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Utilising educational technologies to support inquiry-based learning in natural science

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Abstract

The study explored the technologies that can be used to support Inquiry-Based Learning (IBL) in Natural Science (NS) in Ekurhuleni schools, Gauteng. An interpretivist research philosophy, qualitative research approach and a case study design were employed. Data were collected from participants through interviews and focus group discussions. Findings revealed that the use of IBL methods motivates learners and enables them to understand scientific concepts. However, it is constrained by untrained teachers and lack of resources and time in schools. It was further revealed that some schools have invested in educational technologies that support IBL while some schools have inadequate or lack the required technologies. It is recommended that the Department of Basic Education and schools should train teachers and mobilise material and technological resources that are needed for the implementation of IBL in the science class. In addition, schools should embark on fundraising and income generating projects to raise money for the needed materials and educational technologies. Schools that do not have educational technologies should collaborate with libraries, education institutions and other institutions with available technologies that can be accessed by the learners.

Keywords: *educational technologies, inquiry-based, natural science, Ekurhuleni schools*

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1. Introduction

Most education studies have highlighted limitations of traditional teaching methods where the teacher is the central figure, and have encouraged the use of contemporary teaching and learning methods that focus on learner engagement and learning activities that are learner-centred (Muianga et al., 2018). The paradigm shift from a teacher-centred to a learner-centred approach made Inquiry-based learning (IBL) received a lot of attention and consideration as a modern instructional method. IBL is an instructional approach that invites learners to explore academic content through investigation and answering questions. It puts learners' questions at the centre of the learning process, and places much value on research skills and understanding of content.

In acknowledging the importance of IBL in science education, most countries have established programmes and projects that promote inquiry-based science education pedagogy like Scientix in Belgium, Fibonacci in France, SiS Catalyst in the United Kingdom, and Primas in Germany (Kazeni & Mkhwanazi, 2021). In South Africa, the Curriculum and Assessment Policy Statement (CAPS) of 2012 advocates for the adoption of inquiry-based approach in science classrooms. In fact, the National Curriculum Statement Grades R-12 is based on the principle of active and critical learning, encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths. The aim of the Natural Science (NS) National Curriculum Statement Grades R-12 is to produce learners who are able to identify and solve problems and make decisions using critical and creative thinking, collect, analyse, organise and critically evaluate information, use science and technology effectively and critically. Both the aim and principles of the NS curriculum advocate for the use of a learner-centred approach that promotes inquiry-based methods in the teaching and learning of NS.

The study of Ramnarain and Hlatswayo (2018) found teachers had a positive attitude towards inquiry in the teaching and learning of Physical Sciences. Despite the positive belief towards IBL, teachers were less inclined to enact it in their lessons. They claimed that its implementation was fraught with difficulties, such as availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes, which created tension in their willingness to implement IBL. Samuels and Dudu (2017) highlight that South African schools have a high learner to teacher ratio, which makes it difficult for teachers to implement certain strategies including IBL when teaching science subjects. This is supported by Ncala

(2016) reporting overcrowding in life sciences classrooms. The abnormally large classes in a township public school results to the difficult administration of IBL inclined lessons. Researchers argue that although there are benefits associated with the use of IBL in science education, and strong advocacy and growing consensus among researchers that it should be adopted, this approach is rarely adopted in South African science classrooms due to several challenges (Kazeni & Mkhwanazi, 2021; Ramnarain & Hlatshwayo, 2018).

According to Williams et al. (2016), technology can be used to support and enhance IBL by reducing some of the challenges encountered in its implementation and motivating teachers to adopt it and sustain its implementation. The 21st century has seen a massive advent of technologies that can be used to support and enrich teaching and learning (Madlela, 2022). There is a wide range of web-based technologies that support sharing, co-construction and communication of ideas among learners, teachers and community experts inside and outside the classroom. Such technologies have a potential of encouraging student ownership of their learning while at the same time enriching their understanding of concepts. Hence, this study explored the use of educational technologies to support IBL in the NS subject.

2. Literature Review

2.1. Theoretical framework

Lev Vygotsky, a Russian psychologist regarded as the father of social constructivism, believes that whatever children learn together in a given time can be independently done in the future (Rohman & Fauziati, 2022). Knowledge is socially constructed through dialogue and interaction with others (Churcher, Downsb, & Tewksburya, 2014) and it is co-constructed in a social environment through the process of interaction using language as a tool to construct meaning. According to Akpan et al. (2020), language and culture are frameworks through which humans experience, communicate, and understand reality.

