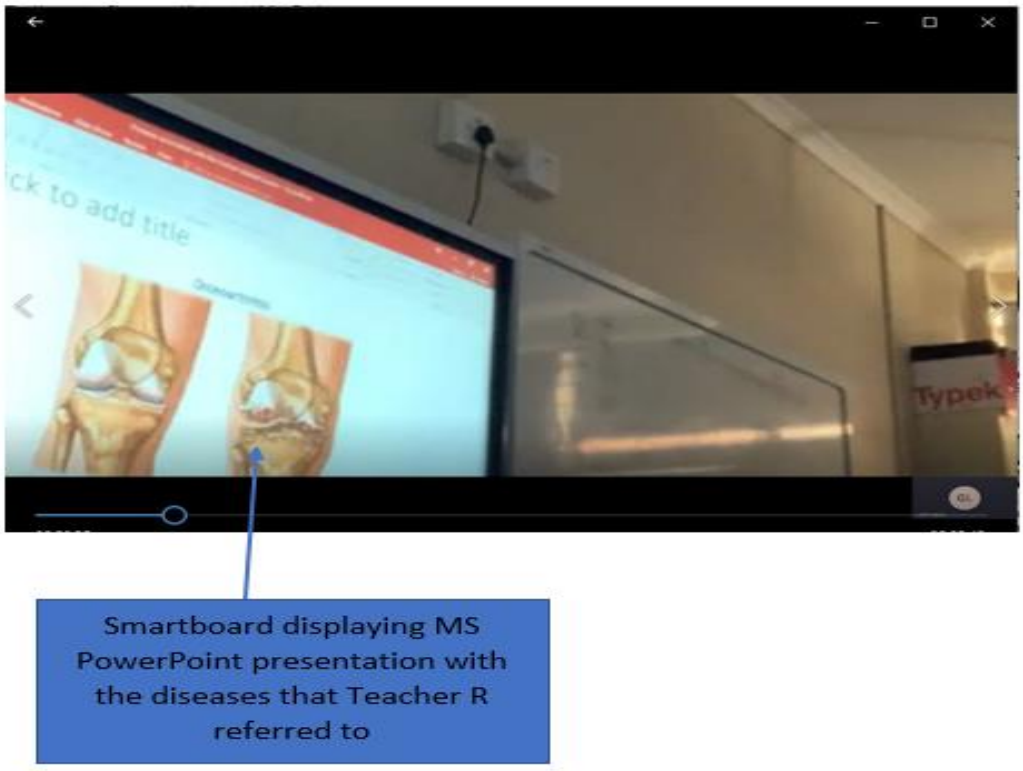


Figure 4: Teacher R's lesson.

The pedagogical value was realized from the use of the narrative and immediacy media forms as cognitive skills, acquire, understand, and analyze. Table 12 illustrates the summary of the results obtained from the lesson observation:

Table 12: Summary of the interview responses.

Media forms	**Observed Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear:	Accessing information on the smartboard through pictures	Seeing how it looks and how it all works		Seeing enabled them to be inquisitive and thus interact with the teacher through question and answer
Interactive	Immediacy:				Learners asking questions regarding the prevention of the diseases of the skeletal system

The following section presents the teachers' responses to the questions after the lesson presentation.

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

The use of ICTs in this lesson is narrative because the teacher used the smartboard to display pictures of the diseases associated with the skeletal system. Teacher R referred to the pictures to explain the various diseases. Teacher R explained,

> *… we actually used the, we were actually scrolling through the pictures, they see, and then they see what is exactly happening. Because what is in that digital is real, is not just, uhm things that eh, like uh, fiction, its real.*

It is evident from the above quote that teacher R attempted to present an authentic lesson through the use of real pictures (Lombardi, 2007). Teacher R claims that this approach was intended to provoke the learners' interest in the lesson. The non-linear use of the PowerPoint presentation to move back and forth from one picture to another created an interactive lesson which led to learner.

The interactive media form was also noted in the teachers' responses. This was observed from the following quote.

> *… as we have been using this and then they see this, and then asking questions, and then also them asking me questions.*

There was immediacy through the question-and-answer process and learners were getting the information in real-time. The visuals brought curiosity among the learners, seeking to know more. The learners might have seen somebody that has a similar disease but did not know the name of the disease. The teacher added,

> *Uhm, we actually used the, we were actually scrolling through the pictures, they see, and then they see what is exactly happening. Because what is in that digital is real, is not just, uhm things that eh, like uh, fiction, its real.*

Learners were able to access information that was provided by their teacher. The teacher believes that learners will be able to describe the different diseases if they were able to see pictures of how it affects the body. The following quote indicates how the information that

was provided by the teacher enabled knowledge acquisition beyond the curriculum objectives:

> *… they are willing to learn more than the content itself.*

Teacher R claimed that the learners were able to understand the content and this was enabled by the interaction between him and the learners facilitated by what they saw. There was no written assessment to validate the teacher's observations; however, the teacher argued,

> *They understood. Yeah, they understood. And then uhm, they, they were actually I could see that actually interested.*
>
> *As the they have seen, as we have been using this and then they see this, and then asking questions, and then also them asking me questions. That's where I have seen that we have actually, uhm, engage with them properly, so that they actually understand the lesson properly.*
>
> *Because learners they have understood it, and then now they could see that it has changed their mindset and then they can able to see exactly what's happening in that topic.*

This explanation points to the adaptive media where learner diversity is catered for and they are all able to concretize concepts.

Teacher R explained that learners should be able to apply the knowledge in their daily lives. This is an indication that they have acquired a skill that is relevant to their lives. The curriculum expects learners to relate the content to their lives. The skill of learners being able to apply knowledge in new contexts is taken from the following responses by teacher R.

> *… because you could see that, like the question they asked me; how, how can I do if.*
>
> *… And then they want to apply it later…*
>
> *… but the things that they gonna apply in their daily lives.*
>
> *Ok, if things are like this, according to the information that I have gathered, we use this, and this, and this, and helping other people.*

The above responses illustrate the effectiveness of the ICTs used in the lesson. Learners were able to ask these questions because they probably seek more information for application in a real-life situation. This skill was acquired in relation to the narrative and interactive media form.

The analytical skill was also drawn from the teacher's responses. It was noted based on the following response by the teacher:

> *… Yeah, they think critically.*

Teacher R believes that learners will be able to critically evaluate scientific information. These are the actions that are associated with the skill of analyzing under specific aim 1.

As the teacher reflected on his teaching in the second interview, he made clear his intentions for his enacted practice and as he did, the adaptive media that facilitated the diversity affordance was added. The teacher argued that this facilitated the learner ability to apply concepts learned in real life.

GRADE 11: TEACHER S

Teacher S had a slightly different approach to his use of ICTs and this was observable in his teaching philosophy that was reflected in his responses to the interview questions below.

STEP 1: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED BEFORE THE LESSON PRESENTATION

The ICT, in this case, the smartboard was used to display an online educational game or quiz called 'Kahoot'. The teacher uses Kahoot in the classroom as follows;

> *… in terms of interactive learning, I use the online tools, such as your 'Kahoot', because Kahoot, as much as the learners call, uh, look at it as a game, but eventually they are learning in the process.*

The learners interact with the smartboard as they learn. The affordance associated with this interactive media form is immediacy. The online educational game has functions for providing immediate feedback for each question. Learners get to see where they went right or wrong and see the correct answer on the smartboard. They also get to understand when their answers are rectified. Another important function that this educational game affords is to display the top five learners that get most of the answers correct and finally the top three at the end of the game. This is supported by the teacher's response as follows.

> *… you know when with Kahoot it displays on the screen the learners who is getting more points and all that. So, that for me it is an informal assessment, but an interesting one. And what I like about it is that each learner is trying to be on top.*

It is evident that teacher S uses ICTs to promote learning through competition among the learners and makes the assessment interesting through Kahoot. While they are playing the game corrections are displayed and as learners access this information acquisition of new knowledge is made possible. Continuous feedback increases the opportunities for learning (Lamb, 2018). Through the interaction that the teacher would have promoted through the online quiz, he also intended on posing open-ended questions. These questions were assumed to provoke the learners to get into a debate which would lead to active learning. That way, learners would be engaged in higher cognitive thinking skills where they analyze what they learn. The teacher explained,

> *… when we look at the higher order thinking, I always ask open-ended questions.*

The teacher's use of open-ended questions promoted higher-order thinking and that contributed to appropriate answers. This would enable classroom conversation where the teacher and learners participated in the development of knowledge. Teacher S asserted with these words:

> *I always ask questions that are going to provoke the learners to think deeper and the questions that are going to, uhm, lead into debate in classroom because once the learners are debating, you know, they are changing points and all in that, and that for me it's uhm, higher order.*

The narrative media form from the smartboard was used to present new information and the interactive media form that facilitated the online quiz and thus, the immediacy affordance of. Table 13 below shows the summary of the interview responses for Teacher S before the lesson.

Table 13: Summary of the interview responses before the lesson observation.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	The presentation of the content	During the classroom conversation initiated by the		I always ask open-ended questions.

		on the smartboard	displayed information on the smartboard		
Interactive	Immediacy:	Learning through online quiz (game) Kahoot			I always ask open-ended questions.

STEP 2: LESSON OBSERVATION RESULTS

Topic: Population ecology

In this lesson, teacher S explained different terminologies that are associated with population ecology. These terms were displayed on the smartboard for the learners to refer to and take some notes. This enabled the learners to acquire the information by accessing it from the smartboard. As teacher S defined the different terminologies, he moved back and forth between his slides to clarify the distinctions. This allowed a non-linear way of presenting the information. This is evident in his reference to three concepts prior to making the distinctions in his introduction where he said,

I just want us to look at emigration, immigration, and migration

The teacher used non-linearity affordance in his presentation of concepts on the smartboard. As a result, learners could ask questions for clarity. This was witnessed from this quotation by one of the learners:

What is the difference between the terms, population, species, and community?

Learners were shown the differences and by so doing, establish their understanding of new knowledge. The interactive media forms were noted from the dialogue between the teacher and the learners. Teacher S asked the learners questions and they were able to answer and immediacy was observed. In the process of explaining the difference between emigration and immigration, he sought learner participation through question and answer as follows.

