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PROJECT TITLE

The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class

A research proposal submitted in partial fulfilment of the requirements of the Master of Education (Coursework and Research Report), University of the Witwatersrand

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Abstract

This report investigates the use of Information and Communication Technologies (ICTs) to promote and enhance critical thinking in learners in a secondary school in South Africa. The aim is to uncover how a teacher incorporated ICTs in her classroom teaching in order to develop the five intellectual resources within critical thinking, as argued by Bailin (1999).

The focus is on how the teacher found a preferable teaching approach to enhance critical thinking through specific ICT tools.

Case study findings illustrate how ICTs were incorporated within a grade ten class to promote critical thinking. In order to promote the five intellectual resources of the critical thinking process in line with Bailin (1999), data was analysed qualitatively from class observation, a questionnaire, interview and samples of learners' tasks.

The theoretical focus comprises of constructivism theory, the critical thinking perception of Bailin (1999), and the specific five intellectual resources. The main purpose of the report is to explore how the teacher used ICTs to create a learning environment where learners were encouraged to interact and engage with their peers and teacher.

Thus, this report demonstrates the ICT types that the teacher incorporated in her Life Science classroom to stimulate and promote those intellectual resources that learners require for deliberate thinking.

Keywords: *Information and Communication Technologies (ICTs), intellectual resources, intellectual products, critical thinking, constructivism, engagement and interactions.*

Declaration

I declare that this research is my own unaided work.

It is submitted for the degree of Master of Education in Educational Technology (Education Department) at the University of Witwatersrand, Johannesburg and has not been previously submitted for any other degree or examination at any other university.

_____

Mei June Luo

25 June 2019

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Chapter 1 INTRODUCTION

1.1 Overview

The South African Curriculum and Assessment Policy Statement (CAPS) document, (DoE, 2011) advocates that Life Sciences teachers integrate critical thinking into their content delivery in order for learners to competently achieve the learning outcomes of the subject. To facilitate critical analysis and the evaluation of scientific issues and processes inherent to Life Sciences, teaching resources must play a crucial role. This is particularly relevant in cases where not all scientific claims can be proven with empirical evidence. Teachers can use attributes of Information and Communication Technologies (ICTs) such as multimedia, to demonstrate and illustrate the complex subject content that learners often struggle to visualise and assimilate. To understand key aspects, specialised ways of dealing with the subject matter is called for. In line with this, the White Paper on e-Education (DoE, 2004) presented ICTs as learning tools with the potential to develop creative thinking.

Critical thinking refers to a quality of good thinking that fits into the appropriate standards or criteria of a subject (Bailin, 1999). When learners possess critical thinking skills, they are able to incorporate skills such as a problem-solving, reasoning, formulating inferences, calculating likelihoods, and making decisions (Halpern, 1999) within a subject context. Critical thinking controls the way such skills are executed within subject context. These skills are not engaged when a learner solves a problem through sloppy, superficial and careless thinking (Bailin, 1999).

The current study seeks to investigate the extent to which a Life Science teacher used ICTs in her teaching. The purpose of this study is to determine how the teacher used digital technology to create a learning environment for learners where they could develop their critical thinking to successfully manipulate the subject matter.

Halpern (1999:69) maintained that technological and workplace changes emphasise the ability to think critically. The already-mentioned South African ICT in education policy document, the White Paper on e-Education (2004:8), acknowledged this view by referring to the global revolution that is constantly taking place in education and training. The so-called revolution is driven by the changing nature of work, the certainties of the information age, new global partnerships and an awareness of the equal distribution of educational

opportunities. Equal education can be interpreted as delivering content in such a way that each subject's standards or criteria are met by all learners, regardless of their learning styles or the learning barriers they might experience. When critical thinking (required to meet these standards) is developed in learners, they are equipped to tackle complex tasks in their subjects.

This study therefore seeks to determine whether a teacher's ICT integration in teaching a Life Sciences topic in a South African school emphasised the development of critical thinking in learners in the Life Sciences classroom.

1.2 Rationale

The influx of digital technology has substantially contributed to the field of Life Sciences. Easy access to information and data processing has rendered more efficient scientific procedures. It is crucial that the school system prepares learners to operate in life science environments by inculcating in them a fundamental understanding of this discipline. The Curriculum and Assessment Policy Statement (2011) highlights the development of critical elements Life Sciences learners. According to this policy, learners should possess:

> *Knowledge of key biological concepts, processes, systems and theories; an ability to critically evaluate and debate scientific issues and processes; greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind; scientific skills and ways of thinking scientifically that enable them to see the flaws in pseudo-science in popular media; and a level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations.*
>
> (Curriculum and Assessment Policy Statement, 2011:14)

The above criteria promote learners to think and operate in particular ways. The question is whether their schooling actually prepares them for real life complex issues and ill-defined problems in the science discipline (Halpern, 1999).

Literature discloses that in most cases Life Science teaching involves that learners memorise factual knowledge, which they then later reproduce in assessments. Bissell and Lemons (2006) maintained that learners merely recite the teacher's facts that they have memorised or learned from the lesson or textbooks. Such learning often negates the acquisition of critical

thinking that should form for learners the basis of understanding and functioning in complex situations.

Sandholtz, Rinstaff and Dwyer (1997:174) identified technology as particularly significant when used with constructivist teaching approaches. Such approaches underline problem solving, concept development, and critical thinking, instead of simply gaining factual knowledge.

Through observing a Life Science teacher, the researcher will investigate if such teacher's approach to using ICTs promotes critical thinking or critical scientific inquiry skills within Life Science learners.

1.3 Research aim

The CAPs document (2011) and the White Paper on e-Education (2004) both accentuate the use of modern technologies to develop critical thinking so that learners can be adequately prepared for participating meaningfully in contemporary society. The aim of this research is to investigate whether the Life Sciences teacher's use of ICTs promoted critical thinking in her teaching. The focus was on themes[1] from the subject matter. To achieve the aim, the following objectives were formulated:

- To establish the extent to which background knowledge influences the promotion of critical thinking in a Grade 10 Life Sciences class.
- To establish the extent to which knowledge is operationalised in order to set the standards or principles for critical thinking in a Grade 10 Life Sciences class.
- To establish the extent to which the Life Sciences teacher promotes learners to identify and apply the correct usage of key critical thinking concepts.
- To establish the extent to which heuristics is promoted in Grade 10 Life Sciences learners, so that they could become conscious of their thinking processes.

To identify whether the Life Sciences teacher develops a habit of critical thinking within learners.

[1] Lesson one focused on biodiversity; lesson two on classification lesson three on evolution and natural habitats; lesson four on animal kingdom and lesson five on bacteria kingdom.

1.4 Research questions

1.4.1 Primary research question

Does the teacher use Information and Communication and Technologies to promote critical thinking while teaching Life Science topics?

1.4.2 Secondary research questions

1. What are the Life Science teacher's perceptions of the critical thinking required for teaching the topic?
2. How does the teacher engage learners with ICTs, in order to develop critical thinking?

    a) What teaching approaches and integration strategies are used by the teacher to promote critical thinking?

        - How does the teacher integrate ICTs to encourage learners to use their background knowledge to think critically?
        - How does the teacher incorporate ICTs into her Grade 10 Life Science class to create standards for critical thinking by means of operationalised knowledge?
        - How does the teacher integrate ICTs into the Life Science class, to enable learners to identify and apply the correct key critical concepts of critical thinking to problems or context?
        - How does the teacher use ICTs to develop learners to become conscious of their thinking processes?
        - How does the teacher integrate ICTs in such a way that Grade 10 Life Science learners develop a habit of critical thinking?

1.5 Research design

According to Visagie (2010:29), the research design is the blueprint for answering to objectives and the research questions. Due to the nature of the current study, the researcher used the qualitative case study approach. The purpose of this study supports the in-depth analysis and perceptions of specific individuals (the Life Science teacher and her learners) regarding their experiences of ICTs and how these experiences or interactions encouraged critical thinking within the Grade 10 Life Science class. In order to make sense of the research questions, the researcher intended to gather sufficient data within a specific case.

1.6 Delimitations

According to Simon (2011:2), the delimitation of the research study defines the borders or parameters of the study. This study focuses on a case study of an individual teacher and a Grade 10 class while the teacher facilitated topics within the Life Sciences class.

The research study does not focus on other grades or on the entire school, as the researcher intends to demonstrate the significant rich experiences of one teacher only. Also, the study focuses on the particular teacher's perceptions of critical thinking in relation to that of the students while she delivered a specific topic. By doing so, the researcher gained a deeper understanding of the teacher's experience with her students and the subject matter that she discussed with the students.

The focus is also on how the teacher's perceptions of learners' states of critical thinking influence her use of ICT in the classroom. ICT becomes tool to promote a richer and more balanced understanding of the topic at hand. Quantitative methods would not have allowed the researcher to obtain this level of understanding. The researcher required a rich set data.

1.7 Chapter outline

- Chapter two (2) covers the literature review that assisted the researcher in gaining insight on related research. This includes the definition of critical thinking, the

teacher's perception of ICTs, the appropriate methodological teaching approach, and a conceptual framework for this study.

- Chapter three (3) reports on the research approach used in this research study. The instruments, data collection and analysis methods are discussed.
- Chapter four (4) sets out the data analysis and records the study findings.
- Chapter five (5) concludes the study and makes recommendations.

1.8 Conclusion

This chapter set out the research topic with the aim of seeking appropriate answers to the carefully formulated research questions. The qualitative case study method was selected as the best approach to address how a teacher promoted critical thinking within her learners through applying Information and Communication Technologies in her teaching. The chapter also presented the research design (which will be further discussed in Chapter 3) and chapter outline.

The next chapter presents the literature review.

Chapter 2 LITERATURE REVIEW

2.1 Introduction

With the influx of Information and Communication Technologies (ICTs) in schools, tertiary institutions and workplaces, educational experiences for both teachers and learners have shifted from a traditional to a learner-centred teaching approach. The new approach seems to favour the use of ICTs as a better alternative to the text-based form of teaching and learning that supports the old style.

The current study is based on new teaching approaches, specifically concerning the Life Science subject at high school level. The study seeks to investigate how a Life Science teacher in Grade 10 used ICTs to develop critical thinking within Life Science subject matter.

This literature review begins by justifying the change of the subject name. Previously, 'Life Sciences' was known as 'Biology' (as used in most literature). The name 'Life Sciences' is currently used in the South African curriculum. Meaningful ICT pedagogical integration and recommended teaching approaches are discussed next. Before critical thinking is discussed within the context of Life Science, discourses are presented on misinterpretations around critical thinking.

The focus of the discussion is on how to measure critical thinking. Lastly, case studies are presented, not only from South Africa, but also from other countries.

2.1.1 From 'Biology' to 'Life Science'

The researcher is in favour of clarifying the origin of the subject name, 'Life Science', as its change relates to the way the discipline should be handled in a teaching and learning context. In the CAPS document (2011), the subject name 'Biology' was changed to 'Life Science', to emphasise that the subject is essentially a science. The implication of this change was that, as a science subject, it would, for content delivery, adopt teaching methods that are also used in other science subjects, like Physical Science and Chemistry. The CAPS document (2011:3) describes Life Science as "…the scientific study of living things from molecular level to their interactions with one another and their environment." This basic principle accentuates the

subject's scientific attributes. Life Science is not merely a study of living things on Earth because it covers a scientific understanding of the interaction between living things and the environment. This study therefore adopts the term 'Life Science', as this is currently the functional name in the South African education context, upon which this research is based.

2.2 Meaningful ICT pedagogical integration

Ertmer (2006) and Belland (2009) both state that ICT integration refers to the teacher's capability to use technology to promote critical thinking within learners through the constructivism approach. Although the use of ICTs or technology integration is crucial in any classroom's teaching and in learning in the current age, most teachers only use technologies on a superficial level in teaching and learning. Belland (2009:354) defines technology integration as "the sustainable and persistent change in the social system of K-12 schools caused by the adoption of technology to help students construct knowledge." Therefore, meaningful classroom teaching happens when a teacher enables learning through the integration of technologies in a constructive manner.

Pierson (2001:427) indicates that technology in the hands of a typical teacher will not automatically produce integrated and meaningful use. If a teacher does not view the use of technology as an essential part of the learning process, it will simply continue as marginal to teaching.

The South African education policy document, the White Paper on e-Education, (2004:16) states the following:

> *In a transformed teaching and learning environment, there is a shift from teacher-centred, task-oriented, memory-based education (with technology at the periphery), to an inclusive and integrated practice where learners work collaboratively, develop shared practices, engage in meaningful contexts and develop creative thinking and problem-solving skills.*

Through integrating ICTs into classroom teaching, a teacher can provide meaningful resources to enable learners to become critical thinkers. For instance, ICTs can be integrated to enrich constructivist teacher attributes, through engaging in dialogue, encouraging thoughtful, open-ended inquiries by learners, elaborating on learners' initial responses, engaging in discussion, and testing hypotheses.

Due to the high demand of technology innovations and the fast growing pace of Information and Communication Technologies (ICTs) in the workplace, teachers are encouraged to use ICTs because it can introduce exciting curricula learning activities into the classroom. Such activities can be based on real-world problems and provide scaffold and tools to enhance learning (Kozma, 2003).

However, teachers often choose to use technology to teach only basic digital literacy skills to learners, instead of integrating Information and Communication Technologies as a tool to teach across the curriculum. This happens because teachers misinterpret the importance of learners' development for job skills (Sandholtz et al. 1997). In fact, teachers need a clear understanding of the definition of ICT integration before they can actually apply it in the classroom meaningfully. Sandholtz et al. (1997) points out that if the use of ICT in schools is to become more relevant than simply preparing learners for technical job skills, teachers' main goal should be to achieve educational outcomes. In other words, their main goal should be

> *to help learners to become more comfortable with using technology and to understand ways in which technology may be most powerful, such as; locating and accessing information, organising and displaying data, creating persuasive arguments, and dynamically demonstrating ideas and conclusions to critical audiences of peers.*
>
> (Sandholtz et al. 1997:175)

ICT integration is thus not the simple use of ICTs to replace traditional worksheets or activities (e.g. using Microsoft Word or Excel spreadsheets for class records or assignments) as a form of drill and practice for learners. The interactivity of technologies therefore becomes a "key feature that enables students to receive feedback on their performance, test and reflect on their ideas, and revise their understanding" (Kozma, 2003:1).

Meaningful integration of ICTs into a teacher's classroom does not depend on the type of ICTs that are used. Instead, it is about *how* teachers use ICTs in the classroom (Bransford et al. 2000 cited in Kozma, 2003). The *how* part of using ICTs may shift the teacher's classroom pedagogy to one that does not hinder learners' learning development. Consequently, in order to use ICTs successfully in any teaching and learning experiences, ICTs must be integrated in

such a manner that the teacher encourages a learner-centred environment (or teaches with a constructivist approach).

2.2.1 ICTs and learner-centred instruction (constructivism)

Ertmer (2006) emphasises that low level technology use is usually associated with teacher-centred practices. On the other hand, high level technology use is associated with student-centred or constructivist practices.

Sandholtz et al. (1997:13) explains as follows: "In knowledge construction classrooms, teacher-student interactions are less didactic, more collaborative." Collaborating or interactions amongst the teacher, learners and between learners create the sense of a real-word learning environment. Since real problems in workplaces are solved through conversations, inquiry, and trial and error, there is a need to constantly compare one approximate solution against another to seek alternative solutions critically and objectively (Sandholtz et al. 1997). Additionally, "the process of inquiry and invention lead to the discovery of facts" (Sandholtz et al. 1997:13). Thus, with the integration of ICTs, a teacher may encourage knowledge construction and collaboration with learners through using various types of computer software (or the internet) to enhance dialogue engagement in the classroom. Consequently, the use of appropriate ICT tools would engage learners in critical inquiry and enable them to seek elaboration on certain discussed concepts.

Although ICTs are regarded as vital in learners' schooling experiences (for developing their critical thinking), it must be borne in mind that technologies cannot replace the role of a teacher (Sandholtz et al. 1997). Teachers, therefore, should be more aware of how they implement ICTs in the classroom when meeting the requirements of a subject's curriculum framework. Teachers need to apply appropriate teaching pedagogies to meet the relevant needs in a particular time or space for the class. Noddings (1990), cited in Sandholtz et al. (1997:13) denotes that, while cognitive principles of constructivism cannot command specific teaching methods, it can present excellent teaching strategies.

In order to investigate how ICTs were used in the Life Science classroom to promote critical thinking in learners, the researcher needs to define critical thinking.

2.3 What is critical thinking?

Most literature defines critical thinking as related to cognitive or mental process skills. For example, Sternberg (1986) and Halpern (1999) describe critical thinking as the use of cognitive skills or mental processes as strategies to increase the probability of a desirable outcome. Additionally, McPeck (1981) emphasises that critical thinking should appropriately use reflective scepticism within the problem area under consideration. Astleitner (2002) further typifies critical thinking as higher order thinking skills, which mainly consist of evaluating arguments.

These definitions of critical thinking nevertheless fail to address the essence of critical thinking. Critical thinking is not simply another term for higher order thinking, nor is it a cognitive skill or mental process that can be physically observed by the teacher. Critical thinking, according to Bailin (2002:363), "is, however, centrally a normative concept." It is therefore the quality of good thinking that fulfils the appropriate standards or criteria in that specific context or subject curriculum (Bailin, 2002). For that reason, critical thinking derives from the norm of the specific subject context.

Critical thinking is often misinterpreted by teachers as a set of skills or abilities that learners have to acquire in order to become successful critical thinkers (Bailin, 1999). It is crucial that the teacher has a clear understanding of critical thinking because learners are prone to think uncritically as long as they receive no guidance on how to engage with the discipline. For instance, if learners were to evaluate or make a moral judgement through superficial or careless procedures that do not meet the relevant norm or standards of the specific context, then evaluations or solutions would be formed in an uncritical manner (Bailin, 2002). As a result, higher order thinking skills (such as the higher levels in Bloom's Taxonomy) would be uncritically if the teacher misinterprets the essence of critical thinking. This explains why, at times, some academically gifted learners fail to score high results in some subjects. The reason is that they might not have taken hold of the critical thinking that is required to function in some areas.

Thus, to demystify the obscure meaning of critical thinking, the teacher should determine what must be understood in order to meet the relevant criteria of good thinking in a particular context (Bailin, 2002). According to Bailin (1999), such an understanding includes intellectual resources, such as key concepts, operational knowledge, heuristics, ideal habits of

mind, and background knowledge. These concepts are outlined in the conceptual framework of this research report.