If there is three of us at home and one of us passes away, what happens to the size of the population?

The learners responded,

It decreases.

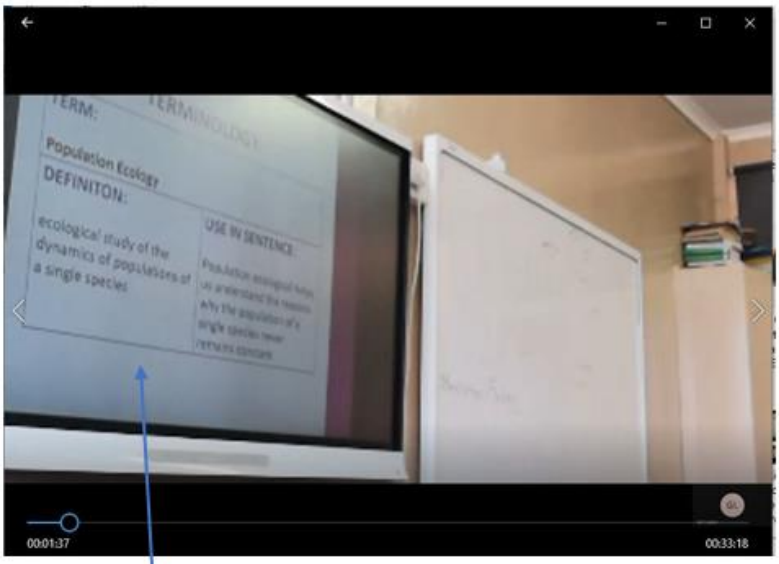
Teacher S further asked the following question:

So, if immigration is moving into the population. Is that going to increase or decrease the population?

The learners responded,

Increase.

There was immediacy between the teacher and the learners in clarifying the terminologies. The learners cooperated and answered questions. The snapshot below shows the terminologies displayed on the smartboard for the learners to see.



Smart board showing the MS PowerPoint presentation used by teacher S showing the terminologies for population ecology

Figure 5: Lesson presented by teacher S.

Table 14 illustrates the summary of the results obtained from the lesson observation:

Table 14: Summary of the lesson observation findings.

		How (ICT) and When (cognitive levels) can it be used in LS

Media forms	**Observed Affordances**	ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	Learners being able to see the definition of the different terminologies	defining the different terminologies back and forth to clarify the distinction		
Interactive	Immediacy	Learners seeking clarity between the different terminologies and the teacher attending to it	Learners learning the distinction between the terms		

The next section presents the responses obtained after the lesson presentation.

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

The media forms that were noted from the interview were narrative and interactive media forms. The narrative media form was noted from the teacher's response based on the following quote:

> *… the PowerPoint really helped because the learners could see where I was reading, what I was talking about.*

The PowerPoint that was displayed on the smartboard enabled the learners to access the information. Like Teacher R, Teacher S believes that learners should see the information that he is talking about as he explains.

The affordance associated with the narrative media form is non-linear. The flow of information and connection of concepts or ideas is enabled by the non-linear affordance. The display of the information on the smartboard triggers the engagement of learners with their

teacher and they can write personal notes as the teacher presents. Learners are able to acquire. This is confirmed from the following quotation:

> *… the PowerPoint slides at its best because some learners were also uhm, able to write a few notes down.*

Moreover, teacher S was able to engage with the learners without having to stop and write on the board and thus disrupt their thinking and the flow of the lesson. In addition, learners could be attended to with immediacy when they had questions. There was therefore pedagogical value in the interplay of the non-linearity and immediacy affordances enabled by the smartboard. The teacher believes in the use of questions during his teaching and this to him is facilitated by the use of ICTs. He explains,

> *… I can give learners ongoing assessments, informal assessments, just so I can get how did they understand. How is the depth of their understanding of the content?*
>
> *The other thing I can do is to ask the same questions but in different ways*

This media form enabled learners to understand and figure out the correct response to questions with the aid of content displayed in different representations. They could answer questions asked using different techniques and this was an indication that the content was comprehended.

This engagement of the affordances enabled learners to acquire information that was displayed on the smartboard. Learners were able to display an understanding of the work by articulating themselves through writing their own notes and responding to questions asked by the teacher as knowledge was developed.

GRADE 12: TEACHER Q

Teacher Q's use of the available technology is more focused on multimedia than teacher R and S.

STEP 1: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED BEFORE THE LESSON PRESENTATION

The teacher uses the narrative and adaptive media form mostly in his use of the smartboard to present content by playing videos and presenting with PowerPoint slides. The affordance in this regard is non-linearity and diversity. According to teacher Q, the videos are meant to provide an explanation of the concepts of evolution for instance. Teacher Q believes that

using videos and slides to display information for learners is better than just spoken explanations. He, therefore, engages both the narrative and the adaptive media (multimedia) in his teaching. He mentioned an example where he used the video and slides the learners were able to understand:

> *There's certain videos that I played for them to see. Like, the reaction of the pituitary gland and stuff.*
>
> *… its funny how I teach them with a textbook they don't understand a thing but start to use the slides. That's when they understand more*

Playing the video to help learners see affords diversity and all learners get to experience the same representation of new content. The narrative media form corresponds with the non-linearity affordance as the slides were used. When PowerPoint is used to display information, all learners can access information at the same time. In addition, learners understand better when teacher Q uses PowerPoint slides. Table 15 shows a summary of the categorization of the responses.

Table 15: Summary of the interview responses.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	Played for them to see.	Understand more. better understanding		
Adaptive	Diversity		The videos concretize concepts they are not familiar with		

STEP 2: LESSON OBSERVATION RESULTS

Topic: Evolution: Darwinism and Lamarckism

Teacher Q used the smartboard to display a PowerPoint presentation as he was explaining the theories of evolution. The narrative media, PowerPoint in this case was used to present

information in a multimodal way. There were pictures of the giraffes for Lamarck's theory to show the changes in the length of the neck. There were also words to explain the theories. The teacher presented the lesson in a non-linear way as he contrasted the theories. This was drawn from the following quotation:

> *So, Lamarck says variation occurs when individuals in the population change. However, Darwin says when characteristics are inherited.*
>
> *Then, you must know the difference between Lamarckism and Darwinism.*

The teacher referred to the information displayed on the smartboard as he was explaining. The interactive media form was observed through the dialogue between the teacher and learners. This promoted the participation of both in the knowledge construction. This is evident in the following quotation:

> *Teacher: Natural selection, organisms produce a large number of offspring. So, in those, that number of offspring…*
>
> *Learners: The ones that are suited to the environment will survive…*
>
> *Teacher: Will survive and the organism without the favorable characteristic will do what?*
>
> *Learner responded: Will die.*
>
> *Teacher: the ones with favourable characteristics will survive, reproduce, and thus pass on the favourable characteristic to their offspring. Guys, do you understand?*

It is evident from the above quotation that the learners had some misconceptions about natural selection and the teacher had to elaborate and clarify the theory. The acquisition of cognitive skills was achieved from the way the information was presented to the learners. They were able to access the information on the smartboard and visualize what the teacher was explaining and could thus have a concrete understanding of the animals. The analytical cognitive skills were achieved through the comparison of the two theories. The learners manifested an understanding of the two theories. The following pictures show the slides that were used during the lesson.

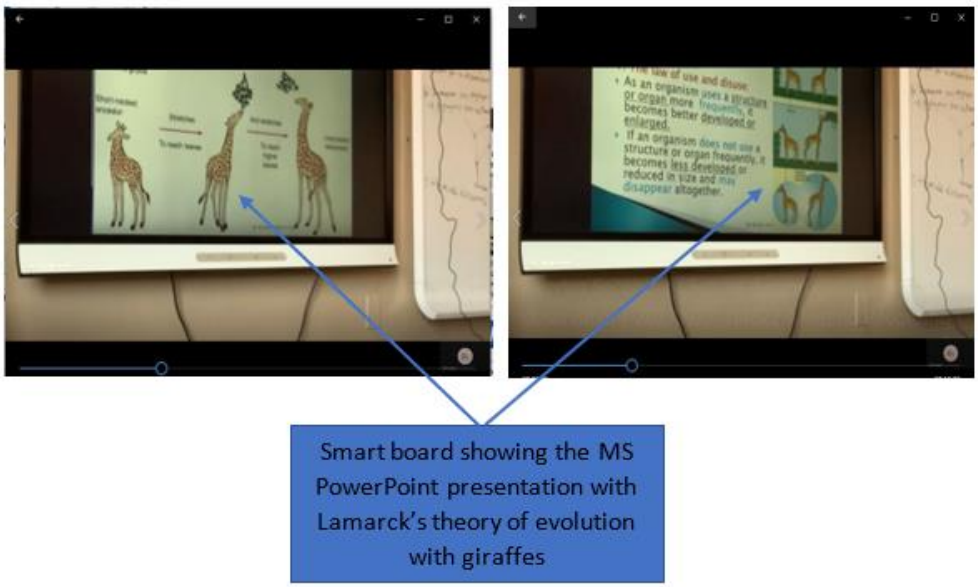


Figure 7: Lesson presented by teacher Q.

The narrative and adaptive media forms were engaged in this lesson. The non-linearity, and diversity affordances enabled the development of the acquisition and analysis of cognitive skills. Table 16 illustrates the summary of the results obtained from the lesson observation.

Table 16: Summary of the lesson observation findings.

Media forms	**How (ICT) and When (cognitive levels) can it be used in LS**				**Observed Affordances**
	ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE	
Narrative	Teacher displaying pictures of the giraffes in Lamarckism and Darwinism	Pictures of the giraffes for Lamarck's theory to show the changes in the length of the neck, combined with words		The dialogue between the teacher and the learners through questions and answers	Non-linear

Adaptive		Learners got to understand the association of the animals with the theories		The comparison developed their ability to analyze the theories	Diversity

The responses from the interview conducted after the lesson follow next.

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

Teacher Q explained that he used slides to show the differences between the neck size in explaining Lamarckism (the law of use and disuse). According to teacher Q, this approach was meant to explain the two theories of evolution through the visuals. He explains,

> *… the slides, I used them for visuals, and they also have uhm, for example; when we talk of the giraffes.*
>
> *I have to display the pictures of the giraffes.*
>
> *So that they can see the differences in the neck size and stuff.*

The interactive media form emerged in the teacher's response. Teacher Q mentioned that by referring to the slides he was able to ask learners questions as he developed learner understanding of the concepts taught. This is drawn from the following statement:

> *So, after explaining. I ask them, uhm, what did they understand from their point of view. Because I can explain something to them and say, Lamarck says that or Darwin says that, but you know, what did he say, from your understanding what did he say?*

The learners had to give an account based on what they understood regarding the two theories. That helps them to demonstrate they have the same understanding of the concepts that are aligned with the desired knowledge. Through interaction, there was an immediacy in terms of the learners' responses. Teacher Q believes that through the interaction learners were able to better understand as they acquire information at their disposal. The way the teacher used ICTs promoted learner understanding as indicated in his following response,

… with the questions, you know, because I asked certain questions and you could see that they have the skills.

From the above quotation, it is clear that teacher Q believed the use of questions assessed the learners' understanding of the theories of evolution. They were, therefore, able to acquire with understanding the intended skills and knowledge. In general, the use of ICTs by teachers in this school promoted the engagement of learner thinking at the acquisition and understanding level.

4. 3 INTERVIEWS AND OBSERVATIONS FOR TEACHERS IN SCHOOL B

This section presents the results that were obtained from teacher interviews, lesson observations and reflections on lessons taught in School B.

GRADE 10: TEACHER X

The presentation begins with the interview responses for teacher X.

STEP 1: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED BEFORE THE LESSON PRESENTATION

The narrative media form was noted based on the way the ICTs were used by teacher X. Teacher X intended to use a smartboard for visual learning. Like teacher R in School A, she believes that learners learn better through seeing:

… the PowerPoint slides. Those are, those are really effective. Especially when it comes to pictures and visual learning and also summary notes as well. And also, I, like notes on…

In this case, PowerPoint would be used to display, for example, the process of mitosis on the smartboard. The benefit associated with this media form is non-linearity. Teacher X intended to present the information in different forms that included pictures and words. This skill was drawn from the following statement made by teacher X,

And also, I, like notes on, like from the department because it's very easy accessible.

Teacher X retrieves teaching resources online from the Department of Basic Education's website. These are in the form of MS PowerPoint Presentations that she intends on using for the lesson. Learners will be able to access these resources through their teacher. Teacher X explains:

… when the slides or the resources that I use, when we share to the learners on their phones, because they always on their phones, WhatsApp them. They can always go back for referencing when they are studying, especially.

We share the questions and we can even do it together in class from the smartboard.

This teacher uses mobile technology to share content with his learners. Such usage of ICTs promotes the acquisition of content as learners have extended exposure to what they have learned. The method that teacher X intends to use for sharing the resources with the learners can be categorized under the communicative media form. The affordance related to this media form is collaboration. According to teacher X, learners are most likely to collaborate as they seek an understanding of what they are learning. Supporting this is the following statement:

… when the information is also shared with the learners, uhm when they do get home or wherever they are they are able to refer back to the information, they are able to understand and that would be assessed when we do the activities,

Learners in this case would be able to acquire scientific information through sharing their ideas regarding the work that they would be doing for that lesson. Teacher X would then ask learners questions based on the topic to find out how much they have understood regarding the topic. This is what she said:

Well, those are questions that they place during the lesson, right, high order thinking, before explaining what the theories actually are. The learners give me an idea of what they think it is, based on prior knowledge.

Through such questions, learners are able to develop analytical skills in which they will reflect on what they know and the unknown.

The narrative and the communicative media form with non-linearity and collaboration affordances were categorized in relation to the following skills: acquire, understanding, and analyze. The summary of the categorization of the interview responses is shown in Table 17.

Table 17: Summary of the interview responses.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE

Narrative	Non-linear	Visual learning, Like notes. Very easily accessible. Information.	Teacher intended to present the information in different forms that includes pictures and words		That would be assessed when we do the activities, their understanding
Communicative	Collaborative	Sharing slides with the learner via their smartphones	The teacher allowing the learners to reflect on their prior knowledge		Learners sharing the notes through their smartphones enables them to interrogate it before and after the lesson

STEP 2: LESSON OBSERVATION RESULTS

Topic: Stages and importance of mitosis

The ICT tools that were used include a smartboard and smartphones. The lesson was based on the phases of *Mitosis* and *Plant tissues*. The smartboard was used to display the PowerPoint presentation. Teacher X referred the learners to the presentation on the smartboard while she was explaining. This is evident from the words that teacher X constantly repeated. She repeated the word 'see' about twenty-four times in this one lesson. These are her words captured in her classroom conversation:

Here see.

You can literally see

Can you see? (Repeated ten times)

See these two nuclei.

Seeing.

See. (Repeated seven times)

She used the PowerPoint presentation as a narrative media form to explain the phases of mitosis and the various plant tissues. In the process of explaining the phases of mitosis, teacher X engaged non-linearity as she made a distinction between the phases by going back and forth. Teacher X also engaged learners through questions as she referred them to the information displayed on the smartboard. At some point, she said:

Ok, which phase of mitosis does this image show?

Learners responded: anaphase.

The MS PowerPoint Presentation contained pictures of the phases and an explanation of each phase. The affordance that was observed in relation to the narrative media form is non-linearity. The acquisition cognitive skill factored in because the learners were able to see and access the information on the smartboard.

The second media forms that were noted are interactive and communicative. This media form was observed when the learners were doing an online quiz 'Kahoot.' The learners connected their smartphones to the smartboards and completed an online quiz. They collaborated as they worked in pairs and in groups of three. They could access their scores immediately after submission and were therefore using the immediacy affordance of the technology. This affordance is based on the immediate feedback that the learners were receiving continuously and at the end of the quiz. The top five learners' scores were displayed on the smartboard as they were doing the quiz. The third media form was observed from the time the learners were doing the quiz. This is the communicative media form based on the connection of the learners' smartphones to the smartboard wirelessly to send their responses to the questions as they collaborated in this learning experience in their groups. Learners were collaborating in answering the questions. The cognitive skill noted with this media form is understanding. Learners manifested their understanding based on mitosis by doing the quiz.

The affordances noted from the media forms engaged are therefore non-linear, immediacy and collaboration. The cognitive levels noted in relation to these media forms are acquire and understand. The following pictures show what transpired during the lesson. Figure 8 shows the MS PowerPoint presentation that teacher X used to explain the phases of mitosis and

Figure 9 shows the online quiz on the smartboard that was administered to assess the learner's comprehension.

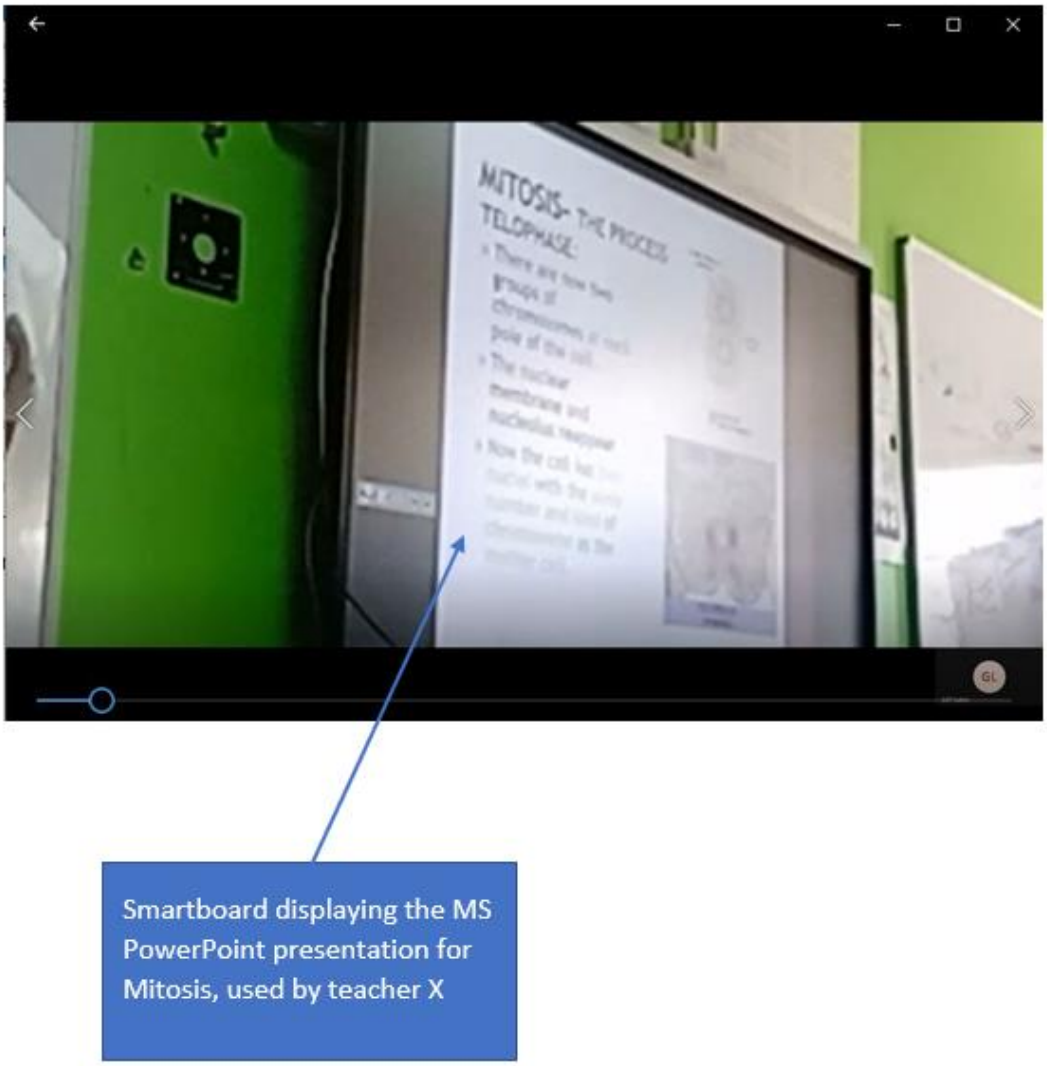


Figure 8: Lesson presented by teacher X.