In the context of this research, the researcher aims to examine the requirements of critical thinking in the Life Science subject matter.

2.4 Critical thinking in Life Science

Since critical thinking is the quality of good thinking, it is contextual. Applying this conception in Life Science involves focusing on criteria for specific tasks, problems and issues in the Life Science curriculum. Likewise, it is necessary to identify the critical thinking needed for accomplishing these tasks (Bailin, 2002). Procedures such as testing hypotheses, planning experiments, and drawing conclusions must be solved or practiced in a critical manner that meets the appropriate standards of the specific context.

Bailin (2002:363) emphasised that while conceptualising critical thinking in terms of a set of procedures is common in science literature, it is also complex. Therefore, we cannot simply assume that scientific skills or procedures (for achieving or overcoming) provide a starting point for teaching and learning critical thinking, simply because critical thinking is scientific inquiry skills, as Zohar and Tamir (1994) argued. Based on Bailin's (2002) argument that is adopted in this research, this is not true.

Case studies from most literature sources, such as the one presented by Zohar and Tamir (1994) investigate higher order thinking skills, instead of critical thinking. Zohar and Tamir (1994) indicate an overlap between critical thinking skills and the skills needed for inquiring scientific manner. These researchers set up a biology critical thinking project in which they carefully designed activities. The aim of these activities were to develop specific critical thinking skills that fit into the biology curriculum (Zohar and Tamir, 1994).

The researchers selected two control groups. One group was investigated under the Biology critical thinking project, while the other group was investigated as they were learning Biology under normal conditions. The group that participated in the Biology critical thinking project improved their critical thinking skills, compared to their initial level, and compared to their counterparts in the control group (Zohar and Tamir, 1994:193). Although Zohar and Tamir claimed to have focused on critical thinking skills in terms of the Biology curriculum, they

failed to develop the nature of critical thinking within their participants. The reason for this can be attributed to their description of critical thinking as skills or critical thinking skills as similar to the skills one needs to inquire scientific manner. As emphasised by Bailin (2002), critical thinking should exist in every scientific skill, for instance in arguments, information gathering, data analysis, data and information synthesis.

The identification of critical thinking in the Life Science subject demands a precise understanding of what type of thinking is needed in the entire learning process. The teacher focuses on particular criteria that are central for the learners' critical evaluation of a particular area. While they do this, the learners apply key concepts, heuristics and strategies to critically respond to biological challenges. In this way, a certain habit of mind is created within learners who think critically and present their intellectual resources (Bailin, 2002).

The process of developing critical thinking has to be continuous if learners are to reach higher levels in the intellectual resources. According to Bailin (2002:370), "We can also try to motivate students to care about thinking well. Thus, it is through teaching the appropriate resources, highlighting the range of areas in which particular intellectual resources apply, and fostering the appropriate habits of mind, that we have our best chance to promote critical thinking." Therefore, a teacher needs to systematically apply appropriate intellectual resources in order to promote and develop the habit of thinking critically in any Life Science classroom. The use of the right teaching approach and resources, as mentioned above, would contribute to successfully imparting critical ways of thinking.

2.5 Measuring critical thinking

According to Bailin (1999), five intellectual resources characterise a critical thinker, namely, (a) background knowledge, (b) operational knowledge of appropriate standards, (c) knowledge of key concepts, (d) possession of effective heuristics, and (e) certain habits of mind. These intellectual resources are useful in providing the teacher with an instrument to measure critical thinking.

One of Bailin's (2002) examples is an activity where learners have to prepare a presentation where they evaluate whether a causal link exists between smoking and stroke in humans. The learners require biological background knowledge of stroke and its causes before they can move to the next step. Thereafter, the learners need to find appropriate key concepts in order

to identify relevant intellectual products for answering the causal link between smoking and stroke. Furthermore, before learners answer the question, they need to determine "the criteria for judging that a causal link does exist would include that studies use adequate sample size that all relevant variables have to be controlled" (Bailin, 2002:372). Therefore, through the process of the above-mentioned intellectual resources, learners develop certain habits of mind in which they can think critically and open-mindedly (Bailin, 2002).

Lombard and Grosser (2008) conducted a quantitative study to determine the effectiveness of curriculum 2005, known as Outcome Based Education (OBE) in inculcating critical thinking. The investigation was carried out with a group of first years in an educational school in South Africa. Since no instrument was designed specifically for the South African context, they used the Watson Glaser Critical Thinking Appraisal Test (WGCTA). This instrument is a "development and refinement history of 50 years" (Lombard and Grosser, 2008:566). The tool measures critical thinking through practical issues found "in original settings" (Lombard and Grosser, 2008:567). Although this instrument is highly recommended, particularly for its flexibility, its weakness in the context of this research is that it is not subject-oriented. It would therefore not assist in determining critical thinking in the context of Life Science. However, the research findings revealed very little evidence concerning the "development of the research participants' critical thinking abilities at school level" (Lombard and Grosser, 2008:572). It is possible that these results could still be relevant today, especially considering the fact that new curriculum statements (CAPS) have been launched. It is therefore in the interest of this research to use a subject-based framework to determine the development of critical thinking through the use of ICTs.

2.6 Theoretical framework

This research adopts a theoretical framework based on principles from Bailin (1999), other researchers' intellectual resources for critical thinking, and constructivists' principles. The intellectual resources are developmental, which leads the learner to a state where he or she acquires the necessary critical thinking to operate efficiently in their learning environment. The concept closely relates to constructivism (Lunenburg, 1998 and Vygotsky, 1978) as it advocates development in learning and in reaching higher levels of understanding.

This framework will attempt to explain how constructivists' approaches and ICTs as meditational tools may assist teachers to develop critical thinking within the context of teaching Life Science.

2.6.1 Intellectual resources of critical thinking

As mentioned earlier, critical thinking is the quality of good thinking, which has to meet relevant criteria or standards (Bailin, 2002). To think critically is to objectively apply appropriate reasoning steps to reach alternative solutions. Critical thinking (as good thinking) fulfils the relevant criteria or standards and for that reason, the appropriate criteria should determine the important traits of critical thinking (Bailin, 1999). However, traits of critical thinkers are often associated with a certain set of skills, abilities, and the disposition that one needs to achieve. These characterisations imply certain outcomes for critical thinking (Bailin 1999). For instance, if the teacher defines critical thinking as the skills or abilities required to complete tasks (gathering information, synthesis and analyse information, etc.) then he or she would measure critical thinking in terms of how successfully learners complete relevant critical thinking tasks.

Therefore, according to Bailin (1999), the best way to describe critical thinking is in relation to intellectual resources. These intellectual resources refer to the resources one needs to become a successful critical thinker. As mentioned before, these intellectual resources are: (a) background knowledge, (b) operational knowledge of appropriate standards, (c) knowledge of key concepts, (d) possession of effective heuristics, and (e) certain vital habits of minds. These five intellectual resources will assist the researcher to identify critical thinking while teaching Life Science topics.

(a) Background knowledge

In order to engage critical thinking in any situation, people critically solve problems with their existing concepts, beliefs, values, and ways of acting within a specific context (Bailin, 1999). Consequently, one's background knowledge determines the standards or criteria for good thinking, since the knowledge or practices one may receive in one's lifetime affect or establish one's level of critical thinking in that specific context (Bailin, 1999). Therefore, critical thinking helps to understand the nature of the problem. It also helps to deliberate with careful consideration in order to accept or reject any alternative solutions. The use of ICTs such as multimedia to

expose learners to experiences that would help them have a clear and vivid understanding of knowledge of biological aspects would be useful. For instance, showing them how the heart pumps blood and the physiological effects of this process through simulation would create a rich learning environment that learners would need to think critically in a situation demanding those understandings.

(b) Operational knowledge of the standards of good thinking

According to Bailin (1999:291), "…knowledge, at the operational level, of the standards that govern critical deliberation and judgement, is necessary for anyone who would think critically."

The knowledge that is learned by a learner helps him or her to create certain required standards or principles to follow within a given situation. These principles could be:

> *Standards of practical deliberation, standards of argumentation, standards used in developing plans of action (as in artistic and athletic performance), and standards governing inquiry and justification in specialised areas of study such as art, biology, history, literary criticism, mathematics, and technology.* (Bailin, 1999:291)

The standards or principles inherent in operational knowledge provide critical thinkers with a set of rules or logic that they need to perform, together with a demonstration that can be used to measure the degree of their critical thinking. Furthermore, these standards or principles are rules that may be criticised or altered, depending on the knowledge or previous knowledge one has about the context (Bailin, 1999). A demonstration of these operations in Life Science might not be feasible, but a video demonstrating it may be useful in giving learners the same or similar experience for them to understand what happens in the real world.

(c) Knowledge of key critical concepts

One needs to distinguish different kinds of intellectual products in order to find relevant evidence or arguments to assess or make better judgements of any complex problems. Bailin (1999:293) emphasise, "Criteria and standards relevant to assessing intellectual products vary from one sort of intellectual product to another." In other words, the outcome desired for a particular unit will have its own key critical concepts

that form the pillar of understanding for that content. Therefore, it becomes critical that the teacher identifies these critical concepts and ensures that learners master them so that they may use them to think critically and make informed decisions. The colourful and three-dimensional images in ICT simulations and other illustrations would make it easy for learners to remember key critical concepts.

(d) Possession of effective heuristics

Learning should be scaffold so that learners are enabled to discover or explore new knowledge for themselves in order to solve problems. This can be done by encouraging them "to ask themselves every five to ten minutes whether they are making progress, whether they should change directions and what their opinions are" (Perkins cited in Bailin 1999:293). The most effective heuristics, according to Bailin (1999:293) are those "designed to guide persons in carrying out specific kinds of tasks." To engage critical thinking, learners need to be in a position to decide what heuristics are critical in carrying out complex tasks. Therefore, it is crucial that the teacher creates a learning environment that encourages learners to be conscious of their thinking progress. Modern technologies through the internet for instance provide access to these strategies and learners can benefit from being exposed to them in a well-planned lesson.

(e) Certain vital habits of minds

According to Bailin (1999:294), "One must also have certain commitments, attitudes or habits of mind that dispose him or her to use these resources to fulfil relevant standards and principles of good thinking." Thus, it is vital for the teacher to consistently construct learning environments where learners will be comfortable to engage critical thinking. In this way they would be able to apply and deepen their understanding of disciplinary knowledge. Working with ICTs, particularly in formative (automated) assessments, is a convenient way to get learners into the habit of thinking that is required for particular tasks, without exhausting any human agent.

The above-mentioned five kinds of intellectual resources portray certain intellectual resources that a teacher should prepare (and constantly be aware of) in order to engage learners in critical thinking. These intellectual resources present the teacher as a mediator, facilitator, and a master of knowledge. The use of ICTs as meditational tools provides the teacher with

resources to use in order to scaffold learners to advance from one level of critical thinking development to the next. The adoption of constructivism as a learning theory therefore makes sense in the development of critical thinking for learners.

2.6.2 Constructivism

The main theme across the theory of constructivism is knowledge construction via a teacher's presentation. The teacher, as a facilitator, guides learners into constructing new knowledge. Duffy and Cunningham (1996:171) indicate that constructivist learning is "…an active process of constructing rather than acquiring knowledge, and instruction is a process of supporting that construction rather than communicating knowledge." With the change of instructional process to constructivism, the principles within a teacher's attributes shifted from one of direct instruction to constructivist instruction. Consequently, the principles of constructivist teaching provide a teacher with the required strategies and tools to scaffold Bailin's five kinds of intellectual resources for critical thinking development.

Furthermore, Bailin's intellectual resources can be considered as the developmental stages for a critical thinker through the developmental states of constructivism, as presented by Vygotsky. According to Vygotsky (1978:84), "Learning and development are interrelated from the child's very first day of life." Thus, learning should be considered as development stages within learners. Additionally, learners exist within the actual level of development in the beginning of any new introduced concepts. As the teacher mediates new knowledge, learners advance from their actual level of development to the next proximal zone. Vygotsky (1978:86) explains as follows: "The zone of proximal development defines those functions that have not already matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state." For instance, when learners reach the level of habits of mind, they would have been well grounded in the lower intellectual resources. Consequently, this is similar to the process that occurs before learners reach the actual level of development.

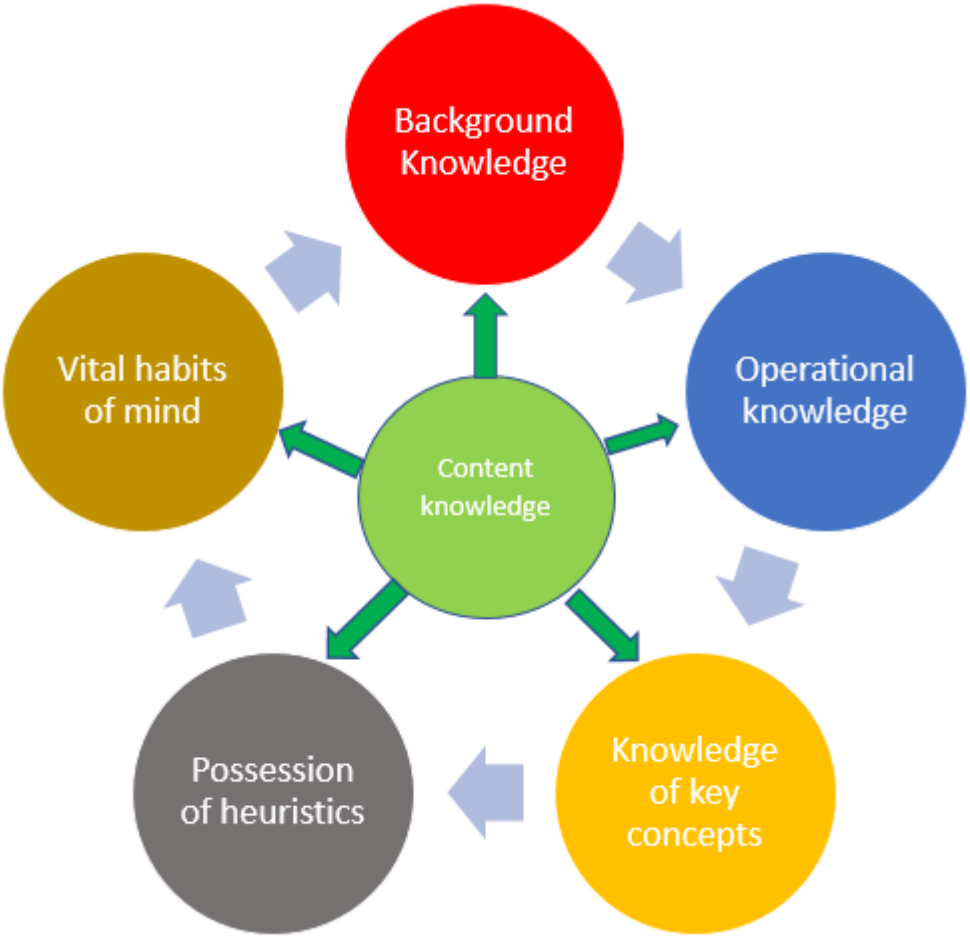
The approaches that the teacher uses to move learners to the next level can be duplicated in understanding the development of intellectual resources. The lower intellectual resources must be established before the learner can be in a space where he or she can be in the habit of thinking critically, and engaging in 'good thinking' spontaneously to solve complex problems. This can be associated with the framework known as Bloom's Taxonomy, which puts forward that higher cognitive engagements are easily reached when the basics are

established. It can be inferred that the cycle in both models begins whenever new knowledge is presented; more so in the intellectual resources, where thinking habits would develop as operational skills and application of key critical concepts have been established over time.

2.6.3 Conceptual framework

The following diagram attempts to illustrate how constructivists' teaching approach and ICTs are instrumental in promoting and developing critical thinking, whenever the teacher presents new knowledge.

Figure 1: Conceptual framework



(Adapted from researcher's own notes)

Key: The external arrows indicate development, while the internal arrows represent the teaching approach (constructivists) and tools (ICTs) used to attain intellectual resources.

Although the above discussion seems to advocate that critical thinking is developmental, the process (as illustrated in Figure 1) is not a given. The teacher must be able to efficiently manipulate content in such a way that basic, critical concepts and operational knowledge are identified, so that the right approach to teaching can be used. This will ideally happen when the most effective resources are engaged to facilitate an environment where critical thinking is evident.

The current research therefore seeks to investigate how a Life Science teacher used ICTs to help learners acquire intellectual resources for critical thinking.

2.7 Conclusion

The literature covered in this research review aims to contribute to a better understanding of critical thinking. It was pointed out how misinterpretation can lead to teaching approaches that fail to achieve educational outcomes. ICTs are advocated as tools to facilitate the acquisition of critical thinking in a Life Science lesson. The constructivism theory is identified and recommended, as it promotes the intellectual resources required for learners' critical thinking.

The next chapter sets out the research methodology.

Chapter 3 METHODOLOGY

3.1 Introduction

This chapter outlines the research method. It provides details about the research design, qualitative approach, participants, sampling design, research site, and data instruments. The researcher also considers the data analysis methods, research validity, and ethical issues.

3.2 Research design

This research report investigates how the use of ICTs can promote critical thinking in a Grade 10 Life Sciences class. The researcher firstly identified the criteria or standards required to efficiently achieve the outcomes of the Life Sciences topic that was discussed. These criteria were then used to determine whether the use of ICTs actually promoted the critical thinking that was necessary to attain the standards of the specific Life Sciences topic, as set by the CAPS document (DoE, 2011). Thus, this research uses a qualitative case study research design.

3.3 Qualitative approach

The qualitative approach was selected for this research report because it allows for better insights concerning the research participants and their environment. Strauss and Corbin (1999) defined qualitative research as any research that produces findings not arrived by statistical procedures or other means of qualification. This definition encompasses a person's lived experiences, behaviour, emotions, as well as the functioning of an organisation, social movements, cultural phenomena, and interactions between two nations. (Strauss and Corbin, 1990). Consequently, the qualitative approach is appropriate and beneficial within this study as it investigated the experience of a teacher as she meaningfully integrated ICTs around a specific Life Sciences topic. Critical thinking within learners was encouraged and developed by the teacher in her use of ICTs.

The findings of the current study were not derived from statistical procedures as per the quantitative approach. Instead, the researcher selected a qualitative approach for the research design.

3.3.1 Case study method

The researcher selected the case study method for this study because it studied a topic from a Grade 10 Life Sciences syllabus. This study investigated how the teacher encouraged her learners to think critically through integrating ICTs into her teaching approach. Key (1997) indicated that case studies are detailed investigations of individuals, groups, institutions, or other social units. Key (1997) further emphasised that the sole attention to one individual, group or a single social unit constitutes the key element of a case study.

The current study thus allowed the researcher to identify characteristics of critical thinking in a Grade 10 Life Sciences class. Simons (2009:3) explained: "The primary purpose for undertaking a case study is to explore the particularity, the uniqueness, of the single case." The researcher was allowed to investigate the kinds of ICTs that a teacher could use in a meaningful manner to promote critical thinking within Life Sciences learners. Yin (2003) in Baxter and Jack (2008:545), argued for using a case study design when: (a) the focus of the study is to respond to 'how' and 'why' questions." Therefore, the qualitative case study research approach allowed the researcher to gain quality insight into how ICTs assisted the teacher to promote critical thinking within learners in a Grade 10 Life Sciences class.

3.4 Research participants

This research was conducted in a Life Sciences classroom of a public school in Johannesburg in South Africa. The participants were the Life Sciences teacher and her Grade 10 learners. The teacher was the participant who integrated ICTs into her Life Sciences lesson. The requirements were that both the teacher and learners had to use ICTs in and out of the classroom for educational purposes.

3.5 Sampling design

The researcher purposefully sampled the participants of this study (the teacher and her Life Sciences class). The teacher displayed features in her use of ICTs that were fitting to the investigation of this study. As Struwig and Stead (2001:123) stated, "Critical cases are those that are selected because they are central to the issue being studied." Consequently, the teacher in this study was a critical participant in investigating how ICTs can be used to promote critical thinking within Life Sciences learners. The teacher offered crucial information to the result of this study, firstly in terms of how her perception of critical thinking influenced the incorporation of ICTs in her classroom teaching. This allowed the researcher to gain insight in how critical thinking was promoted within the learners by critically analysing the case of a single Grade 10 Life Sciences class. Patton (1990:174) in Struwig and Stead (2001), emphasised that a critical case may happen in any situation that is similar to that particular case. Therefore, the researcher selected the critical case sampling approach for this study.

3.6 Research site

This research was carried out in a public secondary school, formally called an ex-model C school. The school is situated in a suburban residential area within the greater Johannesburg area. In this school, most learners come from a middle-class background. Both the teacher and her learners used ICTs as a form of communication tool in and out of school activities.

3.7 Data instruments

In order to investigate how ICTs were used in a Grade 10 Life Sciences class to promote critical thinking in learners, the researcher used five sets of instruments to collect the required data for analysis. The five sets of instruments assisted the researcher to collect data samples before investigating how ICTs were used to encourage critical thinkers in a Grade 10 Life Sciences class.

The five data collection instruments that were used in this study to collect three sets of data were (a) a questionnaire, (b) a video-recording of observations in the Grade 10 Life Sciences class, (c) an audio-recording, (d) transcriptions of a semi-structured interview and field notes to describe the tasks performed by the Grade 10 learners in the specific Life Sciences class.

The first data collection instrument was a questionnaire that was completed by the Grade 10 Life Sciences teacher. This questionnaire allowed the researcher to investigate whether the teacher was aware of what criteria were needed to achieve the unit comes. It was crucial to understand the criteria of the subject unit, without which the teacher would have been unable to develop critical thinking as identified by Bailin (2002). The researcher was able to further investigate the types of ICTs that were used within the classroom setting and how those ICTs were incorporated into the teacher's lessons in order to promote critical thinking within her learners. The second set constituted the scheduled observations. These observations allowed the researcher to observe a complete subject unit within a Grade 10 Life Sciences class. The third set of data constituted the semi-structured interview of the teacher. This was collected subsequent to the class observations. Lastly, all the tasks or activities completed or performed by the learners were recorded by the researcher in a field notebook.

3.7.1 Questionnaire

The use of a questionnaire as data collection instrument enabled the researcher to identify the teacher's understanding of the criteria required to achieve the required outcomes of the Life Sciences topic. As Bailin (2002) denoted, critical thinking is the quality of good thinking that seeks the appropriate criteria or norm within the subject unit. The researcher firstly needed to examine the teacher's perceptions, understanding and processes for promoting critical thinking within her learners before it could be investigated how ICTs were used. Bailin (2002) indicated that misconceptions about the nature of critical thinking are harmful in promoting learners' critical thinking. Thus, the teacher needed to have a clear definition and understanding of the nature of critical thinking before she could encourage learners to think critically within Life Sciences.

3.7.2 Class observations – video recording and field note taking

Scheduled observations as a data collection instrument allowed the researcher to investigate how Information and Communication Technologies (ICTs) were used effectively in a Grade 10 Life Sciences class to promote critical thinking within these learners. According to Cohen, Manion and Morrison (2000), observational data provides the researcher with the opportunity of gathering 'live' data from 'live' situations. This enabled the researcher to understand the context. The researcher noted how the teacher applied the appropriate pedagogy for ICT resources in the classroom in order to meet the subject criteria and promote critical thinking within Life Sciences learners in the classroom.

3.7.3 Video recording

The researcher recorded scheduled observations. Pirie (1996:3) pointed out that video recordings are considered as a means to capture everything that occurs in the classroom, therefore permitting the teacher to postpone that moment of focus and decision taking. Through the use of video recording, the researcher was able to capture other elements in the classroom, such as, the interactions amongst learners and the teacher, the tasks performed by the learners in the classroom and finally the pedagogical styles of the Life Sciences teacher while she promoted critical thinking through ICT integration. As Belland (2009) stated, ICT integration is the teacher's ability to use technology in a meaningful way, so that he or she may develop learners' critical thinking through constructivism.

3.7.4 Field notes

The video recording as a data collection instrument may not have captured all the elements that were occurring in this Grade 10 Life Sciences class, because of the position of the camera. Pirie (1996) denoted that a video recording may be misleading in that the position of the camera and the types of microphone governs or specifies the amount of data that is collected, which then gets lost through the video recording. Therefore, the researcher used a field notebook to record other significant elements in the classroom. These elements could refer to the interactions and the dialogue between learners in a group activity. These elements

assisted the researcher in identifying the intellectual resources that the learners used in order to think critically on a specific issue (Bailin, 2002).

3.7.5 Semi-structured interview as a data collection instrument (audio-recorded and transcribed)

A semi-structured interview was developed by using open-ended questions. This interview initiated the topic of the conversation for the researcher and the interviewee (the Life Sciences teacher). The teacher participant was granted the flexibility of expanding or clarifying her responses. Thus, the semi-structured interview was used to assist the researcher to seek deeper insight into the Life Sciences teacher's perception on critical thinking and the attribution of a critical thinker. Barribal and While (1994:330) established that semi-structured interviews "are well suited for the exploration of the perceptions and opinions of respondents regarding complex and sometimes sensitive issues and enable probing for more information and clarification of answers." The interview allowed the researcher to discover deliberations that the Life Sciences teacher may have taken in creating an environment for learners to think critically. The reason for this was that the criteria within the subject determined the degree or standards of good critical thinking (Bailin, 2002).

3.7.6 Audio-recording and transcription

The researcher audio-recorded the semi-structured interview. The audio recording allowed the researcher to capture all the details of the interview. Consequently, the researcher was able to focus on the dynamics of the situation within the interview. These dynamics included keeping momentum during the conversation, motivating the participant to discuss her thoughts and finally how to overcome the problems of the likely asymmetries of power in the interview (Cohen et al. 2000). Additionally, the researcher transcribed valuable data from the audio-recordings. As Cohen (2006:2) emphasised, since semi-structured interviews often involve open-ended questions, which may move discussions away from the interview guide, it is preferred to first tape-record interviews and later transcribe them for analysis. The interview was scheduled for approximately 30 to 45 minutes.

3.7.7 Tasks or activities completed by learners in class

Tasks or activities performed by the learners offered the researcher the opportunity to investigate whether learners' work reflected critical thinking in their activities. These (in and out of the classroom) activities were recorded on field notes by the researcher. The field notes allowed the researcher to identify whether the activities created by the teacher actually corresponded to Bailin's (1999) five kinds of intellectual resources (background knowledge, operational knowledge, knowledge of key concepts, possession of heuristics and habits of mind in order to promote learners to becoming successful critical thinkers).

3.8 Schedules for data collection

The researcher observed how subject matter (biodiversity, taxonomy and classification, and evolution) was taught in a Grade 10 Life Sciences class. The topic was covered over approximately three weeks and the learners attended the Life Sciences class four times in a cycle of six days. Hence, the researcher observed lessons for four times during the cycle, throughout a three-week period.

3.9 Data analysis

The researcher used the thematic analysis in which themes of the current study were generated inductively from raw data (Boyatzis, 1998). The raw data constituted the notes and transcripts recorded by the researcher, which had to be converted into refined data for analysis. (Marshall and Rossman, 1995). The researcher transcribed the class observations, questionnaire, interview, and audio recordings. These transcripts were then analysed several times so that the researcher could code and categorise the findings according to emerging themes. The themes were categorised according to their similarities. Recurring themes were identified in order for the researcher to gain better understanding in relation to the theoretical framework demonstrated in the literature review.

The conceptual framework of Bailin's five intellectual resources, together with Lunenburg's (1998) attributes of a constructivist teacher, allowed the researcher to better evaluate the extent of how the teacher used ICTs to promote critical thinking for the Life Sciences

learners. In line with Boyatzid's (1998) concept of thematic analysis being a process of encoding qualitative information, the encoding for the current study required explicit 'codes' (for example a list of themes; a complex model of themes, indicators, and qualifications that are casually related). Marshall and Rossman (1995), and Neuman (2000) further indicated that in qualitative research, data is analysed through reading and re-reading data notes, reflecting on what is read, and organising those into similar themes and patterns.

3.10 Research validity

According to Silverman (2011:365), research validity is about interpreting observations, in other words, whether or not the researcher's inferences are backed by data, and how sensible it is, compared with earlier research. Therefore, based on the data sets that were defined, the cross checking of data sets further emphasised the themes that emerged from the data analysis and collection. The instruments used in data collection provided the researcher with guidelines to make certain inferences from the raw data. Some outcomes could be derived from the researcher's own perceptions of the given situation when interpreting specific data. It is therefore crucial that this study does not focus on the use of ICTs as the only evidence of critical thinking in this specific Life Sciences classroom.

3.11 Ethical consideration

According to Adams and Beronsky (2002:36), the process of recruiting participants for research studies is always worthy of ethical consideration. Permission was granted from the Gauteng Department of Education, the principal, and the teacher of the school used for this study. Consent was also granted by the learners and their parents. All the participants were assured of confidentiality as they were provided with pseudonyms for the particular school and all the participating individuals. All the participants were informed that they could withdraw their involvement from the research at any time, without prejudice. Finally, the researcher agreed that she would keep all the video-recordings, audio recordings, field notes and documents in a confidential file. This raw data would be destroyed five years after the completion of the study.

The next chapter presents the research discussions and findings.

Chapter 4 DISCUSSIONS AND FINDINGS

4.1 Introduction

The research findings reveal critical thinking as a process that is developed through engagement and interactions between learners and the teacher. The use of ICT tools stimulated interactions between learners and the teacher, which, in turn, created a learner-centred environment for the enhancement of Bailin's five intellectual resources.

This chapter sets out the themes (such as background knowledge) that form the basis for the five intellectual resources identified by Bailin (1999). The focus is on how the use of ICT enhances these intellectual resources.

4.2 Background knowledge as the foundation to Bailin's intellectual resources of critical thinking

The main theme that emerges from this study is the notion that background knowledge forms the basis for critical thinking development. ICT tools such as PowerPoint slides, online videos and online images assisted the teacher in promoting learners to locate their background knowledge so that they could link it to new subject matter. The above-mentioned ICT tools assisted the teacher to exemplify critical thinking to her learners through online images so as to identify and reinforce the learners' background knowledge. This background knowledge was then incorporated into the stages of critical thinking where it was used to operationalise learnt knowledge and apply it to the particular skills required for critical thinking, especially in the field of Life Sciences.

According to Bailin (1999), the quality of solving a particular problem is determined by what the individual knows and how they are able to locate the recognised knowledge in a specific discipline. Consequently, background knowledge is based on individuals' prior knowledge and their associations within the specified discipline. As such, background knowledge determines the standard or the criteria for critical thinking within the field or the specific context. For instance, with regards to schools, learners need to know the content of the specified discipline in order to set the standards for good thinking, as indicated by Bailin (1999).

As stated by Bailin (1999), the standard of good thinking is shaped by one's background knowledge. This is emphasised by the data of this study, whereby learners' background knowledge determines the criteria of good thinking. Their background knowledge is then stimulated by the teacher's use of ICT tools. These tools ranged from MS PowerPoint presentations to online images.

4.2.1 Microsoft PowerPoint presentation as a teaching tool to stimulate learners' background knowledge

The PowerPoint presentation provided a teaching tool where the teacher was able to use slides as indicators or references for the topic under discussion. For example, when the teacher presented the concept of "biodiversity" as the first lesson of the topic "Classification and Taxonomy", she first defined the term in the first PowerPoint first slide. This particular visual presentation on terminology allowed the teacher to focus and refocus the learners' attention on the core concepts. This was useful if perhaps the teacher was going to be diverted from the content. Consequently, the teacher was able to use visual indicators of concepts and terms as the points that she needed to discuss during class or at a later stage of the curriculum. She further used these indicators in the slide to explain the terminology (as one phrase at a time) to build a better understanding for the learners.

> *Teacher:* *Biodiversity is 'variety of life in an area*[2]'this simply means that you can talk about biodiversity in Africa or biodiversity in other countries, biodiversity in all parts of the world.*

Therefore, through the visual indication of 'variety of life in an area' on the PowerPoint slide, the teacher created opportunities to recall learners' background understanding of the notion that life forms are widely diverse. The notion of diverse life forms was then connected to the new concept of biodiversity, where the teacher applied learners' background understanding to the word 'variety'.

The PowerPoint presentation enabled the teacher to sequence her discussion of the subject matter. Consequently, she was able to follow the sequence from the PowerPoint presentation.

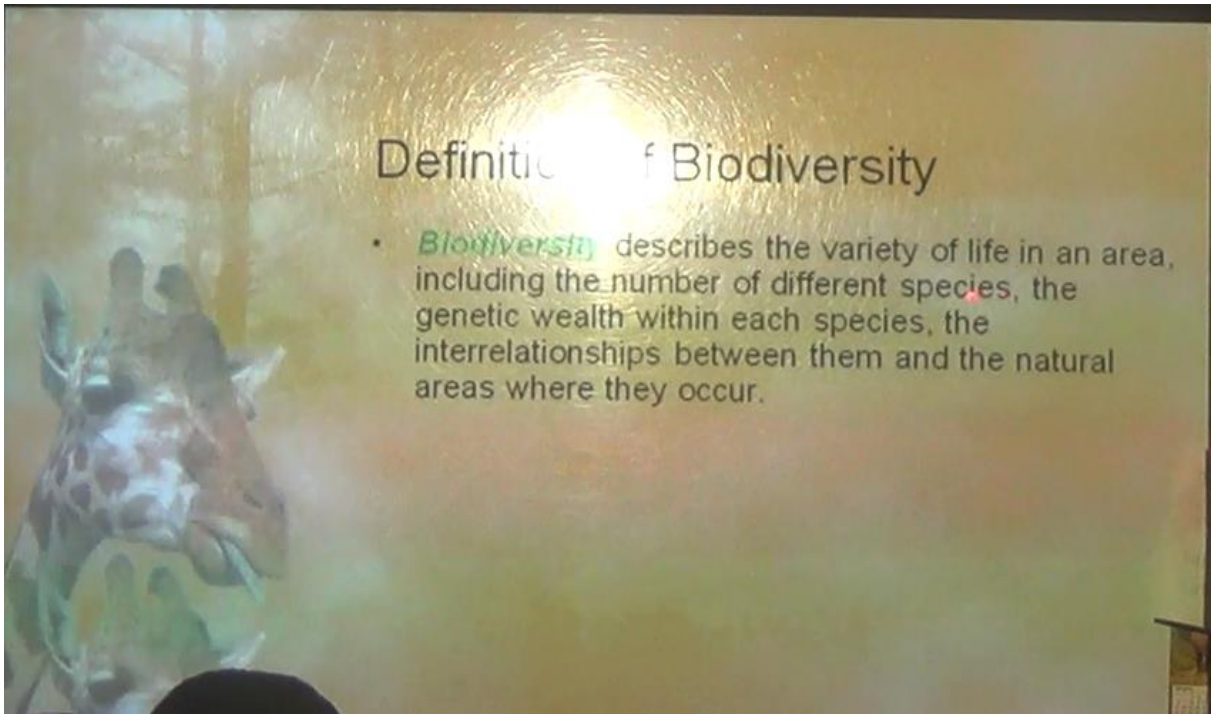
[2] Presented on the PowerPoint Slide: Slide one

This corresponds with Inoue-Smith (2016) emphasis on PowerPoint's ability to assist teachers with organisation and with keeping track of the lesson.

In addition to providing the teacher with step by step guidance to her lessons, the PowerPoint presentation allowed the teacher to visually present the main idea of the subject matter to the learners. Inoue-Smith (2016) argued that the use of PowerPoint assists teachers to make their classes more active and dynamic, since visual and auditory resources are combined.