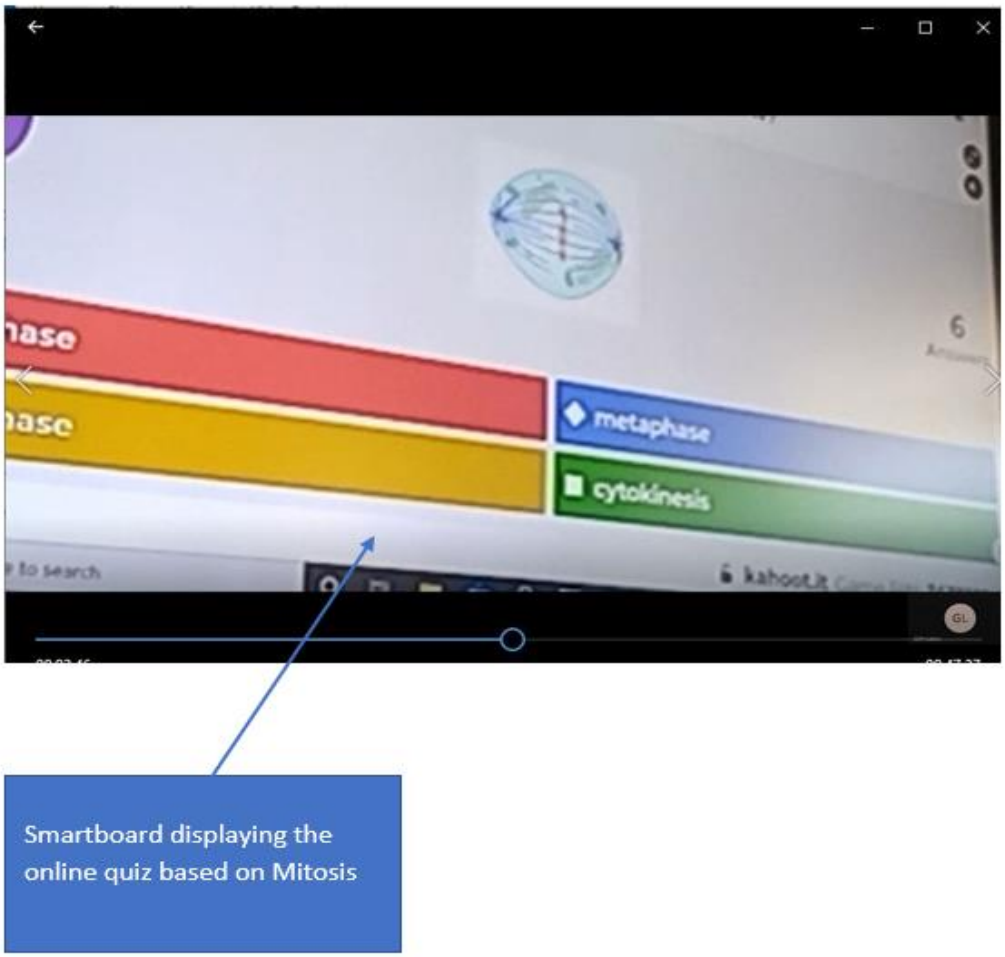


Figure 9: The online quiz.

Moreover, Table 18 illustrates the summary of the results obtained from the lesson observation.

Table 18: Summary of the lesson observation findings.

Media forms	**Observed Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	Teacher referring the learners to the PowerPoint presentation	Information was presented in a multimodal way, with the pictures of the phases and		

		on the smartboard	an explanation of each phase		
Interactive	Immediacy	learners were receiving immediate feedback that the learners were receiving continuously and at the end of the online quiz		Learners interacting with the smartboard with their smartphones to complete an online quiz	
Communicative	Collaboration		Learners providing their answers that reflects on the smartboard	Learners were collaborating in answering the questions	

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

The narrative, interactive, and productive media form was derived from the responses. These media forms were derived based on the teacher's responses. Firstly, the narrative media form was noted because of the following response:

> *Actively engaged conversations during the lesson, questions were asked. Especially, the challenging ones that actually force the learners to think out of the box.*

Teacher X asked the learners challenging questions when teaching mitosis. She explained that this was meant to actively engage the learners in the lesson. The conversations were meant to unpack the process of mitosis for the learners to be able to understand. Through the conversations, the learners were able to interact with their teacher and develop the skill of understanding. Teacher X administered an online quiz 'Kahoot' based on the phases and importance of mitosis two days before the lesson observation. She gave the learners the same

set of online questions during the lesson observation and this was her account on their performance:

Yes, they improved. They actually did better than they did two days before.

The above statement provides a response from teacher X where she was explaining that learners did better in the same activity that they did two days before. This statement was a response to whether the learners understood what was taught. According to teacher X the learners were able to recall the same questions that they did two days before and they did better on the day of the observation. This was an indication of the acquisition cognitive level.

GRADE 11: TEACHER Y

The narration of the categorization of the interview responses and observation findings for teacher Y will be presented in this section.

STEP 1: TEACHER Y RESPONSES FROM THE INTERVIEW CONDUCTED BEFORE THE LESSON PRESENTATION

The media forms that were noted based on the responses are narrative and interactive. In relation to the media forms is the following skills: acquire and understanding. These media forms and skills are presented in relation to the following affordances, non-linearity and immediacy. The first media form is narrative based on the following response.

When it comes to some drawings, which will be very difficult if I have to work with the worksheets because they will only be black and white. So, the colour also help when it comes to, like recently we were looking at the excretion.

According to teacher Y, there are some difficult concepts that should be presented in a colourful format. The teacher uses the smartboard to display information in colour. Teacher Y explained,

And then the other good thing about the booklet in using the smartboard it shows in colour.

She believes that learners would understand the work better if shown in colour. Teacher Y intended to use the smartboard to display information on Human excretion. The skill to acquire was also noted from the manner of presentation. The approach that teacher Y intended to use would enable the learners to access information. Learners could therefore access the information as they acquired knowledge.

Teacher Y intended to use the smartboard for the learners to interact with the assessment through visual displays. This was noted from what she said,

> *It allows not only the teacher to be working, but it, it brings everyone on board and makes the assessment not, eh, one directed a kind of interaction, but all learners are able to interact in the assessment. Besides, because it's not just about writing the assessment, we can even make it oral.*

It is clear from the above statement that teacher Y intended to promote interaction among the learners and immediacy was achieved in this instance. The notion of this approach was to enable active participation and ownership of learning through assessment. The assessment in this case was meant to be oral, by answering the questions displayed on the smartboard and the teacher providing feedback immediately thereafter.

Moreover, through this intended approach by teacher Y, learners could be engaged at the acquisition cognitive level. Teacher Y mentioned that the learners would be able to 'see' the work in colour repeatedly about eight times. The following statement attests to this.

> *… making use of the smartboard, the learners will be able to see colourful diagrams, and they will also be able to visualize virtual representation of those tricky concepts which might be too small to be seen.*

Through visualizing the virtual representation of the diagrams, teacher Y believes that the tricky concepts would be simplified for the learners and enhance their understanding. Table 19 shows a summary of the responses.

Table 19: Summary of the interview responses.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	They can actually see the colours. Everyone	Narration that includes colour promotes understanding		

		else can see. The learners actually, said they want to see a virtual. They could see. Able to see the alveolus. See colourful diagrams. Visualize virtual representati on. Seen. They were trying to give responses.			
Interactive	Immediacy		Learners are able to interact in the assessment. See through the visuals.		

STEP 2: LESSON OBSERVATION RESULTS

Topic: Human excretion

The following media forms were observed from the lesson, namely, narrative, interactive, and communicative. The affordances that were observed were non-linearity, immediacy, and collaboration. The cognitive levels were, acquire and understand. The smartboard was used to display the PowerPoint presentation based on 'Human excretion'. The lesson was based on the function of the excretory system and associated organs. The teacher interacted with

learners in explaining the functions of each organ in the excretory. Teacher Y guided the discussion through questions and the learners answered. This was witnessed in the following quotation.

Teacher: Can someone remind me how can we define excretion?

Learner 1 responded: the body getting rid of metabolic waste. The process of…

The above quotation is an example of the dialogue that took place between the teacher and the learners. Teacher Y guided the lesson with questions and learners were answering. The learners were involved in the process of knowledge building. Teacher Y also allowed the learners to ask questions where they did not understand. The following quotation is evidence that a learner was asking a question.

Learner 2: Madame, what if the bladder is always full? If it is full but with no urine inside?

Teacher: I understand you, but let's hear from the class.

Learner 2: even if there is no urine or the pressure. Like, after 30 minutes you wanna use the bathroom.

Teacher: I wouldn't want to lie. I would want to think about, I would compare you to when you sit there. The frequency of the pee. Remember when we talk about the sensational story. Right, as soon as it staggers, then you would release it. And then as you grow up, as you mature, you know your body becomes sensitive.

The cognitive skill that was noted in this case is the acquiring skill. The smartboard displayed information in the form of pictures and words. When the questions for the activity were displayed on the smartboard the interactive media form was also noted in the interaction between the learners and their teacher and the smartboard. The cognitive skill associated with this approach is understanding. This cognitive skill is based on the observation made where learners were able to answer the questions that were asked by their teacher. Furthermore, the interactive media form was observed from the conversation between the teacher and the learners, while using the smartboard. The process of knowledge construction involved both the teacher and learners. The cognitive skill identified was understanding. Learners were able to apply what they have learnt in the process of answering the questions. The learners took ownership of their learning by leading the question-and-answer session.

This act demonstrated the learners' interest and willingness to learn. The evidence is seen through the following pictures in Figure 10.

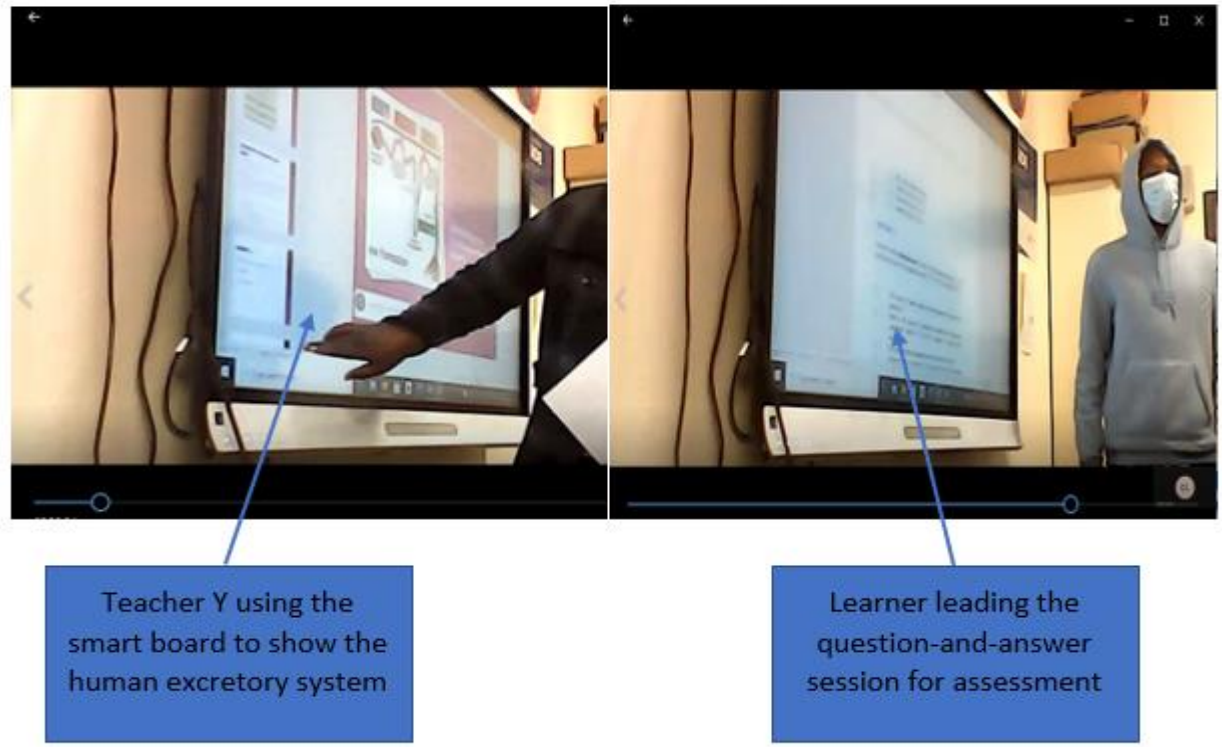


Figure 10: Lesson presented by teacher Y.

Furthermore, Table 20 illustrates the summary of the results obtained from the lesson observation.

Table 20: Summary of the lesson observation findings.

Media forms	**Observed Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	Learners being able to see the functions of the kidney	The source of information was both the teacher and learners		

Interactive	Immediacy	giving the learners a set of time to answer question and then review together	The learners expressing what they know by answering the questions posed by the teacher		

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

The following media forms were noted from the responses: narrative and interactive. These media forms complement what was mentioned by teacher Y during the interview before the lesson presentation. In relation to the media forms, the following skills were noted; acquire and understand. These skills were noted from the following affordances: non-linearity and immediacy. The smartboard was used to display questions for all the learners to see. Through this assessment, teacher Y believes that the learners were able to see the work better on the smartboard. She explicated,

> *Instead of the learners maybe looking at the pages, but they had to see this work in colour from the smartboard. Which I thought was much better.*

According to teacher Y, it was much better to present the work in colour through the smartboard than only giving the learners pages that are printed in black and white. Learners were able to see pictures and words based on human excretion and that made it easy to acquire information in its nature. Teacher Y repeatedly mentioned about four times that learners were able to 'see' the work in colour. The following quotes attest to this.

> *So, firstly we looked at the slides together and that was using the smartboard. And then later we used the smartboard once more to go through the questions.*
>
> *… they had to see this work in colour from the smartboard.*
>
> *And then the other issue the learners might not be able to see when it comes to the drawings, they might not be able to see without the aid a the colour, but now with the power, what's this, smartboard it's much easier, they can see the work from an*

accurate zone, and there those who can't see from the back, they can see in colour and that's much, much better.

The above quotation shows that teacher Y believes that learners must be able to see the work in colour to understand. Furthermore, teacher Y explained that she promoted interactive learning in her lesson. This is witnessed in the following statements.

… the learners had time to think as individuals and then later on they had to interact as a class, where they were trying to give responses.

… this generation they love anything that is shown on the smartboard, unlike the chalkboard, they find the chalkboard boring, but the smartboard it becomes a little bit lively, it makes then makes the interaction much active.

According to teacher Y, the smartboard made the lesson to be interactive. Teacher Y believes that learners prefer learning from the smartboard to using the chalkboard. The interaction enabled the immediacy affordance. Teacher Y explains with these words,

… there is like immediate feedback, to show that at least there was some, uhm, knowledge development.

The above statement indicates that there was immediate feedback from the interaction. This was interpreted by teacher Y as a sign of knowledge development. Teacher Y believes that there are other important skills that her learners were able to develop from the lesson. She explained,

… they would all be shooting up to interact and I feel that there are some skills that are being learnt there, reading skills, the oh, let's not forget self-esteem skills, then the, the interaction in terms of language usage and also scientific terminologies being able to be read and there we were able to correct each other. Yeah, that, that was quite a learning process, besides just learning the scientific content.

In conclusion, teacher Y believes the affordances used in her class promote interaction and thus the development of acquisition and understanding of LS concepts.

GRADE 12: TEACHER Z

The responses from the interviews and lesson observation results for teacher Z will be presented in this section.

STEP 1: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED BEFORE THE LESSON PRESENTATION

This is a narration of the results obtained from the interviews for teacher Z. The media forms noted from the responses are the narrative, and interactive. The affordances that were noted from these media forms are non-linearity and immediacy. The skills that were noted from the affordances are acquire, application and analyzing. The narrative media form was noted based on the following statement.

> *… digital way of giving a lesson makes it interesting, makes it rememberable, it gives them, they are curious, they are excited because they see things from a different, its colourful. It looks like the real, the actual, actual structure.*

Teacher Z is of the belief that learners will gain interest, be able to remember, be curious and excited if she uses digital tools. She further explicated that the benefit of using digital tools is that it shows the actual structure. In the process of teaching a new concept, the idea would be vested around methods that will enable learners to remember. Teacher Z also explained like Teacher Y that using digital tools enables her to use different colours to present different structures. She explained,

> *So, they've seen it and they, they become active in the lesson because why they are so interested in the digital thing, there's various different colours and you can play with it.*

From the above quotation, it is evident that teacher Z is aware of the affordance that comes with the various digital tools she will be using. The following statement supports this claim as she talks about cellphone affordances.

> *Because why, it is at home, they have free access at home. In the comfort of their home use their device. Especially uh, at our school where learners were given laptops. That made it very easy for them. Uh, to assist them in studying, etc. or preparing for assessments.*

Moreover, teacher Z uses the internet to complement the narrative media to access information that she shares with the learners. She mentioned a search engine 'Google' that she uses for unknown terms. This was her explanation,

One must go on google. Normally internet. And then you search must get the information which [is] easy accessible, makes life much easier. Because if I need to maybe refer to a foreign term then we can quickly look for the term.

As they understand the meanings of terms, learners are able to understand the text on what they are learning. The immediacy affordance of interactive media enables this easy access to what learners need to know in the process of their learning. Teacher Z intended to provide the learners investigative questions that would enable them to think critically. The investigative questions would be based on hypothesis testing and data handling. Teacher Z explained,

You always… take like uh, lesson like a hypothesis. Or you give them a data, you give them something to analyze. And by doing so you are able to see what they will conclusions be or the analysis based on data given. Uh, maybe, uh, recording of a graph, uh record a graph. Take information and put on a scale, table of data. Uhm, you look at those type of things.

Learners can then develop analytical skills in the process of hypothesis testing and data handling. The functions that they would perform would indicate a level of understanding of the work. This approach would also promote the application and analytical skills. The table below is a table that entails a summary of the interview responses before the lesson presentation.

Table 21: Summary of the interview responses before the lesson.

Media forms	**Possible Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE
Narrative	Non-linear	learners access different ideas. Visualize. Information also		Recording of a graph.	

		is accessible. Have free access. They are excited because they see. Its colourful.			
Interactive	Immediacy			Allowing the learners to assist with the use of a smartboard	Give them data to analyze. The analysis based on data given.

The lesson observation results are presented in the next section.

STEP 2: LESSON OBSERVATION RESULTS

Topic: Endocrine system, glands, and hormones

The media forms that were observed from the lesson are narrative, interactive, and interaction. The affordances connected to these media forms are non-linear, immediacy, and collaboration. The cognitive levels observed in relation to the media forms and affordances are acquire and understand. The ICT that was used in this lesson was the smartboard. The lesson was based on the endocrine system. Teacher Z used the smartboard to display the PowerPoint presentation. The narrative media form was observed from the way teacher Z explained the function of the endocrine system. Teacher Z displayed the different glands on the smartboard and explained the hormones secreted by the different glands and their functions. This was witnessed from the following statement by teacher Z.

> *There are two types, the endocrine and the exocrine. These endocrine glands and exocrine glands they have specific secretions*

The affordance that was observed from this approach is non-linearity based on the functions of each gland and their relationship. The cognitive skill associated with this media form and

affordance is the acquiring skill. This skill was drawn from the idea that learners were able to access multimodal information from the smartboard. The interactive media form was observed from the interaction between the teacher and learners. Teacher Z engaged the learners through questions. The following is the interaction between the teacher and learners.