Therefore, the teacher was able to define the key concepts within the topic by means of PowerPoint. The slide assisted her to clearly present a key concept that was rich in subject terms but not necessarily easy for learners to comprehend. To help learners grasp the background knowledge, she drew from their prior knowledge, as she provided examples (lesson one) (see below):

Figure 2: The definition of biodiversity (slide one of lesson one)



> *Biodiversity describes the variety of life in an area, including the number of different species (1), the genetic wealth within each species (2), the interrelationships between them, and the natural areas of where they occur (3).*

In her explanation, the teacher focused on one phrase at a time. For instance, with phrase three, 'the interrelationships between them', the teacher referred learners to their prior knowledge of organisms' relationship to their environments. These relationships were termed

biotic and abiotic relationships, in order to demonstrate the interdependency of organisms. In this particular instance, the PowerPoint presentation slide allowed the teacher to recall learners' prior knowledge by drawing on their understanding of the relationship between plants and animals (abiotic and biotic). This enabled the teacher to further illustrate phrase three of slide one. This elaboration of the interrelationship between organisms was further emphasised in that the teacher moved away from the references or points indicated in the first PowerPoint presentation slide to provide her own example of abiotic and biotic relationships and to prompt learners to the correct answer:

> ***Teacher**:* *A bird...where does it live?*
>
> ***Learners**:* *In a nest.*
>
> ***Teacher**:* *In a nest? Where?*
>
> ***Learners**:* *In the tree.*
>
> ***Teacher**:* *In a tree. Ok, so that tree is also living. So that's biotic and abiotic relationship. But remember, both that bird and the tree rely on gases to survive, they rely on sunlight. The tree uses sunlight for photosynthesis, while the bird uses sunlight to see where it's flying during the day. Birds generally don't fly in the night ... the majority of them. You need to think how biotic and abiotic factors in the species are relating to one another."*

The above reference of learners' prior knowledge allowed the teacher to further demonstrate a specific concept in Life Sciences, namely *Biodiversity, genetic wealth within species and their interrelationships*. Furthermore, it further helped the learners to reflect on specific notions that were previously introduced in class. Lai, Tsai and Yu (2011) argued that learners who attended classes where the teacher used PowerPoint presentations believed that the lessons were more organised, clear and interesting. Thus, the teacher was creating an engaging learning environment.

Furthermore, PowerPoint slides were used to illustrate specific Life Sciences' terms. The teacher assisted learners to think critically by referring to a particular phrase at a time. She then elaborated on that specific phrase by referring to examples from learners' prior knowledge. As such, the teacher was able to assist learners in grasping background knowledge of a particular phrase via prior knowledge. Although phrases from the initial slide

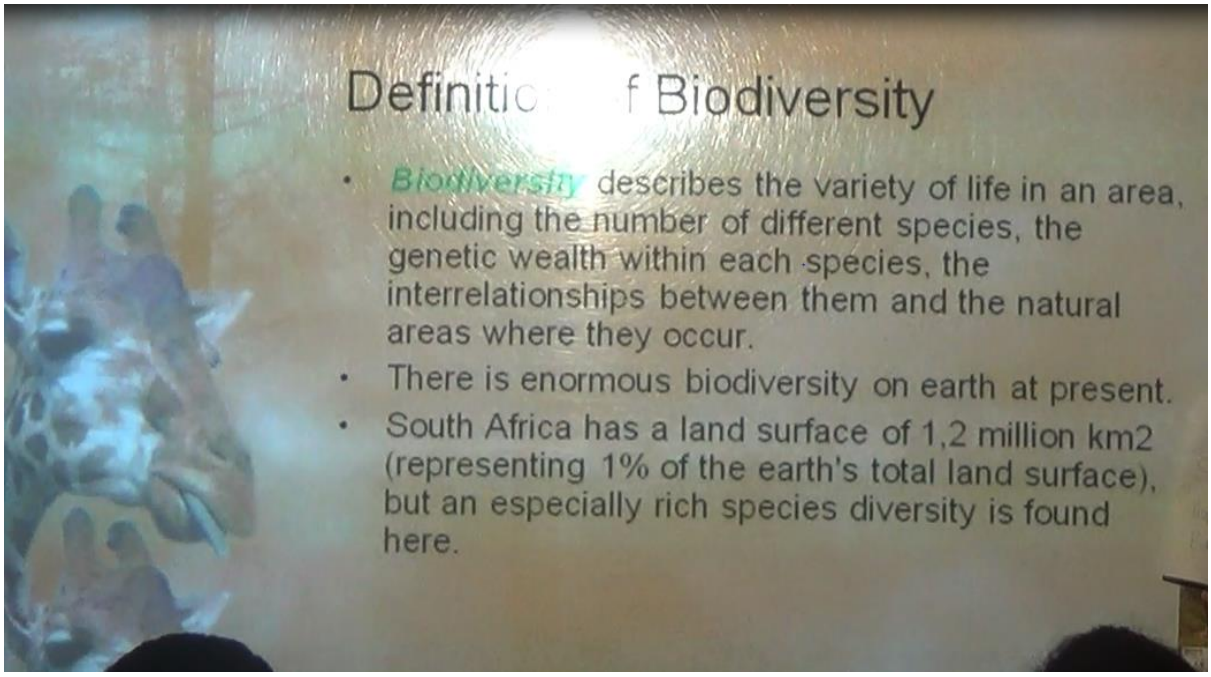
provided the teacher with a reference or indication of the learned discipline, the teacher was unable to fully demonstrate the terms relating to biodiversity in the first slide without stepping away from the presented terms. In order for learners to fully comprehend the content, the teacher provided a real life example through questioning learners' experience of the environment and their prior understanding of the biotic and abiotic relationship between species.

The method in which the teacher approached the presentation of new content for learners links to her perception of good critical thinking that "each topic builds on another, so none are in isolation to another topic" (teacher's questionnaire). Therefore, the teacher's understanding of critical thinking seems to align with Bailin (1999) concept of good critical thinking, where learners require a solid background knowledge of the specified discipline in order to set a good standard of critical thinking within the discipline (in this case within Life Sciences).

According to Liu and Xu (2016:427), PowerPoint is however not a 'magic bullet' and the key to good PowerPoint teaching still remains a good teacher. Only when teachers use PowerPoint appropriately and effectively in their teaching activities, can the full potential of this tool be drawn on.

Learners were again offered the opportunity to demonstrate their understanding of the biodiversity concept. The teacher provided additional facts in the next point of slide one, in order to expand on the concept of biodiversity of the first lesson.

Figure 3: The next point (slide one of lesson one)



South Africa has a land surface of 1.2 million km^2 (4) (representing 1% of the earth's total land surface) (5), but an especially rich species diversity is found here (6)

Similar to the teacher's explanation in phrase three (*interrelationships between them*) (species) from the first slide of lesson one, she further elaborated by taking one phrase at a time. She did this by incorporating learners' prior knowledge. However, in this case, the teacher drew on learners' prior experience of a particular tourist destination (Cradle of Humankind)[3] in order to demonstrate (a) the importance of biodiversity in South Africa and (b) the richness of organisms that create economic growth within the country.

Teacher: *South Africa represents 1% of the 100% of Earth. It's a small amount but there's a rich species diversity, we are extremely lucky, that is why we have so many tourists coming into our country to see our biodiversity (eco-tourism). Be it the proteas, umm, the fynbos biome, like I explained it to you before, or be it... I'm going to get to it...the fossil, like you would find in the Cradle of Humankind.*

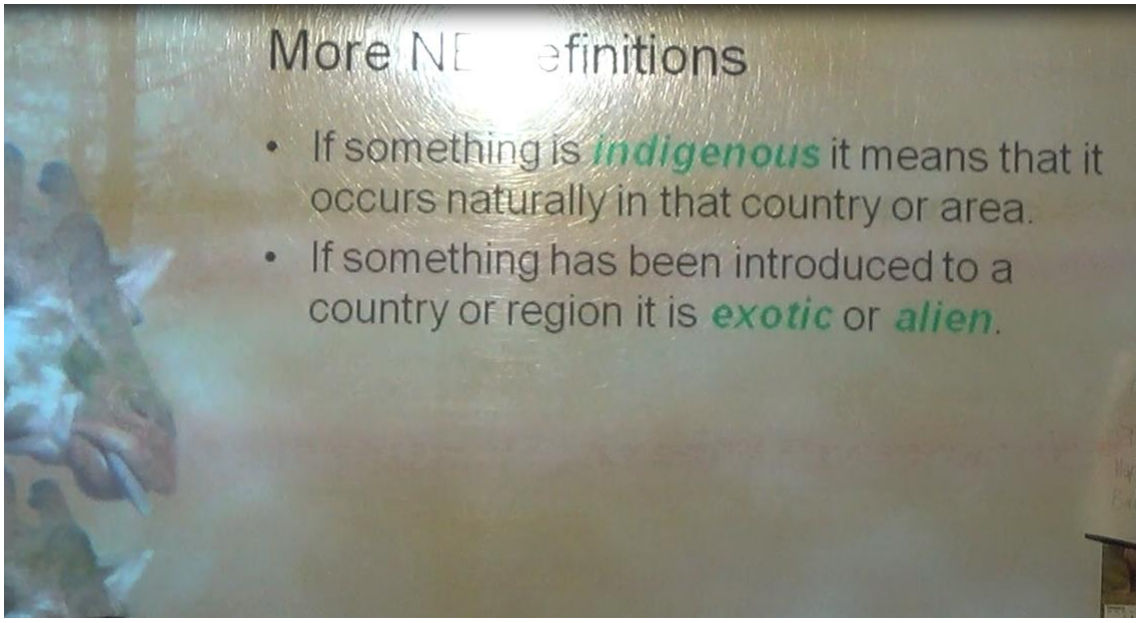
[3] The Cradle of Humankind is a world heritage site in South Africa which is a widely recognised place from which all humankind originates.
(Maropeng, 2019, http://www.maropeng.co.za/content/page/about)

***Teacher**:* *How many of you went to the Cradle of Humankind?*

(Approximately 10 learners raised their hands).

In order for learners to fully comprehend the importance of biodiversity, the teacher was unable to demonstrate the new content without stepping away from her first PowerPoint slide. She incorporated learners' background knowledge into the new content. Through the integration of the PowerPoint presentation slides and by recalling certain aspects of learners' background knowledge, the teacher was able to illustrate to learners how they may set standards for critical thinking, simply by using their background knowledge. The teacher demonstrated this ability of setting standards of good thinking throughout her initial lesson. She often referred to the points on the PowerPoint presentation and to learners' background associations of certain real-life examples. The teacher was therefore able to connect the subject-enriched concepts indicated on the PowerPoint presentation to associations for further understanding. This is illustrated in the highlighted terminology in the slide below.

Figure 4: Slide two of lesson one



Once more, the PowerPoint presentation offered the teacher a visual aid through which she was able to explain rich subject terms. In the next example the teacher explained the terms of exotic or alien species.

Teacher: *If something has been introduced to a country or region. it's either called alien species or exotic species. This here (alien species), we tend to use that word a lot and we don't mean funny creatures from other planets. We are talking about people coming from other countries and having seed stuck under their shoes. And when they exit the airplane, the seed that was stuck under their shoes falls off and then it ends up growing in South Africa. Therefore, that seed that grew into a plant, it's called an alien species because it is not indigenous to our country but brought from foreign soil.*

Again, the teacher could not completely elaborate on her explanation of this terminology of exotic or alien species without providing her own real life example.

Teacher: *For example, let's say a tourist is coming to visit the Kruger National Park and then lands up going back overseas and opens their suitcase and finds a spider inside. Can you see how these things happen accidently? These are simple examples, but it's a problem because I told you before that these alien species end up growing in our country or breeding with other indigenous species. Do they (alien species) have natural predators?*

Learners: *No.*

Teacher: *So this alien plant that might end up growing is going to have a fight with other plants for water, for food, for nutrients in the soil ... makes sense? And by doing that the other plants might suffer. You got an alien plant in an area, what's going to eat it?*

Learners: *Nothing.*

Teacher: *So it (alien plant) will continue to grow.*

As indicated from the observation above, the teacher provided an example of tourists who visit the Kruger National Park[4]. Most South African learners have some prior association of this park as a well-known tourist destination.

In the example, the teacher highlighted how tourists may carry alien species or plants unknowingly, and as a result, an indigenous area would be infected with alien species. This particular example allowed the teacher to locate particular background knowledge within learners. In this way, the learners were able to assess this example in order to defend the reason behind indigenous conservation and the possible causality in the extinction of biodiversity.

4.2.2 Background knowledge forms the basis for operational knowledge through the use of Microsoft PowerPoint presentation tool.

Thus, by means of PowerPoint presentation slides, the teacher was able to present the subject terms where she could explain each term (phrase by phrase) by integrating learners' background knowledge. Consequently, the PowerPoint presentation (with the incorporation of real life examples or learners' background knowledge) provided the teacher with the structure from which she could stimulate interaction between her students.

> *In each lesson, some ICTs are used, especially PowerPoint presentations, as it is very easy to manipulate slides while being around the class and interacting.*
>
> (Teacher's response from the teacher's questionnaire)

When the teacher illustrated the standard of good thinking within a topic of Life Sciences through the PowerPoint presentation slide, learners were able to utilise their background knowledge and set certain logical rules to solve complex problems. Through operationalised knowledge, standards were set within the specific context, and learners were subsequently able to identify key critical concepts. These concepts then enabled them to analyse a particular situation (whether in a real life example or within the specified discipline).

[4] Kruger National Park, in northeastern South Africa, is one of Africa's largest game reserves. Its high density of wild animals includes the Big 5: lions, leopards, rhinos, elephants and buffalos.
(Sanparks, 2019, https://www.sanparks.org/parks/kruger/default.php/)

As Bailin (1999) indicated, the knowledge that the learners gain for a specified discipline assist them to create standards or principles, to critically analyse or operate in a given situation. These principles are:

Standards of practical deliberation, standards of argumentation, standards used in developing plans of action (as in artistic and athletic performance), and standards governing inquiry and justification in specialised areas of study such as art, biology, history, literary criticism, mathematics, and technology.

(Bailin, 1999:291)

These standards or principles, as mentioned by Bailin, are inherent in operational knowledge or learnt knowledge. They provide critical thinkers with the set of rules or logic they need to perform accordingly. Furthermore, the degree of these standards depends on these critical thinkers' background knowledge for the specified discipline. Bailin (1999) reiterate that the standards or principles may be criticised or altered, depending on one's knowledge or previous knowledge of the context.

In lesson one, the teacher explained (phrase by phrase) content-rich concepts as PowerPoint presentation slides. In this way the teacher constructed the learners' background knowledge. As presented in the data, background knowledge is vital for the subject of Life Sciences, specifically for the achievement of critical thinking through Bailin's (1999) five intellectual resources. The phrase by phrase explanation and the aid of the PowerPoint presentation slide, presenting the concepts or terms as integrated with real life situations or learners' prior knowledge, set the standard of good thinking. As a result, a particular learner would have been able to identify the rules or logic within the context. Together with his or her background knowledge, such learner would have been able to further comprehend the factors that contribute to the rich diverse lives within South Africa.

Teacher A: *So think! Why do we have so many people (tourists) coming here (South Africa)? We have a rich biodiversity.*

Learner 1: *So why do we have a better diversity compared to other countries?*

Teacher A: *It could be because of the climate (in South Africa).*

Learner 1: *But how come there are so many diverse organisms living by the equator? When the climate close to the equator is so harsh and hot? It's very different to the climate in here (South Africa).*

Teacher A: *Your plants and animals that live close to the equator are able to survive those harsh conditions, ok? Just because we are further away from the equator doesn't mean we have greater biodiversity than some area that is closer (to the equator). It's just that. Just that happens that way, ok. It's more involved than that and we are going to get to that with our next topic of mass distinction. How the Earth was basically one big land mass and then it started to split, ok, that's also involved. It will make sense later on.*

Through the teacher's use of a real life example of eco-tourism in her explanation of biodiversity in South Africa from the PowerPoint presentation slide, Learner 1 was able to utilise what he had understood about the concept 'rich in diversity' within South Africa. This learner therefore followed the standards within the discipline set by the teacher in his critical deliberation on the possible element that contributed to the biodiversity in South Africa. With the teacher's response to the learner's deliberate question, this particular learner was thereafter able to identify the intellectual product, by evaluating the teacher's feedback that climate was a contributing factor to the diverse species lives within South Africa. From the result of his evaluation, this particular learner was also able to further assess the teacher's motivation of biodiversity within South Africa, based on his prior association of biodiversity in other countries, especially those on the equator.

Consequently, Learner 1 was able to critically assess whether climate was a sufficient contributing factor to the rich diverse species in a particular country. The learner could do this because he understood (from his background knowledge) that while biodiversity existed in other equatorial countries, the climate of those countries was very different to the climate of South Africa. As a result, this particular learner deducted that climate could not be the only contributing factor to biodiversity within South Africa. This led him to deliberately question the teacher's analysis. Through this particular discussion, the teacher was then able to indicate to the learner the concept of natural selection within species. She also explained their adaptation to their habitat when she responded to Learner 1's subsequent question - *Your*

plants and animals that live close to the equator are able to survive those harsh conditions, ok? Just because we are further away from the equator doesn't mean we have greater biodiversity than some area that is closer (to the equator).

This utilisation of the knowledge that was presented by the teacher through the PowerPoint presentation slides allowed the teacher to create a learning environment whereby she was able to set and convey the standards of good thinking within Life Sciences for the learners. The standard of good thinking was set through the use of technology as a tool or learning aid to present key terms, which she then explained (phrase by phrase), while integrating learners' prior knowledge or prior associations of real life situations. This integration of prior knowledge or background association helped to create discussions between the teacher and the learners on the given topic.

The interactions and reference to background knowledge (presented in the PowerPoint slides or in the teacher's explanation) offered learners the opportunity to identify the correct key critical concepts (intellectual products). As a result, learners could further develop certain heuristics that were essential to critical thinking. In the above instance, Learner 1 was able to develop the heuristic in improving the logic or standard which was set by the teacher, by evaluating the teacher's response with his own background knowledge. These heuristics, as mentioned, developed through background knowledge about subject matter concepts, which then was stimulated by means of a PowerPoint presentation.

4.2.3 The use of online videos and MS PowerPoint as presentation tools to recall background knowledge for operationalised knowledge

With regard to Life Sciences, it seems that the teacher provided examples of the context or the background knowledge of that specified discipline in order for her to demonstrate the standards that learners need to think critically.

The teacher further demonstrated these standards of good thinking through her second lesson. She began the lesson by showing learners a YouTube video to introduce the idea of classification and taxonomy in the animal kingdom through animation. In this particular video, learners were shown how a lion is classified into groups in order for scientists to find

its scientific name.[5] Through viewing this online video, the teacher was able to locate some background knowledge within learners. Consequently, learners recalled the logic behind categorising items into specific groups or systems. Hence the background knowledge of categorising items provided the learners with the ability to set the logic or rules for the features of categorising, especially for the concept of classification. The online video provided background knowledge for a group activity of grouping various kinds of potato crisps. The video guided learners in terms of the possible steps they needed to consider for categorising the crisps.