Teacher: Now learners remember in the reproduction we've done the testes and the ovaries. Am I correct?

Learners 3: yes.

Teacher: so, which hormone is produced in the testes?

Learners 4: testosterone.

Teacher: testosterone neh. Ok, what is the function of the hormone?

Learners 5: it is responsible for male secondary characteristics.

Teacher: Ok, secondary characteristics. Can you mention one there, Wade?

Learner 6: Madame, its pubic hair.

Teacher: Pubic hair, etcetera. What are the hormones are produced by ovaries?

Learners 6: progesterone.

The affordance drawn from this media form is immediacy. The learners provided their answers and teacher Z was able to provide them with immediate feedback. The cognitive skill that was noted in relation to the media form and affordance is understanding. Through the interaction, the learners were able to express their understanding based on the questions asked. The following is a dialogue that took place between the teacher and learners.

Teacher: What is the function of estrogen? To secure secondary female characteristics. To ensure those secondary characteristics. Give one example of the secondary characteristics?

Learners 7: enlarging of the breasts.

Teacher: enlarging of the breasts. What I want you to do for me learners. I want you to draw a frame of the endocrine system and quickly list for me the hormones and the gland. I will come around to see if you are doing it. Just a simple diagram. Busi which one produces? Which one increase blood sugar levels?

Learner 8: glucagon.

The smartboard was used for visualization and to guide the lesson. Teacher Z also administered a written assessment where learners had to list the various glands and their secretions. The Figure below shows how the smartboard was used for the lesson.



Figure 11: Lesson presented by teacher Z.

The following Table illustrates the summary of the results obtained from the lesson observation.

Table 22: Summary of the lesson observation findings.

Media forms	**Observed Affordances**	**How (ICT) and When (cognitive levels) can it be used in LS**			
		ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE

Narrative	Non-linear	Displaying the different glands on the smartboard	displayed the different glands on the smartboard and explained the hormones secreted by the different gland		
Interactive	Immediacy		learners providing their answers and teacher Z was able to provide them with immediate feedback		

STEP 3: TEACHER'S RESPONSES FROM THE INTERVIEW CONDUCTED AFTER THE LESSON PRESENTATION

The following media forms were obtained from the interview responses: narrative and productive. The affordances drawn from these media forms are non-linearity and articulation. In relation to media forms and affordances, the skills based on specific aim 1 are: acquire, understand and analyze. The use of a smartboard enabled a non-linear way of presenting the information to the learners. They were able to see information presented in colour on the smartboard. This affordance is categorized with the skill to acquire. This is because learners were able to access the information presented by their teacher. Teacher Z explains how she used the smartboard during the lesson.

> *… it was very nice because I could just use a button on the smartboard. Refer to, use the smartboard, and let the system give much with the information I needed based on the endocrine.*

Teacher Z explained that during the lesson she gave the learners to draw a diagram of the glands and the associated hormones. This is an assessment that the teacher administered to check whether the learners understood the work or not. She explained,

> *I asked them to at the end of the lesson to draw a diagram where they now had to uh, place those glands with their hormones. And also, the secretions, maybe the functions, the functions that they perform in the body.*

This practice appeared effective because learners could articulate their understanding of the endocrine system. The learners were able to understand the work and this was shown through the assessment. Teacher Z explained that the lesson was effective because the learners understood the work. She elaborated,

> *… they are skilled in a way because they were able to answer the questions and they did the drawing they could relate, uh, attach a gland with a hormone and also uhm, I'm certain of this because why I went around and checked the diagrams that they had drawn. They had an understanding how do we… match the gland and the hormones and the function.*

Another skill that was noted from this approach is the analytical skill. This skill was noted based on the ability to match the glands with the hormone they secrete and the function they carry.

4.4 CONCLUSION

This chapter presented the data that were obtained from both the teacher interviews and the lesson observations for all the teacher participants. The data revealed some insights on how ICTs can be used to enhance the understanding of LS. Therefore, the next chapter will provide a discussion of the findings drawn from the data.

CHAPTER 5: DISCUSSION OF THE FINDINGS

5.1 INTRODUCTION

This chapter provides a discussion of the findings that were presented in Chapter 4. It begins by revisiting the research questions and a summary of the findings that led to the identification and discussion of the main themes. It will also address the analysis of the findings, the contribution of the study, limitations, and recommendations for further studies and a conclusion of the study.

The main research question for this study is:

How does the integration of ICTs by teachers enhance learning in LS (or not)?

The sub-questions that will assist in answering the main question are:

1. What are the teachers' perceptions regarding the pedagogical value of ICTs in LS teaching?
2. What are the pedagogies employed by teachers to integrate ICTs in LS classrooms?
3. How does teachers' use of ICTs enhance the teaching and learning of Life Sciences?

5.2 SUMMARY OF THE FINDINGS

Two teachers (S and X) claimed that they designed their own MS PowerPoint presentation slides, and this would mean that they used a laptop or desktop. The other teachers used MS PowerPoint which was prepared by the Department of Basic Education. They were able to access these presentations from the internet. The use of MS PowerPoint presentations was motivated by the belief that the smartboard will display colourful diagrams as opposed to diagrams that are drawn on the whiteboard or chalkboard. The teachers anticipated that the colourful diagrams would benefit the learners. During observations, learners could see clear visualizations of the concepts being taught. Considering the uniformity in the way the teachers used ICT, there were two teachers that applied different pedagogies. Teachers X and Y implemented a more learner-centered approach. Teacher X used the smartboard to promote the learners' engagement and interaction through an online quiz. The learners had to link their smartphones and laptops to the smartboard to complete an online quiz. In another lesson, teacher Y decided to give learners the platform to interact with the

smartboard and answer questions. Table 23 on the next pages shows the summary for both the interviews and lesson observations for all six teachers.

Table 5.2.1: Summary for both the interviews and lesson observations of all teachers.

TEACHERS	Int./Obs./Ref.	Med. Forms	Affordances	Cognitive skills	Pedagogies	Enhancement
Teacher R (10 years teaching experience + 4 years in ICT)	Interview	Narrative Interactive	Non-linear Immediacy	Acquire + Analyze Acquire + Understanding + Analyze	Explanation–pics-multimedia. Question-and-Answer. Interact with learners to encourage participation	Learners were able to acquire, understand, apply, and analyze the different skeletal diseases. Learners were able to access (see) information, build a conceptual framework of the diseases, asking practical questions on how to help people the diseases and analyzing what they knew based on the diseases and identifying the relationship with the new concept
	Observation	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Analyze. Acquire + Understanding + Analyze.	Using the smartboard to display MS PowerPoint with pictures of the skeletal system diseases. Interacting with learners through questions-and-answers	
	Reflection interview	Narrative Interactive Adaptive	Non-linear Immediacy Diversity	Acquire + Understanding + Analyze. Application.	Pictures attracted the learners, enabled participation, asked questions that are	

					beyond the classroom (authenticity)	
Teacher S (5 years teaching experience + 2 years in ICT)	Interview	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Analyze. Acquire + Analyze.	Online educational game. Open-ended questions	Access terminologies on population ecology. Compare terminologies. Responding to questions (oral assessment)
	Observation	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Acquire + Understanding +	Using the smartboard to display different terminologies in population ecology. Defining the different terminologies back and forth to clarify the distinction through question-and-answer	
	Reflection interview	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding +	Displaying different terminologies on the smartboard. Explaining. Ongoing assessment, informal assessment	

Teacher Q (5 years teaching experience + 2 year in ICT)	Interview	Narrative Adaptive	Non-linear Diversity	Acquire + Understanding.	Playing videos and presenting with PowerPoint slides.	The question-and-answer approach enabled the learners to express their understanding through oral assessment, access information on the smartboard. Contrast the two theories of evolution
	Observation	Narrative Adaptive	Non-linear Diversity	Acquire + Understanding + Analyze + Understanding + Analyze.	Explanation–pics-multimedia. Question-and-answer.	
	Reflection interview	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Acquire + Understanding.	Multimedia. Comparison. Giving account of the theories	
Teacher X (5 years teaching experience + 2 years in ICT)	Interview	Narrative Communicative	Non-linear Collaborative	Acquire + Understanding + Analyze + Acquire + Understanding	Pictures + visual learning. Using smartphones (WhatsApp) for sharing notes. Collaborating with the learners	Learners were able to access information on the smartboard based on mitosis. Their understanding was assessed through an online

	Observation	Narrative Interactive Communicative	Non-linear Immediacy Collaborative	Acquire + Understanding + Analyze + Acquire + Application + Understanding + Analyze.	Multimedia. Online assessment. Explanation.	quiz that provided positive immediate feedback. There was ongoing oral assessment
	Reflection int.	Narrative Interactive	Non-linear Immediacy	Understanding + Acquire + Understanding.	Multiple assessment (pre & post assessment). Pictures. Interaction (asking challenging questions)	
Teacher Y (10 years in teaching + 4 years in ICT)	Interview	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Understanding.	Using a smartboard to display content in colour. Collaborative learning.	Learners was enhanced through collaborative learning. Oral and Written assessment were learners successfully answered the questions on human excretion.
	Observation	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Acquire + Understanding.	Interactive learning. Question-and-answer. Written assessment	

	Reflection int.	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Acquire + Understanding.	Learners seeing the work in colour. Interactive learning.	
Teacher Z (10 years teaching experience + 4 years in ICT)	Interview	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Application + Analyze.	Using digital tools. Multimedia. Hypothesis testing.	Learning was enhanced. Learners were able access information on the smartboard, list the glands and the associated hormone and function
	Observation	Narrative Interactive	Non-linear Immediacy	Acquire + Understanding + Understanding +	Explaining. Question & answer. Written assessment	
	Reflection int.	Narrative Productive	Non-linear Articulation	Acquire + Understanding + Analyze.	Explaining. Multimedia. Oral and written assessment	

It was evident from the interviews that teacher R believes that ICTs can enhance learners' understanding through visuals. He believes that learners are able to remember what they were taught if they were able to see the actual images. This perception was also evident from the lesson observation when the teacher used the smartboard to display images showing the different diseases associated with the skeletal system.