Through the initial online video, the teacher introduced the new subject concept of classification and taxonomy. Thanks to this initiation with the use of online tool, the teacher was able to illustrate a context for classifying the concepts and for learning about taxonomy (naming system of organisms). The teacher employed a potato crisps classification group activity where learners had to classify the variety of crisps according to their common shared features. The online video from YouTube created a form of scaffolding where learners used a similar concept of categorising (as shown in the video) for their activity of grouping potato crisps. This activity permitted the teacher to draw out learners' skills of grouping and categorising items. This helped the learners to expand their understanding of the concept of taxonomy and classification within organisms as the teacher referred their background knowledge through the use of a PowerPoint presentation:

> *Classification: sorting or grouping things according to similarities and differences. Scientists do this as it is more convenient to study life forms in this way. The science of naming and classifying a wide range of living things is called taxonomy.*

The teacher was able to guide learners in terms of the concept of taxonomy and classification as presented on the PowerPoint slide through the association of the potato crisps activity. In doing so, the teacher was able to operate learners' background knowledge of categorising items. She therefore managed to set a particular standard of thinking for Life Science through her explanation:

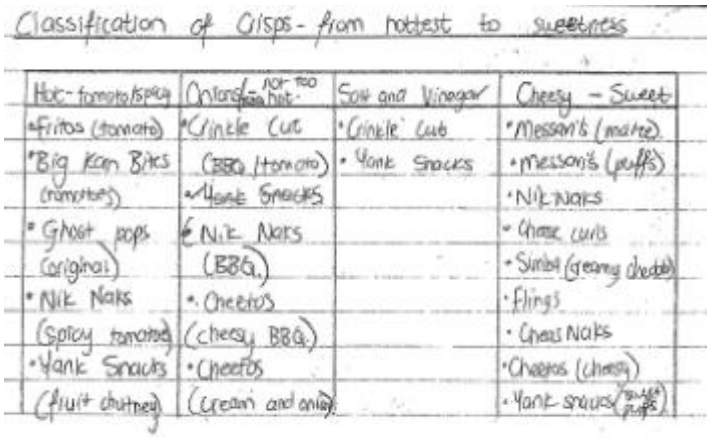
[5] Drolinger, M. (2012, November 15). *YouTube*. Retrieved January 29, 2014, from YouTube: http://www.youtube.com/watch?v=vqxomJIBGcY

***Teacher**:* *Listen to me, the fact that you guys just classified things, ok? It's called taxonomy. Classifying living things is called taxonomy. Classification is to make it more convenient to study it or to find things about it. You guys were sorting out (the crisps activity) according to similarities and differences. You were able, you know, ok based on knowledge...ok...this is cheese...that's different to tomato flavour. You know that based on your knowledge of crisps flavours. Even if you haven't tasted the chips or whatever.*

Therefore, according to McMahon (2009), ICT cannot be used in isolation. With the assistance of the teacher within a classroom, ICT tools provide a learning environment where a teacher is able to manipulate more conducive learning. In the above instance, the teacher incorporated an online video to introduce the concept. Together with the group activity, she was operationalised learners' background knowledge of categorising items. Thus, the rules of standards and logic were set within the subject matter as the learners were able to critically deliberate on the concept of taxonomy and classification, as presented in the teacher's PowerPoint slide.

Figure 5: Samples of learners' potato crisps categorisation table

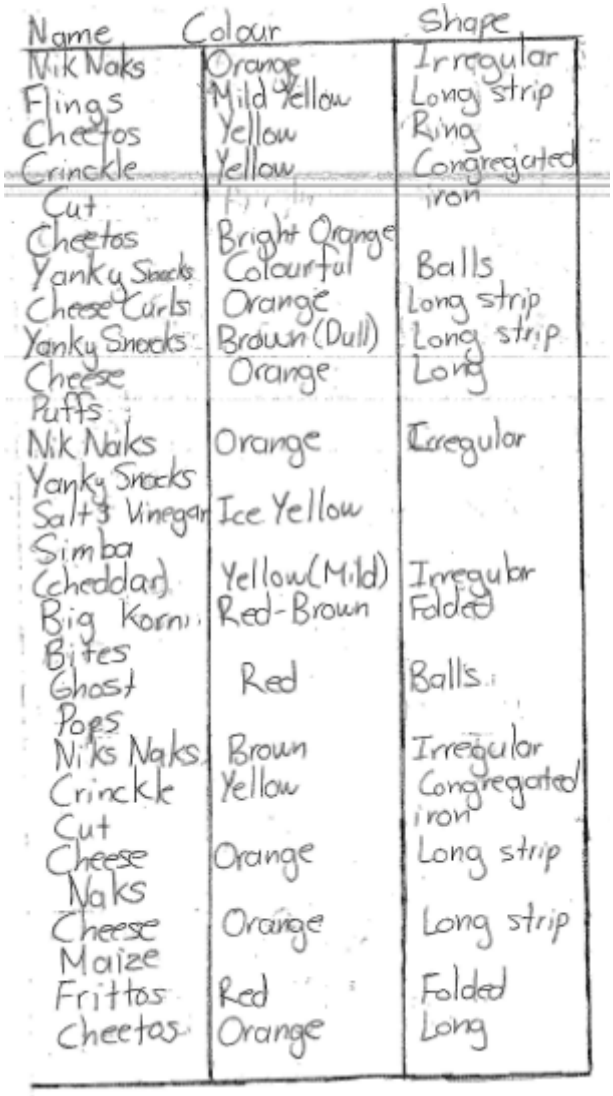
Learner 1:



Classification of Crisps - from hottest to sweetness

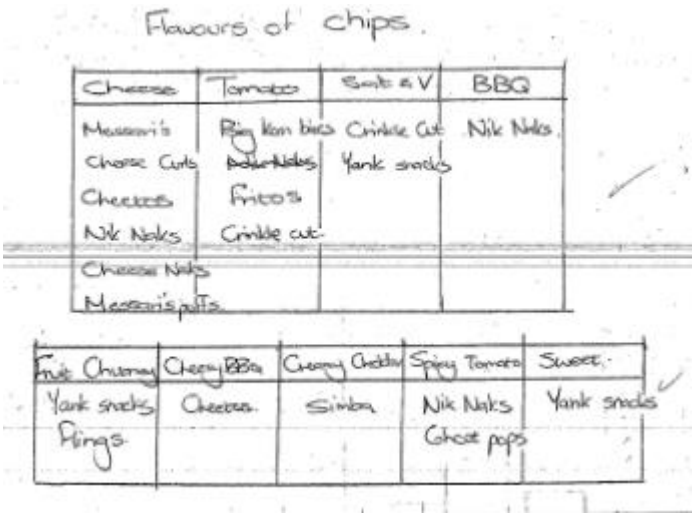
Hot - tomato/spicy	Onions/ not too hot	Salt and Vinegar	Cheesy - Sweet
• Fritos (tomato)	• Crinkle Cut	• Crinkle Cut	• Messan's (maize)
• Big Kan Bites (tomatoes)	(BBQ / tomato)	• Yank Snacks	• Messan's (puffs)
	• Yank Snacks		• Nik Naks
• Ghost pops (original)	• Nik Naks (BBQ)		• Cheese curls
			• Simba (creamy cheddar)
• Nik Naks (spicy tomatoes)	• Cheetos (cheesy BBQ)		• Flings
			• Cheese Naks
• Yank Snacks (fruit chutney)	• Cheetos (cream and onion)		• Cheetos (cheesy)
			• Yank snacks (sweet puffs)

Learner 2:



Name	Colour	Shape
Nik Naks	Orange	Irregular
Flings	Mild Yellow	Long strip
Cheetos	Yellow	Ring
Crinckle Cut	Yellow	Congregated iron
Cheetos	Bright Orange	
Yanky Snacks	Colourful	Balls
Cheese Curls	Orange	Long strip
Yanky Snacks	Brown (Dull)	Long strip
Cheese Puffs	Orange	Long
Nik Naks	Orange	Iregular
Yanky Snacks Salt & Vinegar	Ice Yellow	
Simba Cheddar	Yellow (Mild)	Irregular
Big Korn Bites	Red-Brown	Folded
Ghost Pops	Red	Balls
Niks Naks	Brown	Irregular
Crinckle Cut	Yellow	Congregated iron
Cheese Naks	Orange	Long strip
Cheese Maize	Orange	Long strip
Frittos	Red	Folded
Cheetos	Orange	Long

Learner 3:

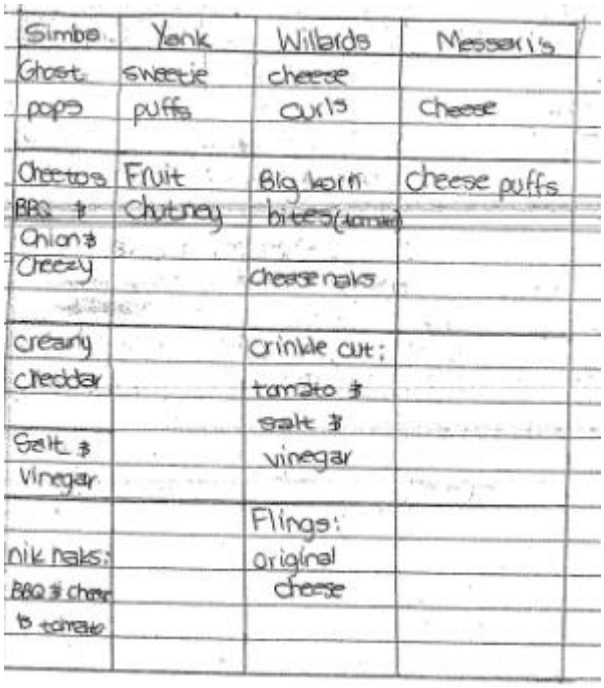


Flavours of chips.

Cheese	Tomato	Salt & V	BBQ
Messoni's	Big korn bites	Crinkle Cut	Nik Naks
Cheese Curls	~~Nik Naks~~	Yank snacks	
Cheetos	Frittos		
Nik Naks	Crinkle cut		
Cheese Naks			
Messoni's puffs			

Fruit Chutney	Cheesy BBQ	Creamy Cheddar	Spicy Tomato	Sweet
Yank snacks	Cheetos	Simba	Nik Naks	Yank snacks
Flings			Ghost pops	

Learner 4:



Simba	Yank	Willards	Messari's
Ghost pops	sweetie puffs	cheese curls	Cheese
Cheetos BBQ & Onion & Cheezy	Fruit Chutney	Big korn bites (tomato) cheese naks	cheese puffs
creamy cheddar		crinkle cut: tomato & salt & vinegar	
Salt & Vinegar			
nik naks: BBQ & cheese & tomato		Flings: original cheese	

Learner 5:

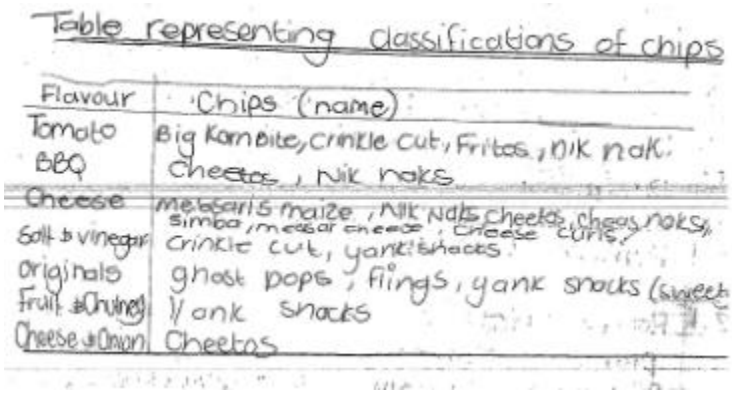
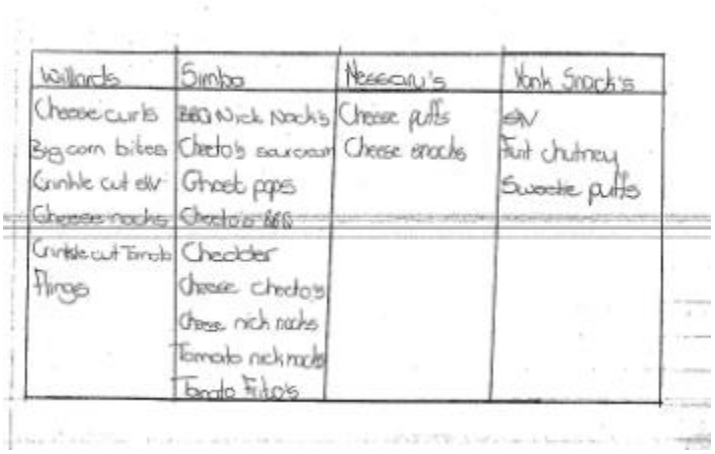


Table representing classifications of chips

Flavour	Chips (name)
Tomato	Big Korn bite, crinkle cut, Fritos, nik nak.
BBQ	Cheetos, Nik naks
Cheese	Messaris maize, Nik Naks cheetos, cheese naks, simba, messar cheese, Cheese curls,
Salt & vinegar	crinkle cut, yank snacks
Originals	ghost pops, flings, yank snacks (sweet
Fruit & Chutney	Yank snacks
Cheese & Onion	Cheetos

Learner 6:



Willards	Simba	Nessan's	York Snack's
Cheese curls	BBQ Nick Nack's	Cheese puffs	Salt
Big corn bites	Cheeto's sourcream	Cheese snacks	Fruit chutney
Crinkle cut salt	Cheese pops		Sweetie puffs
Cheese nachos	Cheeto's BBQ		
Crinkle cut Tomato	Cheddar		
Flings	Cheese cheeto's		
	Cheese nick nacks		
	Tomato nick nacks		
	Tomato Fito's		

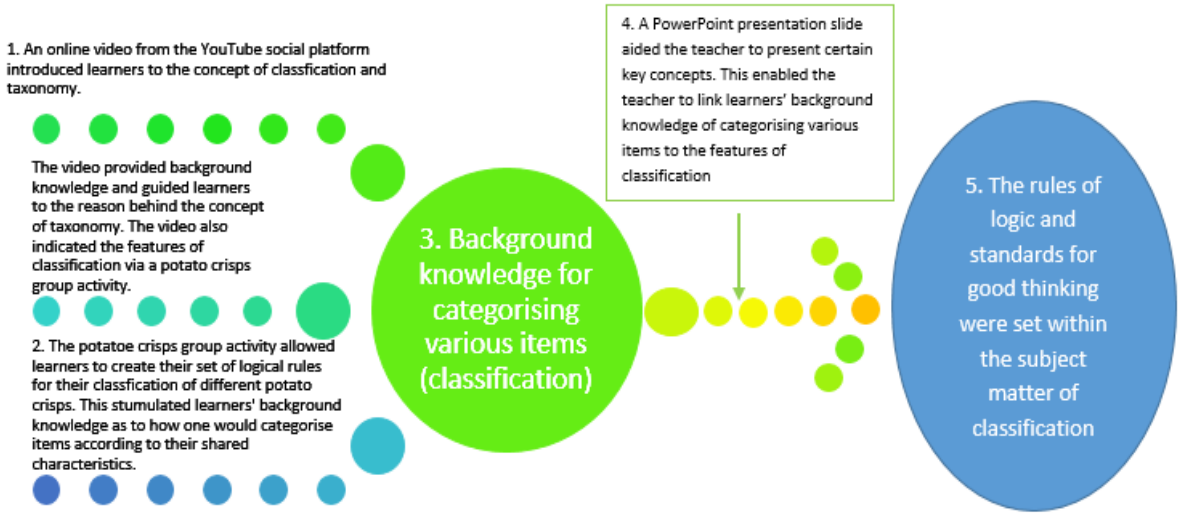
Based on the samples of these learners' potato classification table, it is clear that learners were able to identify the factors required for categorising things, in this instance, categorising potato crisps. For instance, Learners 4 and 6 grouped the potato crisps according to their brands, whereas Learners 3 and 5 categorised the potato crisps according to their flavours. However, interestingly enough, Learner 2 classified the potato crisps according to colour. This emphasises that learners were able to indicate the number of common features shared by the potato crisps as they placed them according to their tables. Hence, learners were able to locate their background knowledge of categorisation from the way they viewed the categorisation video of the animal kingdom. They managed to apply similar concepts of categorisation into the potato crisps classification activity. This demonstrates the teacher's explanation of scientists' revision of hypotheses in learners' tables, where each table contained the learners' own categories.

The teacher further set the standards of critical thinking based on the specified context of classification and taxonomy. In this instance, she created an environment where she was able to use learners' background knowledge of categorisation based on the potato crisps activity. Inevitably, she linked these new concepts from the learners' background knowledge (of categorising items; how items should be distinguished according to their common characteristics for differentiating between various items) to how scientists categorised organisms into their appropriate groups or families within the classification matter.

Therefore, it seems that the learners were able to identify and comprehend how scientists classified organisms, based on the set of logical rules that they had used in the potato crisps

activity. Similar classification systems apply to the standards that scientists would use to classify organisms according to different species and genus (family groups).

Figure 6: The process of critical thinking development within operationalised knowledge



In the above instance, the incorporation of the online video stimulated learners' background knowledge. This allowed the teacher to use the background knowledge indicated in the video content for introducing the concept of classification and taxonomy. By doing so, learners acquired an inclination of how to complete the potato crisps activity by operationalising their prior knowledge of categorisation through using ICT tools and media.

The teacher further affirmed learners' understanding of the classification of organisms through another class activity where learners were required to view online images of various organisms from the teacher's PowerPoint presentation and classify these images according to their shared characteristics.

This activity seemed to demonstrate learners' ability to operationalise their prior knowledge of classification (from the potato crisps activity). They were able to connect this particular standard of categorisation to achieve the outcomes required for the class activity. Furthermore, it seemed that learners were encouraged to operationalise their background knowledge through standards of good thinking set by the teacher in the following class discussion:

Learner 2: *We can classify them (images from the above figure) into groups of animals and plants.*

Teacher: *What about this image over here (amoeba)? Can we group it into either plant or animal kingdom?*

Learner 3: *It doesn't look like plants, maybe it is an animal?*

Teacher: *Does it have similar features to the animals in the animal kingdom?*

Learner 4: *Ma'am, it looks more like a cell or something.*

Teacher: *It is definitely a cell, unicellular, it is called an amoeba. It is an animated amoeba, alright? You basically all said now, plants and animals as possible groupings. Except that (amoeba), it is the odd one out (it is not plant or animal)*

Learner 4: *We can group it into bacteria group or animal with one cell (amoeba)?*

Teacher: *Yes! Yes, we can.*

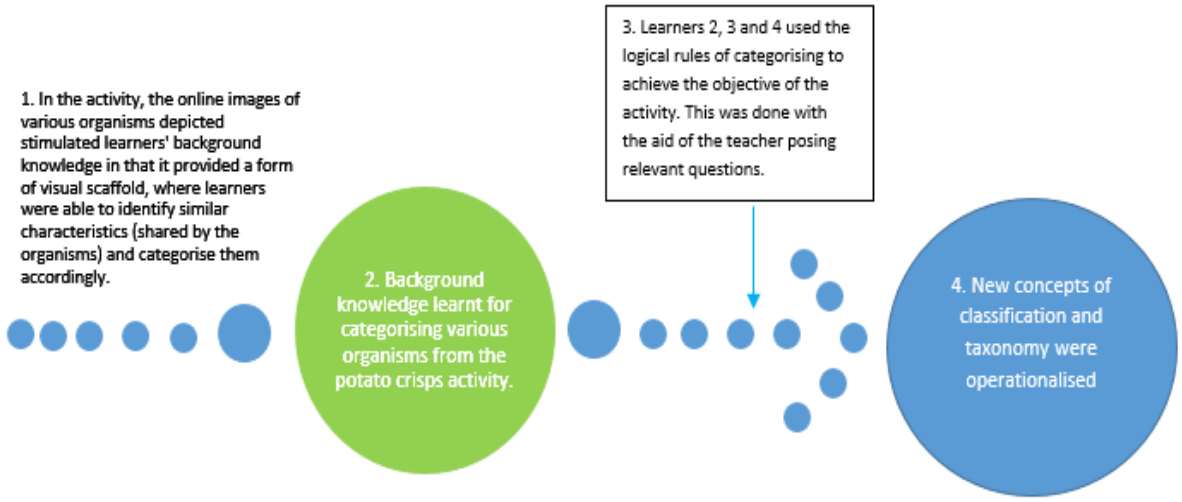
The above discussion further solidified and cemented learners' ability to operationalise their background knowledge through the standards or logical rules set within the subject matter. The online images provided a form of visual scaffold for these learners where they were able to identify the common features of the various organisms and then categorise them according to their shared characteristics. Thus, some of the images were classified into plants and others were classified into animals, however, the teacher purposefully focused learners' attention to the image of amoeba as its characteristics differed from other organisms used in the class activity.

Subsequently, Learner 3 consciously operationalised his understanding of categorisation and applied those rules of logic in his categorisation. However, it seemed that his background knowledge was limited as he categorised amoeba into the animal kingdom. He did so because he thought that the amoeba shared features of animals. This idea was technically incorrect but it allowed the teacher to pose a relevant question to further stimulate his critical thinking on this concept. Consequently, Learner 4 was offered an opportunity to expand on Learner 3's

critical analysis and to further operationalise this critical analysis into an appropriate response that the teacher was aiming for (as part of her critical discussion).

Guiding learners in their conscious thinking therefore allowed the teacher to develop the intellectual products that one requires in critical thinking. According to Khine (2003), as cited in Ng'ambi and Johnston (2006), learners should not be left alone to explore. Instead, the teacher should provide support, coaching and modelling to the learners and take on the role of a facilitator in order to make certain learning to take place.

Figure 7: The process of critical thinking development within operationalised knowledge with the use of online images



Hence, the use of online images provided learners with a reference point to the previous categorisation of the potato crisps activity. Furthermore, the online images provided a reference platform from where learners could compare their past understandings with new information. Furthermore, learners were able to collaboratively demonstrate their way of thinking through small group work, which encouraged discussions between peers and the teacher (McMahon, 2009).

Using ICT within the critical learning discussion related to the subject matter. Therefore, it allowed the teacher to seamlessly introduce background knowledge within the learning environment. This resulted in stimulating the learners' critical and analytical discussion to

further scaffold the prior understanding (the background knowledge) that they had attained. Learners were able to infer a hypothesis (that it possibly was a once-celled organism). By deducing that it could be a bacteria or a microcellular organism, the learners realised that it must be an amoeba.

The above scenario shows how ICT can be used to enhance a teaching method. ICT fittingly provides an effective tool that can actually improve critical thinking in terms of the subject matter under discussion (in line with the objective of the teacher for this particular lesson). Therefore, according to Ng'ambi and Johnston (2006), ICT tools stimulate learners in their critical engagement, in that it poses appropriate questions, which allow them to create meaning for themselves.

4.2.4 A teacher's perception of the use of ICT tools within the classroom influences the incorporation of ICT to promote learners background knowledge, this in turn helps to formulate the standards of good thinking.

The observation of lesson two on classification, tied in to how the teacher perceived critical thinking and how her perception influenced the development of learners' critical thinking processes. Therefore, critical thinking was gained through the ability of linking previously learnt knowledge to current content. In the teacher's questionnaire, the specific discipline that the teacher had highlighted to encourage critical thinking was to assist learners to reflect and link previous information to more current information through her teaching method. The teacher's perception of critical thinking illustrates Bailin (1999) argument that critical thinking background knowledge helps to operationalise knowledge and sets the standards of good thinking in a new specified concept.

The teacher utilised learners' background knowledge to create the standard of good thinking within the Life Science lesson three. In this instance, the teacher demonstrated to the learners the set of logical rules which was used to illustrate the concept of taxonomy via the PowerPoint presentation slide. However, the teacher had to set further standards or a set of rules for good thinking within Life Sciences. She was required to provide learners with the opportunity to build their background knowledge on the new concept. She did this by first revising the previously learnt concept of classification, before connecting that prior knowledge with the use of another YouTube online video. The teacher firstly provided a brief

context to the learners on the content of the video before showing it to them. This perhaps allowed the learners to easier assimilate the content related to the new concept. The particular YouTube online video[6] provided background history of Carl Linnaeus, an influential scientist in the 16th century. This video informed the viewers that Carl Linnaeus invented a system that scientists used to group living organisms into their appropriate categories. This particular online video introduced learners to the standards or rules required for this new concept of taxonomy (naming system of organisms) by exposing learners to the procedures that Carl Linnaeus used before he invented a specific classification system. Subsequently, by using this particular online video of Carl Linnaeus, the teacher was able to link learners' prior knowledge of classification from the activities in lesson two, to the concept of taxonomy

Teacher: *This (YouTube video of Carl Linnaeus) is just to give you an idea of the era or history of how classification came about. What is mentioned in the video now, is a reference of a binomial system. Okay, the fact that he (Carl Linnaeus) uses two different names to name different species.*

The teacher further provided terms or facts regarding taxonomy through a PowerPoint presentation. She presented the definition visually to the learners. Subsequently, she was able to explain the rich terms of classification and taxonomy, phrase by phrase, with an example from the learners' prior association of the scientific term for human species. Again the teacher explained the terms phrase by phrase from the slide by incorporating learners' prior association of the online video of classification, the potato crisps activity, and the online images categorisation class activity. She did this in order to fully demonstrate the characteristics of the taxonomy system.

Teacher A: *Taxonomy involves with naming organisms. Now we have to name animals and plants, in order for them to be easily identified, or to discuss or study across the world. Now the fact that we name organisms (learners' background knowledge of naming organisms as a form of identification) is called 'nomenclature' (term from the slide). The fact that we put them into groups (learners' prior association of*

[6] National History Museum (2008, December 11). *YouTube*. Retrieved March 15, 2015, from YouTube: https://www.youtube.com/watch?v=Gb_IO-SzLgk

the potato crisps activity where they place crisps into different categories) is called 'systematics' (term from the slide). So you are systematically putting them into different groups. Like you have just done in the back (referring to the crisps classification activity and the

online image categorisation class activity). 'Discovering how they are relating to one another is called phylogeny'. The fact that we name organisms is called 'binomial'. Ok, there's a binomial system. Bi means?

Learners: *Two.*

Teacher A: *Yes, like bicycles have two wheels. So binomials, two names. So who knows what our names are as human beings?*

Learners: *Homo Sapiens.*

Teacher A: *Yes, Homo...Sapiens...two names. We are going to get what they are called later, now listen, the naming of organisms is done in Latin.*

In the above example, the teacher created a standard of good thinking within the specific context of the binomial naming system by using learners' prior association of the meaning of the prefix bi and their association of the word *bi*cycles to further demonstrate the concept of the two naming systems within taxonomy. This explanation further elaborated that standards or rules in thinking cannot be set without a solid background knowledge of any given discipline, as indicated by Bailin (1999). Standards can only be set through the knowledge learned within the discipline and these standards are set through the integration of various ICT tools such as online images, online videos and the use of PowerPoint presentation slides, where the teacher associates learners' background knowledge into her explanation. As a result, it set the standard of associating background knowledge in one's critical analysis of any given situation or topic within the specified discipline.

Hence, the teacher's perception on the use of ICT tools is greatly influenced for enhancing critical thinking in learners. She exhibited an enhanced ability to successfully get the learners to grasp the various concepts through the effective use of ICT within the classroom. This improved her ability to get the learners to associate the various concepts in order to build the

logical rulesets for the critical thinking process within the specific discipline. As a result, the learners conceptualised the new ideas that were presented rapidly and accurately. Behar-Horensteim and Niu (2011:27) further demonstrated that teachers should "model the how to: define and clarify information, ask appropriate questions, clarify or challenge statements or beliefs, judge the credibility of sources, and solve problems by predicting probable outcomes logically or through deducing."

4.2.5 The use of ICT tools to stimulate background knowledge for enhancing learners' knowledge of key critical concepts

According to Bailin (1999), critical thinking involves the acknowledgement of intellectual products, such as judgement, arguments, analysis, definition and etc., before one may think critically through responsible deliberation. Consequently, learners need to distinguish the different kinds of intellectual products in order to find relevant evidences or arguments to assess or make better judgement of any complex problems. Bailin (1999:291) further emphasised, "Criteria and standards relevant to assessing intellectual products vary from one sort of intellectual product to another." In other words, the outcome desired for a particular unit will have its own key critical concepts that form the pillar for understanding such content. Consequently, it seems that key critical concepts are based on the background knowledge of that specified unit or topic.

The intellectual products of key critical concepts refer to one's ability to critically analyse and evaluate a certain problem in order to solve that particular problem. Therefore, in order to ensure that learners think with deliberation, the teacher had to create an environment where learners were able to deliberate the kinds of intellectual resources required for their problem solving within the discipline. These deliberate critical analyses or thinking modes were created through the example of showing to the learners of the processes that one should follow in order to think critically by the teacher. In the instance of lesson four, the teacher revised learners' background knowledge of classification and taxonomy by showing them another YouTube online video on the history in theory of evolution. In this particular video, learners were introduced to Charles Darwin's theory of evolution through images of animals in their natural habitats or environment and how he reinvented the classification system through the natural selection. By showing this online video to the learners, the teacher identified to the learners of the critical processes required to reinvent existing knowledge

such as the classification and naming system of Carl Linnaeus and how Charles Darwin used that existing system, re-evaluated it and developed it into an advanced classification system:

Teacher: *Do you remember the YouTube video about Carl Linnaeus from the previous lesson? Yes? Ok, so Carl Linnaeus created a classification system for the different kinds of organisms we have today, but he was not the first scientist to invent the classification and taxonomy system. It was by a guy named Aristotle, he was a Greek philosopher during ancient times. He classified organisms into either those have bloods and those who does not (have bloods). And imagine we only have two groups for classifying organisms. It will be a very long lists under those two categories and scientists from different parts of the world will confuse each other if they only have two groups to refer to. So therefore, Carl Linnaeus took an existing idea, re-evaluate the system and developed it into a more complex system for the wide variety of organisms we have currently.*

However, as we saw from the video now (Charles Darwin Theory of Evolution), evolution is the changing of organisms of billions, billions and billions of years. So, then Charles Darwin came into the picture (of scientists that created classification and taxonomy of organisms), he starts to group things together, understood a bit more that organisms change overtime, there weren't new organisms, they have just evolved, so they were actually the same thing but just changed overtime. Therefore, Charles Darwin took the existing ideas just like Carl Linnaeus, and Charles Darwin evaluated the previous classification system and he identified the missing gaps in the system as he believed that organisms evolve overtime. So, then Charles Darwin developed a better classification system through a process called natural selection. As it pointed out in the video, natural selection is the survival of the fittest. Those are the strongest survives.

Subsequently, with the use of another YouTube video, the teacher was able to interpret the role of the online video to the learners where she specifically indicated to the learners the

intention of viewing this online video. The teacher emphasised that organisms were selected and grouped according to their natural selection. Through that indication, the teacher further illustrated to learners the key critical concepts that are needed to solve a complex issue such as creating classification system for the widely diverse organisms on Earth. The teacher exemplified the key critical concepts required within the Life Science discipline by connecting learners' background knowledge of the previous video of Carl Linnaeus and how he developed the classification system to the similar critical key concepts that Charles Darwin used for his advancement of the classification system.

Illustrating to the learners, allowed the teacher to demonstrate the critical key concepts that scientists took to reach any hypothesis. For instance, in the above observation, the teacher seemed to use words such as 'identified', 'evaluate' and 're-evaluation' purposefully in order to familiarise learners in the vocabularies and this in turn demonstrated to the learners of the intellectual procedures one should follow in order to solve complex issues within Life Science. Furthermore, the teacher was able to exhibit the kinds of key critical concepts one should take in order to think with deliberation within the subject matter through the use of online video by highlighting the idea that classification and taxonomy progressed overtime because of its complex factors within the discipline.

With the aid of the YouTube videos and previous activities such as the potato crisps and classification of online images of various organisms from previous lessons, the teacher was able to further illustrate the content in the division of plant and animal kingdom in lesson four. During the teacher's explanation from the PowerPoint presentation slides of plant kingdom, her learners came across the term 'Euglena' presented bold in the PowerPoint slide. In this instance, a learner was able to think responsibly as she deliberately requested the teacher to show her an image of the Euglena, as this particular learner did not recognise the organism, Euglena, simply by looking at the term presented in bold letters from the slide. The learner could not recognise this particular organism Euglena perhaps because she did not have any background association or knowledge about this organism. To assist this particular learner in her deliberation the teacher used the Internet search engine Google to show the learners an online image of Euglena:

Learner 5: *What do they (Euglena) look like?*

Teacher A: *You should be able to find a picture in your textbook, but I'll Google one picture now.*

Subsequently the teacher's carried on with her explanation that Euglena was neither classified as plant or animal after showing the image of Euglena to the learners, another learner critically identified a gap in his background knowledge which was triggered by the online image from Google. Consequently, this particular learner raised his hand and deliberately asked the teacher about the function of Euglena:

Learner 4: *Ma'am, what does it (Euglena) do?*

Teacher A: *Hold on, let us Google on it.*

The teacher went to the Wikipedia site and briefly showed to the learners that Euglena is a unicellular protists and Euglena is widely studied member of phylum Euglenozoan.

In the above instance, Learner 4 recognised that a specific part of his background knowledge lacked in terms of knowledge of Euglena. As such, this particular learner was able to identify key concepts such as deliberately requesting the teacher to research on more facts on the organism Euglena through his question posed on her. Consequently, this learner was able to identify the appropriate intellectual product such as the responsible deliberation and apply this critical deliberation through the assistance of an internet search engine (Google) in order to fill the gap in his background knowledge of Euglena.

From the above example of the class observation, it seems that ICT stimulated the interactions between the teacher and learners. It seemed that ICT functioned as a tool where learners were able to think deliberately through the use of an internet search engine as an aid for their research in order to find relevant evidences to scaffold their background knowledge of a particular content with its relevant key critical concepts. The integration of technology within the classroom allowed the teacher to achieve critical thinking within learners. In the teacher's questionnaire, the teacher mentioned the strategies that she used to develop learners' critical thinking are through "hands-on activities". These "hands-on activities" involved the potato crisps group activity, the online image categorisation class activity, the viewing of online videos and the images shown to learners. All these activities created an interactive environment for the teacher and her learners whereby they were able to discuss the subject matter within Life Science. The online video clips and online images from her PowerPoint presentation acted as a further visualisation tool for learners. These "hands-on activities" such as the online image enhanced the interactions between the teacher and her learners:

Hands-on activities are always better than theory as it is very interactive and fun as well. Learners like to have freedom to learn in a fun way.

In the case of the above example, the teacher incorporated an online image of Euglena as the hands-on activity which she used to clarify learners' comprehension of the organism, Euglena. With the integration of an online image attained from an internet search engine, learners were provided with a visual image of Euglena and the teacher was able to explain why Euglena was neither an animal nor plant. The image and the Wikipedia website offered the information that a Euglena is a unicellular life form which fitted into the category of the protist kingdom. Therefore, it is clear that ICT drastically enabled the teacher and the learner with instant information of the subject matter. In turn, this assisted the teacher to fully demonstrate the characteristics of organisms within the protist kingdom more proficiently, therefore improving the quality of the lesson and learners' ability to grasp new concepts on Life Science. Behar-Horenstein and Niu (2011) stated that strengthening learners' intellectual functioning in relating old to new materials allowed the teacher to encourage learners to use their intellectual products in their thinking process.

Further development of exemplifying learners' knowledge of intellectual products was also seen in the first lesson of biodiversity, where the teacher utilised the online image of a Blue Crane to enhance interactions within her learners in order to demonstrate the concept of 'hot spot'. In this particular discussion of the South African national bird (Blue Crane), learners identified various intellectual products to critically assess how the Blue Crane illustrate the concept of 'hot spot' within the biodiversity content. By viewing the online image of the Blue Crane, learners recognised that the Blue Crane was unique to the ecological area which was in South Africa. As a result, the teacher was able to demonstrate further in her explanation of the term "hot spot" from her PowerPoint slide that "hot spot" is an unique ecological area where there are diversity of endemic organisms that are threatened to be extinct. Through this particular recognition of the South African National Bird (Blue Crane) from learners' background knowledge, Learners 5 and 6 were able to identify the intellectual products needed for the understanding in the importance of conserving the natural environments for variety of organisms. For instance, Learners 5 and 6 initially evaluated their existing knowledge of the Blue Crane species, before they identified the missing gap in their prior knowledge. It seemed like that these learners thereafter deliberately posed critical questions to the teacher in order to re-evaluate their background knowledge (Blue Crane as a unique organism in South Africa) so to analyse their prior understanding and link it to the new

concept of how Blue Crane being a unique organism could possibly be an endangered species in South Africa.