Teacher S's responses before and after the lesson revealed that she believes that ICTs can enable learners to actively participate in online quizzes. Teacher S also believes that learning is stimulated through open-ended questions. Similar to teacher R, she also believes that learners learn better if they see the definitions of the terms displayed on the smartboard. It was also observed from the lesson presentation that the definitions of the terminologies were displayed on the smartboard. However, the interaction was only through verbal communication and not through an online quiz. Teacher Q believes that playing videos for learners enables them to understand the concepts. Teacher Q also believes that visuals enhance learners' understanding. This was observed during the lesson presentation when teacher Q used the smartboard to display the images of differences in neck sizes while explaining Lamarckism.

Teacher X believes that sharing the notes in the form of an MS PowerPoint presentation can facilitate learning. These notes can be shared over the learners' smartphones through WhatsApp. It was common with the first three teachers that learners learn better through visuals. Teacher X confessed that she saw that the pictures assisted the learners to understand the work. It was observed that teacher X used the smartboard to display an MS PowerPoint presentation with images of the phases of mitosis and its descriptions, and the online quiz. Teacher X was the only teacher that administered an online interactive assessment to the learners.

What was common in teacher Y's lesson was the use of a smartboard as an ICT tool. However, teacher Y used the smartboard differently from teachers R, S, Q and X. She gave the learners control when they were doing the assessment. The teacher only gave clarity where there was uncertainty.

Teacher Z also used the smartboard to display an MS PowerPoint presentation on the endocrine system. This was similar to all the other teachers that used the smartboard as a visual aid. Teacher Z also believes that learners would understand better when they see what they are taught. ICT has the ability to bridge the learners' imaginary gap and they would be able to see actual glands. Therefore, she showed the learners the different glands, their location in the human body and their functions. The following section unpacks the analysis of these findings.

5.3 ANALYSIS OF FINDINGS FOR SCHOOLS A AND B

This section presents a detailed interpretation of the findings, identifies the themes, discusses the analytical framework in relation to the findings and provides recommendations. Both interviews and the lesson observation were meant to understand the teachers' perception of the use of ICTs and the exploration of the actual use of ICTs in an LS lesson. The themes were identified as uniform across all the teacher participants. The themes were strategically established according to the focus of the study and constitute the mini findings of this study. Three themes were identified in relation to the research topic and this is presented in the following Table 24.

Table 24: Summary of the themes.

Categories	Themes
1. Perception towards the use of ICT	Perception and implementing the approach that learners understand the content if they see it in colour
2. ICT integration in LS teaching	The use of a smartboard as an ICT or digital tool to skill and enhance learners' understanding
3. Media forms used	Pedagogies belonging into the narrative, interactive, and communicative media forms

(Adu & Ojo, 2018)

The value of ICT in education was revealed in the literature review from different studies. This was revealed by Ojo and Adu (2018), Ferk Savec (2017), Mwanda et al (2017) Ndlovu (2015) and Draper (2010), to name a few. Khalo (2020) focused on the use of ICT in teaching and learning Life Sciences in rural schools, and its associated challenges. It was central for this study to explore the use of ICT in LS to enhance learners' understanding. Section 2.1 discussed the broad specific aims of the subject as stated in the CAPS document. These aims are aligned with the specific Learning Outcomes (LOs) for various topics within the subject across the grades. LOs are what the learners are expected to know at the end of a given topic or lesson. Success or failure is measured through the achievement of the LOs at the end of a lesson.

This can be determined through formal and informal assessments. Informal assessment is defined in the LS CAPS document as a daily practiced act for monitoring learners' progress (DBE, 2021). Formal assessment in this context refers to tasks that are marked and formally recorded by the teacher for promotion and certification purposes (DBE, 2021). The use of formal and informal assessments will depend on the teacher and the timeframe. The success of a lesson is determined by whether the learners can display what is mentioned in the LS specific aims within the curriculum. This can certify the effectiveness of the teaching strategy and tools used for a lesson.

The effectiveness of a lesson and the tools used depends on various factors. One of the factors that was discussed in the literature review section is teacher and learner perception towards LS. It was discussed earlier in Chapter 2 that perception influences how teachers perceive LS as a subject and how they teach it (Okwara, 2016). It was also observed in this study that teacher perception determines the drive to explore and integrate ICT in their teaching.
The teachers' perceptions towards ICT were explored through the teachers' responses during the interviews. The teachers' responses were studied during the lesson observations. Teachers who perceive value in the use of ICT are well-vested in its integration. These teachers are informed about various media forms, their affordance, and the possible pedagogical value that it brings. This was also witnessed from the data that was accumulated from both the data collection tools. The analytical tool that was discussed in Chapter 3 under data analysis was used as an observation tool.

5.3.1 TEACHERS' PERCEPTIONS OF THE PEDAGOGICAL VALUE OF ICTS.

The findings showed that teachers' perception towards the pedagogical value of ICTs was positive. According to Silviyanti and Yusuf (2015), this kind of perception is regarded as positive perception because it leads to the use of ICT. The findings showed some similarities with other studies on ICT perception. Those similarities include the following: perception shapes how teachers use ICTs in their teaching and that perception is influenced by factors like teacher training or workshops and the context. In this study, perception of the use of ICT was explored in the practical data collection, namely, the interviews and lesson observations. From the data that was collected, it was found that teachers that believed that ICT integration will enhance learners' understanding were driven to try new ICT tools. All the teachers showed an understanding that some of the concepts in LS are abstract to understand from textbooks printed in black and white. The evidence was given in Chapter 4 where the data were presented. The use of an ICT tool like the smartboard allowed the teachers to present abstract concepts in colour for better visualization. They all believed that using a smartboard to display MS PowerPoint Presentations with pictures and words enabled the learners to see the content colourfully, and these enabled learners to understand better.

The interviews before the lesson were meant to get an insight into what the teachers intend to do during the lesson. It was also to explore the teacher's perception of the pedagogical value of ICTs, the pedagogy that will be used to integrate the ICTs into the lesson and how the teacher uses the ICTs to enhance learning. This data collection procedure was systematically followed to explore how perceptions towards the pedagogical value of ICTs can influence how it is integrated if it is integrated at all. The main objective of this study explored the use of ICT to enhance learning LS. However, as mentioned earlier in Chapter 2 section 2.4, there was a need to understand the teachers' perceptions because teaching does not happen in isolation. The results from this study attested to this assertion. Therefore, the pedagogical value of ICT in enhancing understanding within LS requires teachers to have a positive perception towards its integration.

5.3.2 THE PEDAGOGIES EMPLOYED BY TEACHERS TO INTEGRATE ICTS IN LS CLASSROOMS

The type of ICTs used and the pedagogy in which it was used determined the effectiveness of each lesson. It is important to note that the pedagogy that is used by teachers is influenced

by their perceptions on the use of ICTs in teaching and learning. The ICTs that were used in this study included the smartboard in the classrooms, laptops, and smartphones. These ICT tools may hold value within the classroom depending on how the teacher exploits their pedagogical value (Ndlovu, 2015). The smartboard was used to display the content and questions based on the topic of the day by all six teachers. The smartboard was also used to access online interactive quizzes for the learners. The smartphones were used by the learners to link with the online quiz. The learners also used their smartphones to access the information related to the topic. The online quiz encouraged interactive learning with immediate feedback. Displaying the content on the smartboard assisted with the visualization of abstract concepts in LS. This confirms the findings by Van Roy (2012) that the use of multimedia enhances understanding of abstract concepts and this can be supported by formal science language and informal discussion between the teachers and learners.

The lessons were mostly teacher-centered, except for one lesson where the teacher decided to allow the learners to take ownership of their learning. Allowing learners to take ownership of their learning promoted their understanding of the content. Van Roy (2012) concluded that experienced teachers use digital technologies to improve the quality of learning through engagement.

5.3.3 THE USE OF ICTS BY TEACHERS TO ENHANCE LEARNING IN LS

From all six lessons, it is not explicitly clear whether the use of ICTs was effective or not. However, all the teachers were convinced that their lessons were effective and this was made possible by the ICTs. Teachers asserted that the evidence of learners' understanding of the content was deduced from the level of interaction between the learners and the teacher, amongst learners themselves. The learners' responses to the questions during the lesson and after the lesson promoted active learning and served as an indication that learning was enhanced (Khan, Khan, Din & Ismail, 2015). According to the LS CAPS document as it was discussed in Chapter 2 the curriculum imperatives, the participation of learners by being able to: Name, List, Discuss, Describe, Explain, State, and Identify certifies that they understood the content and therefore learning was enhanced. However, this is what is known as shallow learning and not the kind of deep learning that endures. By deep learning, I mean,

> *Students should thus be given opportunities to reflect on course material and connect it to their own lives. Our contention is that the integration of intellectual and personal will lead to deep learning that endures. Students learn better when the content evokes their personal experiences and emotions. When information is emotionally relevant, it comes alive and students are likely to better understand, remember and apply it, resulting in deeper learning. Such learning goes beyond academics and the development of the intellect… (Agherdien & van Breda, 2012, p. 127)*

The assessment was conducted verbally and written as a form of confirmation that the learners understood the content. However, it should not be taken for granted that learning is enhanced when learners are participating during the lesson. The learners' participation at that point could be attributed to other factors, namely, the excitement of wanting to know a concept, the fear of being passive and submitting to the expectations of the teacher. Therefore, this calls upon the significance of formal assessment which was discussed in section 5.3.

These findings conformed to the conceptual framework illustrated by Figure 2 in section 2.10 that understanding the uses of ICTs (media forms and their affordances) should reveal the pedagogical value based on how the learning will be enhanced. The affordances that were revealed from the findings include multimodality, articulation, immediate feedback, and group discussion. The media forms identified are narrative, interactive, and communication. The implication of these findings is that teachers should have a positive perception towards the use of ICTs. This means that teachers would be able to see the pedagogical value that comes with the use of ICTs.