Thus, while evaluating their existing background knowledge of the Blue Crane with the teacher, Learners 5 and 6 were also able to critically assess how the association of the National Bird (Blue Crane) illustrates the concept of "hot spot in biodiversity.

Learner 5, Isn't there different kinds of Blue Cranes?

Teacher A, Yea, there are plenty different types. That is something we should look into.

Learner 6, Ma'am, is Blue Crane an endangered species?

Teacher A, Ah...I don't think it's endangered.

Learner 5: Let's Google about it and come back with the info (information).

In addition, a learner was able to locate a digital tool (Google search engine) in order to seek the information required to answer their questions. Perhaps at this stage, this particular learner was able to identify the key critical concepts based on what they know (background knowledge of Blue Cranes) in order to progress on their development of critical thinking. Furthermore, Learner 5 was encouraged to discover the missing knowledge of Blue Crane with the aid of the internet search engine (Google), as such this particular learner developed the heuristic of self-learning to further his comprehension of whether Blue Cranes are endangered species in South Africa. It seemed that through the ability of identifying certain intellectual products in critical concepts to apply in learner's critical thinking, this learner was able to evaluate the feedback that he received from the teacher about whether Blue Cranes are endangered species, however, the teacher was unsure of her answer to the question posed by Learner 5, as such this learner was encouraged to use the internet search engine (Google) to self-educate himself on the specie of Blue Crane. Although the teacher did not provide a clear answer to the learner's question, however, she is able to create a learning environment where learners are offer the opportunity to research information through the use of an ICT by setting an example of using ICT in the teacher's classroom.

Consequently, the teacher was able to assist learners in identifying the key critical concepts by providing real life examples or association of the Blue Crane. In this way, she utilised learners' background knowledge and set the standards for thinking critically in that specific

unit which is the term “hot spot” of biodiversity in Life Sciences, so learners may proceed to the stage whereby they were able to identify these standards set initially by the teacher in order to evaluate a given situation. In so doing, it created a better understanding of the new content “hot spot” through learners’ prior association of the Blue Crane. In this instance, it seems that knowledge was operationalised before learners were able to identify the key critical concepts, to find relevant resources for evaluating the link between their background knowledge and new concept.

Figure 8: The process of critical thinking within the knowledge of key concepts resource



4.2.6 The use of Microsoft PowerPoint to stimulate interactions for enhancing heuristics within critical thinking

To encourage critical thinking, learners need to be in a position to decide what heuristics are critical in carrying out complex tasks. Consequently, learning should be scaffold in a way that learners are enabled to discover or explore new knowledge for themselves to solve problems. This could be done by encouraging them "to ask themselves every five to ten minutes whether they are making progress, whether they should change directions and what they options are." Perkins in Bailin (1999:294). Therefore, the teacher needs to create an environment that will encourage learners to be conscious of their thinking progress.

In the case of the observed lesson one, the teacher assisted the learners to evaluate what they know and clarified certain factors in the extinction of biodiversity. Through the teacher's discussion of human error in the extinction of biodiversity indicated in the PowerPoint presentation phrase by phrase. A learner was able to locate what they know (background knowledge) and his association of traditional or herbal medicine:

Teacher: *Our biodiversity is decreasing in an alarming rate... Approximately 34000 plant species are currently faced with extinction mainly as a result of a human activity. So it's our fault...our fault.*

Learner 6: *Isn't indigenous plants or herbal plants used for medicinal purposes? Could that also be one of the reasons for plant extinction?*

Teacher: *Yes.*

In the above example, the learner was able to apply his association of indigenous plants for medicinal purposes into the factor that contributed to the extinction of biodiversity. In so doing, learners were able to consciously in their thinking interpret what they know and apply their interpretation and defend their claims of the factors that may contribute to the decrease of indigenous species within South Africa (see below):

Teacher: *...explain to me what does it mean? (Because plants form the basis of terrestrial food webs, the extinction of life that is dependent on these plants will soon follow.)*

Learner 4: *Because the plant has been taking out of the food web. So there's no producer for the animal.*

Teacher: *Ok, if there is no producer?*

Learners: *No consumers.*

Teacher: *"Yes, we or other carnivores would not have much food to eat, so it will cause extinction."*

From this particular stage it seems that learners were able to self-improve their understanding of their background knowledge of biodiversity through the standards set by the teacher in the rich subject terms presented in the PowerPoint presentation. These PowerPoint slides assisted the teacher to create a learning environment where learners were able to interact with the teachers within the given topic. Consequently, this use of PowerPoint to present subject terms or concepts together with learners' background knowledge developed a certain habit of discussion between teacher and the learner. These discussions permitted learners to identify appropriate key critical concepts within the discipline in order to fully comprehend the given concept. These identifications of key critical concepts developed certain heuristics within learners where they are able to consciously self-educate themselves and evaluate the discussions and references from PowerPoint to further improve on their understanding.

For example, in lesson five, the teacher explained the concept in the divisions of organisms by firstly providing learners the structure of the division in the PowerPoint presentation then she provided real life online images of two animals (Zebra and horse/ lion and tiger) that were similar in features but different characteristics to further elaborated on the division between genus and family within species.

Teacher A: *Now look, this is what I was talking about here again. If you have those two, you have the zebra and horse, and you have the Lion and*

the Tiger, obviously you would group these two animals together (pointing at the images of the Lion and the Tiger). You can see that they are the same but they fall under the same genus, but obviously different because they are different species. So Panthera Leo and Panthera Tigris.

Learner 2: *Ma'am, wouldn't mammals be subphylum? (Which is indicated in the teacher's previous PowerPoint slide)*

Teacher A: *They don't have a subphylum here (textbook), I just took it down and break it a little further.*

In the above instance, the teacher provided the learners with images of lion and tiger in order to stimulate learners' background associations for the physical features of a lion and a tiger. These images allowed the teacher to further illustrate her point that although a lion and tiger may have certain similar features which resulted them to be placed in the same group genus, however, these two animals were different in certain characteristics and in their living habit which resulted in placing lion and tiger in a different family. Furthermore, with the teacher's explanation with the aid of online images from the PowerPoint, a learner was able to consciously assess that mammals belonged to certain subgroup rather than placing these mammals into phylum group as indicated in the teacher's previous PowerPoint slide. It seems that this particular learner was able to knowingly defend her argument by referring the teacher to her previous slide. As a result, this particular learner developed the heuristics of evaluating the teacher's explanation by what she had learned in the earlier slide to perhaps correct or extend further her understanding of divisions in organisms and in this case mammals should be grouped in the division of subphylum based on the fact presented in the previous slide.

Therefore, it seems that the enhancement of ICTs, created a constructive learner-centred environment. Zhao (2016) further illustrated that the use of ICT within classroom teaching enhances learning interest with visual and auditory components, improves the effectiveness of classroom teaching and it develop learners' ability to analyse problems. Hence, the development of critical thinking within learners is the combination of learner-centred environment with the use of ICT tools to enhance interactions and engagement in order to build a certain heuristic one required to think with deliberation.

4.3 The constructivist approach to fostering habits of mind

Throughout the teacher's lessons on classification and taxonomy, it seemed that creating an interactive learning environment was crucial for the learners' critical thinking development. Interaction via class discussion allowed the teacher to develop intellectual products for learners' habits of conscious thinking. From the discussions in lessons two, three, four and five, learners were able to consciously deliberate on the types of intellectual resources required to solve complex issues and to comprehend new concepts. As emphasised by Vygotky (1978), such knowledge entails the internalisation of social activity.

The approach that the teacher used in her classroom with the use of ICT exemplified and solidified the intellectual resources one would require to develop conscious thinking. As the teacher indicated during the interview, her teaching approach allowed for the development of critical thinking within her learners, especially where she assigned learners to group activities in class.:

> *They are learning about how to interact as a group to team work. Oh, ok this is my leader now for this particular group. Even though I assign a leader, it's just a way for them to learn, to critically think now I am part of a team, I need to now listen to an instruction or perhaps I am a strong enough person, let me take the lead if no one else is.*

(Teacher's interview)

It seems that assigning learners in group activities allowed learners to use the intellectual products that were shown to them during class teaching. Intellectual products, such as investigating, identifying, researching, evaluating and judgement, were required within the discussion. Interactions in class created a learning environment where learners were able to think with deliberation with their peers and their teacher. Subsequently, learners developed the habits of conscious thinking through the teacher's teaching approach. These habits ultimately provided them the freedom to use their intellectual resources for the subject matter:

> *Sometimes it's quite important to see them interact. And they enjoyed it as well... to me that's important. I like to see the interactions between learners. I gave to them (assigning group activities to the learners) and I left them (to their own accord to complete the tasks).*

(Teacher's interview)

Furthermore, ICT tools enhanced the teacher's ability to create an interactive and engaging learning environment for her learners as indicated in the above observation of lessons two, three, four and five. Simultaneously, the teacher's perception of using ICT influenced the type of teaching methodology she applied in her classroom teaching:

> *Just by interacting. Interacting is the best. Interaction, just by giving them something to look at or just to write down and not have that interaction going on or seeing that video clip, doing the activity, you are not going to get anything out of them. These kids today are into technologies into seeing you know, they work on their phones and they got access to the internet on their phones.*

(Teacher's interview)

Teacher and learner access to ICT tools created an interactive and engaging learning environment which was crucial to develop critical thinking within the Life Science learners. According to Martin and Carr (2015), teachers who integrate technology into their lessons encourage and enhance curricular goals and classroom instruction. Subsequently, ICT tools seem to offer an opportunity as it allows the teacher to expose learners to different learning styles. In turn, these different learning styles allow the learners to adopt habits that they require to consciously think with deliberation:

> *I think, definitely the technology, because to stand in front of them and not have something that they can refer to. It's unlike standing in front of them, reading out the textbook, it's ok, it's nice to see it as well. To me, to be able to talk about it and see it on the smartboard, is to reinforce it (learners' understanding of the topic). Like I said, some learners are visual and they will remember what they see, especially with the picture. Sometimes, it's not a problem to stand and have a discussion, but that is extra reinforcement in my mind. I also do think it's my style of teaching, I feel like I do explain quite nicely to them that I give them examples to (even if it's silly examples), just day to day, basic examples that they can relate to the topic to the subject concepts.*

(Teacher's interview)

The use of ICT tools allowed the teacher to reinforce the learners' background knowledge, which, as indicated at the beginning of the chapter, is fundamental to intellectual resources for critical thinking. In the classroom under study, the ICT tools assisted the teacher to build those intellectual products that the learners required to achieve habits of mind, such as using online videos, images, and PowerPoint presentations to stimulate their background knowledge.

These ICT tools subsequently allowed learners to practice their deliberate thinking within the Life Science subject matter. This, in turn, provided learners the freedom to debate, analyse and learn from their teacher and peers. Fu (2013) demonstrated that ICT tools assist teaching in that they transform a teaching environment into a learner-centred one. Such an environment results in active learner participation in learning processes. Hence, the teacher and the learners were afforded with educational advancement without limitations.

4.4 Conclusion

From this chapter it becomes evident that ICT can be an effective tool for teachers to enhance the five intellectual resources, as identified by Bailin (1999). The aim of this tool is to enable learners to think with deliberation. Furthermore, it emerges that ICT tools, such as online videos, online images and PowerPoint presentations, help learners to connect their background knowledge to their knowledge of previous concepts.

The observed teacher was able to build learners' background knowledge into the critical intellectual resources required for conscious thinking. She played an important role in developing critical thinking in the classroom through enhancing Bailin's (1999) five intellectual resources.

The next chapter concludes the study and makes recommendations.

Chapter 5 CONCLUSION AND RECOMMENDATION

5.1 Introduction

Critical thinking is crucial in every aspect of one's life -- especially in an educational discipline. Bailin (2002) emphasises that critical thinking is a normative concept, where it is derived from the norm of specific subject matter. It is significant that this report reveals that critical thinking is stimulated and developed by the teacher's pedagogical beliefs as well as by her willingness to implement ICTs into her classroom teaching.

5.2 Background knowledge as the foundation of all stages of five intellectual resources

In all the lessons related to the topic of classification and taxonomy, the teacher seemed to have used learners' background knowledge, rapidly established through the use of ICT tools, as a reference point to introduce any new concept or item of knowledge that was taught throughout the subject matter.

The use of background knowledge within learners features in the majority (if not in all) of the five intellectual resources. Through the use of ICT to promote critical thinking, the pattern that prevailed with this teacher's use of the learners' background knowledge encouraged and stimulated the learners' critical thinking about the topics that were discussed in class. This demonstrates that background knowledge is critical when building on learners' prior understanding of a particular concept or subject. This was evident, as background knowledge appeared in all five stages of Bailin's intellectual resources (Bailin, 1999) during the observed lessons. As the lessons progressed, background knowledge emerged in all five stages of critical thinking in the majority of the teacher's lessons. Background knowledge therefore established itself as a key component and became the foundation that learners used to operationalise their knowledge. Through the use of ICT tools, the rapidly acquired knowledge resulted in learners' application of this knowledge to certain set skills for critical thinking in Life Sciences field.

Rapidly instilled background knowledge allowed learners to identify the critical concepts of solving problems, based on specific context. Since background knowledge is a critical component in human beings' critical thinking abilities, it can lead to inference and hypotheses on possible solutions for successfully solving problems for the symptoms or

conditions observed or presented. The learners' relevant background knowledge was operationalised in order to set a certain criterion or standard of thinking. Bailin (1999) contextualised this as background knowledge that determines the standard or criteria for good thinking.

5.3 The use of ICT to promote five intellectual resources of critical thinking in learners

With the advent of the fourth industrial revolution, interconnectivity enables a connected world. There is widespread Internet and smart mobile devices like smart phones and tablets, while ICT as an information gathering and sharing tool is widely adopted as the preferred method of exchanging information. Today, ICT has become mainstream and far reaching, as it is accessible to mass audiences hungry for all types of critical enabling information. It allows for large amounts of data on a particular topic to be distributed seamlessly to those who seek relevant detail and information. For students who need to gain foundational knowledge and understanding on a new concept. For those who have not been exposed to it previously, the use of ICT is a great tool that can be leveraged to provide seamless access to sought-after detail. The latter is now at one's fingertips, thanks to the use of ICT, enabled by modern technology. The ability of ICT to break down physical, logistical and economical barriers, enabling easy access to life-changing information has been demonstrated across the globe. Allowing rapid assimilation of information, it also enables learners to acquire background knowledge at a rate not previous observed in the history of modern humans' existence.

The advancement of ICT can also be seen in its effective application as a critical thinking enabling tool in the learning environment. In the example observed with the classroom under study, YouTube online videos provided learners with a visual concept to knowledge introduced by the teacher. Through YouTube online videos an effective ICT tool, learners were able to visually identify critical background knowledge on the topics posed by the teacher. Furthermore, it seems that the visual moving pictures of YouTube videos allowed learners to interact with their previously learnt knowledge base. As a result, learners were able to locate or recall any part of the background knowledge, operationalise it or use the newly acquired knowledge to set a standard for critical thinking.

For instance, in lesson four, moving images of animals in their natural habitats were shown in the video of Charles Darwin. By watching this particular video within the context of the topic of natural selection, learners could identify visually the natural habitats of those organisms in the video. Learners could illustrate their thinking, particularly about how the environments or the change in environments, affect certain features from one organism to the other.

Consequently, learners could evaluate their thinking via the images displayed through the YouTube videos. In lesson four, learners were able to identify the term 'natural selection' by assessing their 'interaction' with the organisms' features and structures. This then motivated the teacher's ability to further incorporate YouTube videos as a form of reinforcement, revision, or as a recalling mechanism to emphasise the concepts being taught in the classroom.

Ngi'ambi and Johnston (2006) illustrated that ICT can be useful to teachers when it is carefully integrated into the curriculum. The teacher in the current study used a PowerPoint presentation as a form of ICT tool to organise concepts for the content that she intended to discuss in class. This particular integration of ICT allowed her to visually represent enriched terms within Life Science. ICTs should be properly implemented into the appropriate teaching approach in order to create a meaningful learning for learners, whether it is the simple use of PowerPoint, online videos, online images or the internet web.

5.4 Interaction and discussions were encouraged through the teacher's use of ICT tools in order to develop learners critical thinking skill sets

Constructive interactions between the teacher and learners seemed to have rapidly assisted the development of critical thinking within learners. For instance, through the questions posed by the teacher and through the appropriate responses provided in the learners', they were able to reference, reaffirm and reinforce their newly acquired background knowledge on the subject matter. Moreover, the learners were able to identify the specific topic that was posed by the teacher and locate the relevant background knowledge as reference point. This allowed them to critically solve or identify the possible answers to the questions. For example, in lesson three, the teacher requested the learners to provide her with the correct term or the specific scientific name of the human species; a learner was able to provide the correct answer ("Homo Sapiens"), by locating a part of his background knowledge, by operationalising or using that particular recalled information to provide the only plausible

solution to the question. Therefore, according to Ngi'ambi and Johnston (2006), merely providing access to ICTs, does not guarantee constructivist learning. Thus teachers are required to provide at least some guidance or coaching to allow learners to create their own meaning, as in the case of the teacher in this study.

Online images or illustrations from the Internet act further as an additional form of interaction between teachers and learners. The teacher was able to provide examples or images as a reference to the subject under discussion. Through those images, the learners were able to correctly visually and identify the organisms that the teacher was referring at that moment. Consequently, through the use of the visual image ICT resources, learners were able to critically think and critically discuss certain aspects with the teacher. This enriched the lesson for both the learners and teacher and resulted in a more rewarding learning experience overall. Martin and Carr (2015) further argued that teachers incorporated a variety of ICT tools in their classroom to enhance their lessons and to create an engaging learning environment for their learners. For example, in lesson four, a learner was able to engage the teacher through the image of Euglena, which the teacher was able to quickly research (via Google, while being in class) in order to provide a real example or reference to the discussion.

After viewing the image of the Euglena, some learners posed a question about its functions. The teacher then briefly explained the various functions of this organism by referring to other online resources that were available for viewing. The resources included a website with more relevant content. This was provided through the use of an ICT tool, namely the Google search engine. Images in Life Sciences provided the learners with the visual concepts in a shorter timeframe or without the need to leave the classroom, in order for the learners to compare and identify these specific organisms – stimulants for critical thinking. As phrased by the teacher from the teacher's questionnaire, *images spark learners' critical engagement which allows them to draw from their memory and as a result encourage critical mutually beneficial discussions in the class.*

5.5 How teacher perceptions of ICT influence the promotion of habits of conscious thinking

Habits of the mind are built and intertwined with critical thinking skills that can be applied across the board in multiple disciplines. This allows people to acquire essential knowledge in various study fields, due to ICT mechanisms that have become mainstream and accessible to the masses. This allows for large amounts of data on a particular topic to be distributed seamlessly to those who seek details, including learners who need to gain relevant foundational understanding to any new concepts. The use of ICT is a great tool to provide access to this details. It virtually provides details at one's fingertips. ICT also has the ability to break down physical, logical and economical barriers to access critical information.

Furthermore, ICT allows for rapid information assimilation, which enables learners to acquire background knowledge at a more phenomenal rate than what was previously observed in the history of human existence. Due to the rapid rate of ICT development, teachers are more willing to incorporate new teaching methods and new ways for learners to learn (Petras, 2010 in Ngi'ambi and Johnston, 2006). This is perhaps why the particular teacher in this report was more willing to use ICT to create a constructivist environment:

> *These kids today are into technologies into seeing you know, they work on their phones and they got access to the internet on their phones. And definitely our teaching methods go hand in hand with the technologies we use.*
>
> (Teacher's interview)

5.6 Recommendations

It is recommended that ICT cases in other disciplines be researched further. This will shed more light on ICT's role and benefit within the teaching and learning environment.

Further investigation on implementing and integrating ICT as a tool may enhance the learning environment, as experienced by learners within different disciplines.

Further studies are also recommended to explore whether the critical thinking process within Life Science can be transferred to other disciplines.

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Appendix A: Teacher Questionnaire Information Sheet

Dear Teacher,

This questionnaire forms part of the data for the research topic, namely the use of Information and Communication Technologies (ICTs) as a tool to promote critical thinking in a Grade Ten Life Science class. This particular research topic aims to investigate whether the use of ICTs in the teaching of a topic or chapter in Life Science by a teacher from a South African school does actually emphasise on the development of learners' critical thinking in Life Science.

Therefore, I would be very grateful if you may respond to the questions from this questionnaire with honesty.

If you have any further queries please feel free to contact me, please see below for my contact details:

Cellular number: xxx xxx xxxx

Email address: xxxxxxxxxxxxxxx

Thank you for your participation!

Yours sincerely,

Mei June Luo

Appendix B: Teacher Questionnaire

Section A

1. (a) What Information and Communication Technologies (ICTs) do you currently use to teach Life Science? Please list them.

   _____
   _____
   _____
   _____
   _____

   (b) Are you confident in using these ICTs which you mentioned for teaching? Please provide explanations.

   _____
   _____
   _____
   _____

2. Do you have enough time to prepare adequately for ICT use in the Life Science class?

   _____
   _____
   _____
   _____

3. What is meant by ICT integration?

   _____
   _____
   _____
   _____

4. What are the benefits of using ICTs into your teaching of Life Science?

5. How do you integrate ICTs into your teaching of Life Science class?

Section B

1. What teaching methods do you currently use to teach Life Science?

2. (a) What do you think critical thinking is?

   (b) What do you think critical thinking entails in Life Science?

(c) What principles or strategies so you use to achieve critical thinking in the Life Science topic that you are going to teach?

3. Do you think critical thinking is vital to promote learners' understanding of concepts in Life Science?

4. How will you use ICTs to promote critical thinking in your Life Science classes?

5. Do you feel you have enough ICT knowledge to help develop learners' critical thinking in Life Science?

6. Do your learners have adequate computer skills to help them competently engage in critical thinking in Life Science?

Section C

1. (a) What background knowledge is presented in the topic or chapter that you will teach?

   (b) i. Will you use ICTs to provide the background knowledge?

   ii. If yes, how would you use them?

2. (a) What concepts would you use to achieve the critical thinking required for this topic or chapter?

(b) i. Would you integrate ICTs in your use of concepts in order to achieve critical thinking?

ii. If so, how would you use them?

3. (a) What are the key critical concepts for this particular topic or chapter?

(b) i. Would you use ICTs to help learners identify and apply the key critical concepts?

ii. If so, how would you use them?

4. (a) How would you make your learners become aware of the critical thinking processes for this topic or chapter?

(b) i. Would you use ICTs to make your learners become aware of the critical thinking processes for this topic or chapter?

ii. If so, how would you use them?

5. (a) What teaching strategies or methods would you use to inculcate the thinking practices critical for this topic or chapter?

(b) i. Would you use ICTs in your teaching strategies or methods to inculcate the thinking practices critical for this topic or chapter?

ii. If you were to use ICTs, how would you use them?

Appendix C: Semi-structured Interview Questions for the Grade Ten Life Science Teacher

Research Topic: *The Use of Information and Communication Technologies (ICTs) to ` Promote Critical Thinking in a Grade Ten Life Science Class*

Questions	Responses
1. (a) Do you think you have successfully developed learners' critical thinking in your teaching subject?	
1. (b) If you did, what aspects of your teaching would you attribute to the development of learners' critical thinking?	
1. (c) Would you say your use of and or your learners' use of ICTs contributed to the development of critical thinking processes for learners?	
2. What other factors do you think would be accountable for your success in the development of learners' critical thinking in this particular topic or chapter?	
3. Were the evidences that you used to see whether learners acquire critical thinking reliable? Please explain.	

Appendix D: Informed Consent Letter to the Headmaster/Headmistress

Student Number: 0700624W

Protocol Number: 2013ECE110M

Date: 29 August 2013

Dear Sir/Madam

My name is Mei June Luo. I am a part-time student studying a Master's degree in Education in the School of Education at the University of Witwatersrand.

I am conducting research on the use of information and communication technologies (ICTs) to promote critical thinking in a grade ten Life Science class.

My research involves observing the teacher's use of digital technologies in her teaching of a unit or topic from the Life Science syllabus, in order to promote grade ten learners' critical thinking.

In order to investigate the outcomes of the research, I will request the Life Science teacher to fill out a questionnaire before she introduces the Life Science unit. This questionnaire will take 30 minutes for the teacher to complete.

I would need to video-record classroom observations to understand how ICTs are used effectively in the grade ten Life Science class to promote learners' critical thinking for the subject. Additionally, field notes will be used to record other important elements in the classroom, which a camera might not be able to capture.

After observing a complete unit or topic from the Life Science syllabus, I will interview the teacher. This would help me to reflect on her deliberations on promoting critical thinking in her classroom. This interview will last 30 to 40 minutes. Lastly, I intend using samples of learners' tasks that used during the Life Science unit that was observed. These tasks will

assist me in the analysis state, to determine whether engagement reflects the development of learners' critical thinking.

I will collect the above-mentioned data in September 2013, once permission has been granted by the school's headmaster, the grade ten Life Science teacher, her learners and their parents.

The reason why I have chosen your school is because I have identified a teacher (from the school) who integrates ICTs into her teaching of Life Science. I was wondering whether you would be so kind to give me permission to conduct my research in your school, since I am very likely to here find the data I need to respond to my research topic.

The research participants will not be disadvantaged in any way. They will be reassured that they can withdraw from the research at any time during this project, without any prejudice. There are no foreseeable risks in participating in this study and participants will not be paid for their participation.

The names of the research participants and the identity of the school will both be kept anonymous at all times and in all academic writing related to this study. The privacy of the school and of the individual participants will be maintained in all published and written data resulting from the study.

All research data will be destroyed within three to five years after the completion of this study.

Please let me know if you require any further information.

I look forward to your response.

Thank you.

Yours sincerely,

Mei June Luo

Appendix E Information Sheet: Teacher

Student Number: 0700624W

Protocol Number: 2013ECE110M

Date: 29 August 2013

Dear Teacher,

My name is Mei June Luo. I am a part-time student studying for a Master's degree in Education in the School of Education at the University of Witwatersrand.

I am conducting research on the use of information and communication technologies (ICTs) to promote critical thinking in a grade ten Life Science class.

My research involves the observation of your use of digital technologies in a grade ten Life Science class. It is in the interests of this research to determine whether the use of digital technologies creates a learning environment where your learners can develop critical thinking required to successfully manipulate their subject matter.

In order to investigate the concerns of this research, I will need your consent in completing a questionnaire which seeks to investigate your perception on critical thinking as well as on integrating digital technologies in your classroom teaching. In addition to the questionnaire, I request to observe and video record you while you teach a complete unit or chapter from the grade ten Life Science syllabus. After the observations, I would like to also conduct an interview with you. It should take between thirty to forty-five minutes to complete. In this interview, I seek to understand your deliberation in creating the environment for your learners to think critically. Lastly, I would like to collect the samples of your learners' tasks that they complete in this particular grade ten Life Science unit. I will seek their permission and their parent's consent since they are under the age of eighteen years.

The reason as to why I have chosen to work with you, is because of the way you implement ICTs in your classroom teaching.

I would like to request permission from you to observe and video record your lessons and to complete my questionnaire and interview. Your voluntary participation in this research will greatly assist me in examining whether the use of digital technologies promote critical thinking in your grade ten Life Science learners.

Your name and identity will remain anonymous and will be kept in confidentiality in this research report. Your individual privacy will be maintained in all published and written data resulting from this study.

All research data will be destroyed within three to five years after completion of this study

You will not be disadvantaged in any way by participating in this research. Since your participation is voluntary, you may withdraw, without any prejudice, from this research at any time during the duration of this study. There are no foreseeable risks in participating and you will not be paid for this research.

Please do not hesitate to contact me for further queries.

Your assistance and participation is greatly appreciated.

Yours sincerely,

Mei June Luo

Student Number: 0700624W

Protocol Number: 2013ECE110M

Teacher's Consent Form: Videotaping

Please complete and return the reply slip below and indicate your willingness to have your classroom teaching video-taped for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be video-taped

My name: _____

I give/ do not give (please circle your selection) my consent to have the classroom observations video-taped.

[ ] I know that I may withdraw from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I know that I can stop the video-taping at any time without repercussions.

[ ] I know that the tapes will be destroyed within three to five years after completion of the study and will be kept safe until then.

Teacher's signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Teacher's Consent Form: Class Observations

Please complete and return the reply slip below and indicate your willingness for your teaching to be observed in class for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be observed

I, _____

grant/ do not grant (please circle your selection) my consent to be observed in class for this research.

[ ] I know that I may withdraw from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I am aware that the researcher will keep all the information confidential in all academic writing.

[ ] I know that the observations will only be used for this research report.

Teacher's signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Teacher's Consent Form: Interview

Please complete and return the reply slip below and indicate your willingness to be interviewed for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be interviewed

I, _____

grant/ do not grant (please circle your selection) my consent to be observed in class for this research.

[ ] I know that I may withdraw from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I am aware that the researcher will keep all the information confidential in all academic writing.

[ ] I am aware that my interview transcript will be destroyed within three to five years after the completion of this study.

Teacher's signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Teacher's Consent Form: Audio-taping

Please complete and return the reply slip below and indicate your willingness to have your interview audiotaped for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be audio-taped

I, _____

grant/ do not grant (please circle your selection) my consent to be observed in class for this research.

[ ] I know that I may withdraw from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I know that I can stop the audio-taping at any time without repercussions.

[ ] I know that the tapes will be destroyed within three to five years after completion of the study and will be kept safe until then.

Teacher's signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Teacher's Consent Form: Questionnaire

Please complete and return the reply slip below and indicate your willingness to be interviewed for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission for the use of a questionnaire

I, _____

grant/ do not grant (please circle your selection) my consent to be observed in class for this research.

[ ] I know that I may withdraw from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I know that I can decline to answer any questions from the questionnaire

[ ] I am aware that the researcher will keep all the information confidential in all academic writing.

[ ] I am aware that my questionnaire will be destroyed within three to five years after the completion of this study.

Teacher's signature: _____ Date: _____

Appendix F Information Sheet: Parents

Student Number: 0700624W

Protocol Number: 2013ECE110M

Date: 29 August 2013

Dear Parent/ Guardian,

My name is Mei June Luo, I am a part-time student studying a Master's degree in Education in the School of Education at the University of Witwatersrand.

I am doing a research on the use of information and communication technologies (ICTs) to promote critical thinking in a grade ten Life Science class.

My research involves observing and video-recording your child's participation in his or her grade ten Life Science Class. These observations will last for the duration in which your child will be attending lessons on a Grade Ten Life Science unit. The video-recording will allow me to closely determine if the use of digital technologies by your child's Life Science teacher promotes critical thinking in her teaching. Additionally, I will need your permission to collect samples of your child's Life Science tasks for the unit of work which I will observe. The analysis of these tasks will help me determine if your child's engagement reflects critical thinking.

The reason why I have chosen your child's class is because your child's Life Science teacher incorporates digital technologies in her classroom teaching. As such, I would like to request permission from you to collect data from your child during the duration of this research. I will require to video record class observations and collect sample of your child's work in Life Science.

Your child will not be advantaged or disadvantaged in any way. He or she will be reassured that he or she may withdraw his or her participation at any time during this research without

any prejudice. There are no foreseeable risks in participating and your child will not be paid from the participation.

All research data will be destroyed within three to five years after completion of this study.

Please do not hesitate to contact me if you have any further questions.

I look forward to your response as soon as is convenient. Thank you.

Yours sincerely,

Mei June Luo

Student Number: 0700624W

Protocol Number: 2013ECE110M

Parent's/Guardian's Consent Form: Video-taping

Please complete and return the reply slip below and indicate your willingness to allow your child's class attendance to be video-taped for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be video-taped

I, _____parent/ guardian of _____ (your child's name)

grant/ do not grant (please circle your selection) my consent to have my child's classroom attendance to be videotaped.

[ ] I know that I may withdraw my child from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I know that I can stop the video-taping of my child at any time without repercussions.

[ ] I know that the tapes will be destroyed within three to five years after completion of the study and will be kept safe until then.

Parent's/ Guardian's Signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Parent's/ Guardian's Consent Form: Class Observations

Please fill and return the reply slip below and indicate your willingness for your teaching to be observed in class for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be observed

I, _____ parent/ guardian of _____ (your child's name)

grant/ do not grant (please circle your selection) my consent to be observed in class for this research.

[ ] I know that I may withdraw my child from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I am aware that the researcher will keep all the information confidential in all academic writing.

[ ] I know that the observations will only be used for this research report.

Parent's/ guardian's signature: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Parent'/ Guardian's Consent Form: Documents

Please complete and return the reply slip below and indicate your willingness to allow me to use certain documents (work tasks related to the Life Science unit that your child will complete during class) for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission for the use of tasks related to the Life Science unit that your child will complete.

I, _____ parent/ guardian of _____ (your child's name)

grant/ do not grant (please circle your selection) my consent for the researcher to look at the following documents: tasks relating to the Life Science unit that your child will participate in).

[ ] I know that I may withdraw my child from the study at any time and will not be disadvantaged or advantaged in any way.

[ ] I know that my child's documents (tasks related to the Life Science unit) will be used for this research only.

[ ] I know that if photographs of the documents are taken that the identity of my child will not be disclosed.

Parent's/ Guardian's signature: _____ Date: _____

Appendix G Information Sheet: Learners

Student Number: 0700624W

Protocol Number: 2013ECE110M

Date: 29 August 2013

Dear Parent/ Guardian,

My name is Mei June Luo, I am a part-time student studying for a Master's degree in Education in the School of Education at the University of Witwatersrand.

I am conducting research on the use of information and communication technologies (ICTs) to promote critical thinking in a Grade Ten Life Science class.

My investigation involves observing your attendance in your Life Science lessons. These observations will allow me to discover how you interact with your classroom peers and your Life Science teacher and how these interactions encourage you to think critically within the subject matter. In addition, these observations will allow me to see if the digital technologies that your Life Science teacher uses in the classroom assist you to think critically in the tasks you perform. Thus, I will need your permission to video-record and observe your attendance in the Life Science lessons. These observations will last for the entire period of one unit of your Life Science syllabus. I will also need your permission to make copies of your tasks or activities that you will complete during the observed unit so I may see if you are using critical thinking needed to learn and understand within Life Science.

I would like to request permission from you in observing your participation in Life Science lessons. This will allow me to see whether your teacher’s use of digital technologies create an interactive and engaging learning environment where you will develop your critical thinking.

Please note that this is not a test, it is not for marks and it is completely voluntary. If at any point in time you decide withdraw your participation from this research. It will not affect you negatively as a learner in your school and no prejudice will be given to you.

I will keep your identity in confidentiality in my research report. All information about you will be kept confidential in this research report. Furthermore, all data collected from this research will be stored safely and destroyed within three to five years after I have completed my research.

If you are under the age of eighteen, your parents will require to give their permissions for your participation in this research.

I look forward to be working with you!

Please do not hesitate to contact me if you have any further questions.

Thank you.

Yours sincerely,

Mei June Luo

Student Number: 0700624W

Protocol Number: 2013ECE110M

Consent Form: Observation of Learners

Please fill and return the reply slip below if you agree to let me observe you in class for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission for observations

My name is _____

I would like to be part of this project. YES/ NO

I agree to be observed in class. YES/ NO

I know that the researcher will keep my information confidential

And destroy any notes collected within three to five years after

completion of this research. YES/ NO

I know that I can request you to leave me out of this research at any time. YES/ NO

Sign: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Consent Form: Learner's videotaping

Please complete and return the reply slip below if you agree to have your participation in the Life Science class video-taped for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission to be video-taped

My name is _____

I agree to be videotaped during my Life Science class time. YES/ NO

I know that I can stop the video-recording at any time. YES/ NO

I know that the video-tapings will be used for this research only. YES/ NO

I know that the video-tapings will be destroyed within three to five years after the completion of this research and it will be kept safe until then. YES/ NO

Sign: _____ Date: _____

Student Number: 0700624W

Protocol Number: 2013ECE110M

Consent Form: Learner's Documents

Please complete and return the reply slip below if you agree to have your tasks or activities that you complete in the Life Science classes to be analysed for my research report: The Use of Information and Communication Technologies (ICTs) to Promote Critical Thinking in a Grade Ten Life Science Class.

Permission for collecting tasks or activities relating to the subject unit

My name is _____

I agree that my tasks or activities that are completed during my Life Science classes will only be used for this research. YES/ NO

I know that the researcher will keep my information safe and in confidentiality and that my real name will not be used in this research. YES/ NO

Sign: _____ Date: _____