In essence, the main aim of education is to ensure that learners are equipped with knowledge, skills, attitudes, and values that could serve them in their daily lives. This is partly achieved when their understanding of the subject is enhanced. Therefore, it is crucial for LS teachers to employ pedagogies that will enhance learners' understanding of the subject. It is also at their (the teachers') discretion to choose ICT tools and pedagogies according to the requirements

of what will be taught. The following section provides an analysis of the factors influenced by teachers' perceptions.

5.4 FACTORS INFLUENCED BY THE TEACHERS' PERCEPTION

This study revealed that the factors in the analytical tool were influenced by teachers' perceptions towards the use of ICT in LS. Those factors include media forms, cognitive skills, and affordances. This in turn determines the enhancement of learning in LS. It should be noted that learning in this context is certified only if it is aligned with the specific aims stipulated in the LS CAPS document and LOs. An analytical framework was formulated from the results on how perception influences the use of ICT. This framework was used to present the findings. The schematic representation of the framework is illustrated in Figure 12 below.

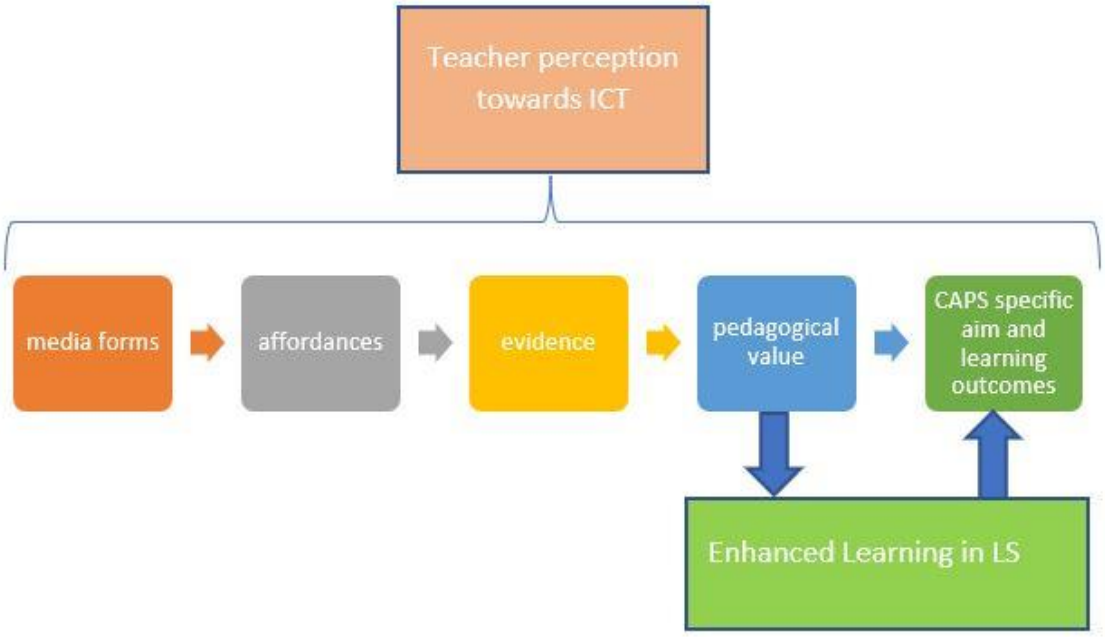


Figure 12: Relationship between perception and the factors in the analytical tool.

Figure 12 illustrates how teacher perception towards the use of ICT influences its effectiveness to enhance learning in LS. According to this analytical framework, the way in which teachers perceive the media forms, the affordances associated with the media form, the evidence, determines whether they will see the pedagogical value that can enhance learning in LS, which in turn aligns with the CAPS specific aims and achieves the LOs. The following section provides the contribution of the study.

5.5 CONTRIBUTIONS OF THE STUDY

This study strengthens the assertion made by the Minister of Education (2004), Naledi Pandor (see section 2.7) who asserted that many schools are exploiting the benefits of ICTs to enhance the standard of teaching and learning (DBE, 2004). This study witnessed and confirmed that the use of ICTs enhanced learners' understanding of LS, provided that the pedagogy was sound. There was a relationship between the teachers' perception of the pedagogical value of ICTs and how they integrated it to enhance learners' understanding. The study revealed the affordances of ICTs in LS teaching and learning. All six LS teachers were confident of their preparation and their use of ICTs in their teaching, and this contributed to the way they presented their lessons to enhance learning. There was consistency between what the teachers planned and communicated during the interview before the lesson presentation, what took place during the actual lesson presentation, and their responses during the interview after the lesson presentation. It can be concluded that ICTs can be used to enhance learners' understanding of LS. However, it should be noted that this conclusion is based on verbal assessment that was conducted by the teachers and the researcher's creation of reality. This is because there were time constraints. Therefore, there was still a need for written assessment to ascertain the learners' understanding.

The theoretical implications of these findings are based on an interpretivist paradigm that was discussed in section 3.2. The results show that reality was created through the pedagogies implemented by the teachers during their lesson presentations. The practical implication of these findings is that the use of ICTs is based on pedagogies that can be universal and subject specific. Section 2.6 revealed that there is still a gap to provide subject-specific ICT pedagogies. These pedagogies might not be implemented in their natural form but can provide guidelines for teachers to tailor according to their needs. The limitations that were identified in this study are discussed in the following section.

5.6 LIMITATIONS

Limitations in the context of this study refers to the factors that disturbed the smooth collection of data. According to the scale of this study, the findings were limited based on the scope and duration. A limitation of this study is that the use of technological applications like

MS Teams and WhatsApp disturbed the data collection process. Being limited to technology for data collection, there were issues of poor network coverage which led to unclear communication and loss of some information. The challenges included poor network connection, low performance laptop devices, and load shedding or power outages. Poor network connection made it difficult for me and my participants to connect through MS Teams for the lesson observation. This was time-consuming, and some time was wasted in the process. The usage of low performance laptops was probably another cause of the unclear view of the MS Teams video, the sound freezing of the device. The power outage disturbed the schedule planned for data collection and this inconvenienced one of the teachers in terms of time. These factors also made it impossible to use certain functions that are afforded by MS Teams, like the transcription of the meeting.

The small sample size did not allow a plethora of data to make a firm conclusion. The major limitation of this study is the effect of the global pandemic, Covid-19 led to a delay and restricted time granted for collecting data by GDE. This study was limited by the time constraints for data collection. The sample makes these findings less generalizable to address the research question. The study did not evaluate the use of ICT beyond the school level for teachers and learners. It is unfortunate that the study did not include socio-economic factors that could affect the use of ICTs in LS. The main weakness of this study is to base learners' understanding on their participation during the lesson. Since the study was limited to time, it was not possible to formally assess the learners' understanding. An issue that was not addressed in this study was whether these pedagogies are really subject-specific or not. I suspect that it may not be. Therefore, the following section provides recommendations for further studies.

5.7 RECOMMENDATIONS FOR FURTHER STUDIES

The findings in this study revealed the need to establish subject-specific pedagogies that are ICT integrated. The rationale for this study was to bridge the gap between general ICT pedagogies and subject-specific pedagogies. However, there is still a need to explore and expand the same topic. The limitations that were mentioned in section 5.6 might have restricted the collection of data. Therefore, further studies are required to explore more subject and topic-specific ICT-integrated pedagogies that can enhance learning in the subject.

This is necessary because LS consists of various topics that may require different pedagogies. Consequently, teachers require guidelines on how to use ICT across the subject and different topics.

Possible research questions for consideration are:

1. How can teachers integrate ICT to teach different topics in LS?
2. What are the factors that can influence the pragmatic use of ICTs in LS?
3. How could LS teachers' perceptions, emotions, knowledge, skills, and experience shape the successful integration of ICTs in teaching?

5.8 CONCLUSION

This study managed to explore the uses of ICTs in LS teaching and learning. There were similarities across the ICT-integrated pedagogies employed by the LS teachers in their lessons. The ICT tool that was common in all the lessons was a smartboard. All the teachers used the smartboard to display information multimodal. The pictures and words elucidated the content for the learners. This approach afforded interactive participation between the teacher and learners. It can be concluded that an understanding of the pedagogical value of ICT creates more opportunities for learning to be enhanced.

While it is teachers that invest in trying different ICT pedagogies that will increase the likelihood for learners to learn deeply, both learners and teachers matter in ICT integration to enhance learning in LS. Perhaps more importantly, if learners are not given opportunities to apply the learning, engage in a critical way and ultimately relate its importance to their lives, pedagogical/ICT integration efforts remain futile.

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APPENDIXES

A. Observation tool

What ICTs are used? (Computers, Laptops, Smartboard, Smartphones, Overhead projector)	Which Media form do they belong to? (Narrative, Interactive, Communicative, Adaptive or Productive)	When are the ICTs used in the lesson? (Lesson introduction, body of the lesson, summary of the lesson)	What are the ICT affordances used? (Non-linear, Immediacy, Collaboration, Diversity, Articulation)	How are the Affordances used? (Multimodality, Immediate feedback, Discussion: class/ group, Reproduction: experiment/ role play, Product: animation/model)	What pedagogical value does it add? (Does it enhance learning)	Is learning enhanced? (Does it achieve the CAPS objectives, evidence)

B. Interview questions

Before the lesson presentation:

1. How do you maintain curriculum focus?
2. How do you intend to actively engage my learners in higher order thinking and interactive activities?
3. How do you make the best use of digital tools?
4. How are you going to find and use digital content?
5. How will the digital tools and resources facilitate assessment?
6. Will your learners be more skilled and have better understanding of the subject content?

After the lesson presentation:

1. How did you maintain curriculum focus?
2. How did you actively engage my learners in higher order thinking and interactive activities?
3. How did you make the best use of digital tools?
4. How were you able to find and use effective digital content?
5. Have digital tools and resources facilitated assessment?
6. Are your learners likely to be more skilled and have better understanding of the subject content, and how did I ascertain this?

C. Analytical tool

Media forms	**How (ICT) and When (cognitive levels) can it be used in LS**				**Affordances**
	ACQUIRE	UNDERSTANDING	APPLICATION	ANALYZE	
Narrative					Non-linear
Interactive					Immediacy
Communicative					Collaboration
Adaptive					Diversity
Productive					Articulation