According to the teaching of social constructivism, social learning actually leads to cognitive development. All learning tasks irrespective of the level of difficulty can be performed by learners under adult guidance or with peer collaboration. Students can collaborate with the teacher or peers to construct knowledge and understanding (Akpan et al., 2020). Social construction of knowledge could be achieved through team work, group discussion or any instructional interaction in an educational setting (Kapur, 2018). Social constructivism allows a variety of groupings and interactive methods which include class discussions, small group discussions or learners working in pairs on given tasks. The core factor of the theory is that learners work in groups to brainstorm, share ideas trying to discover cause and effect, answers to problems or to create something new to add to existing knowledge (Akpan et al., 2020).

With the advent of technology in education, social constructivism became the most suitable theory to guide the incorporation of digital technologies into pedagogy. The landscape of education is swiftly changing due to technological improvement (Secore, 2017). As teaching and learning gradually migrate to online platforms, contentious debates have arisen on the models to be adopted for implementation. Research often points to social constructivism as the preferred delivery mode of online learning technologies (Secore, 2017). If used properly, online technologies can strengthen IBL strategies that call for active learner participation and sharing of ideas with peers. IBL, as rooted on the principles of constructivism, make emphasis on learner involvement and participation in class. Social constructivism corroborates the principles of IBL because central to both social constructivism and IBL is the view that social interaction is a vital aspect of learning (Ncala, 2016). Hence, technological gadgets and software can facilitate learner interaction in an IBL classroom.

2.2. Types of inquiry-based learning

Inquiry occurs at four levels; confirmatory inquiry, structured inquiry, guided inquiry and open inquiry. These four levels are distinguished by the amount of teacher involvement in learning and teacher involvement decreases with the increasing inquiry level (Artayasa et al., 2018).

In ***confirmatory IBL***, the teacher develops questions and methods for learners. Learners are guided through an activity with known results. The aim of the investigation is to confirm the known results rather than to construct new knowledge, which makes it the lowest level of inquiry. Meanwhile, in ***structured inquiry***, learners are given the question to be investigated and the procedure to be followed to answer the question, but they are not given the outcome (Whitworth et al., 2015). Learners then investigate the teacher-presented question through a prescribed procedure. The teacher is involved in this process through giving step-by-step guidelines at each stage. The limitation of this method is that learners do not acquire the ability to think autonomously, since they do not have the opportunity to set their own questions and to generate their own processes to seek answers to the questions. On the other hand, in ***guided inquiry***, learners are given a question, and they determine their own method of gathering data. They are responsible for the interpretation of the results and drawing up of conclusions (Ncala, 2016). The teacher's role is to prepare material for the lesson, design activities that will enable learners to discover and gain necessary experiences, and also develop questions that learners should focus on to search for answers (Warner & Myers, 2020). When using this approach, the teacher gives the material and a brief introduction. While learners are involved in the discovery process, the teacher moves around the class providing limited assistance through asking further simplified questions or providing hints. It is advisable for the teacher to encourage learners to discuss with each other throughout the process and avoid giving learners answers (Warner & Myers, 2020). Lastly, ***open inquiry*** is the most complex level which provides learners with a high degree of autonomy. Learners pose their own questions that guide inquiry activities (Pontinen et al., 2019). This way, learners take charge of their own learning. After posing questions themselves, they conduct scientific investigations to generate data to answer questions autonomously (Van Uum et al., 2017). Teachers give support to learners, particularly in the early stages of the inquiry process, referred to as scaffolding (Van Uum et al., 2017). The four strands of inquiry and the level of teacher scaffolding are illustrated in table 1.

Table 1

The four strands of inquiry and the level of scaffolding

Level of inquiry	Type of inquiry	What the teacher provides the learner		
		Question?	**Methods?**	**Solution?**
1	Confirmatory inquiry	X	X	X
2	Structured inquiry	X	X	
3	Guided inquiry	X		
4	Open inquiry			

Source: Adapted from Ncala (2016)

The table illustrates that at the lowest level of inquiry, the teacher is more involved to provide scaffolds to learners. As levels of inquiry go up, the level of teacher involvement diminishes and learners start to work autonomously.

2.3. Inquiry-based teaching methods

Ncala (2016) posits that IBL shows significant efficacy in the retention of scientific knowledge by learners in all science disciplines. It enables learners to utilise their current knowledge to construct new knowledge (Bevins & Price, 2016) and motivates learners to understand abstract scientific concepts (Ramnarain & Hlatswayo, 2018). IBL emphasises most on critical thinking, problem solving, and communication abilities. According to Gholam (2019), when students learn by discovery and investigation in authentic settings, they improve their critical thinking skills. In IBL, learners take full responsibility of their own learning and participate in the production of knowledge that is used to solve identified problems.

Guido (2017) identifies seven benefits of IBL as reinforcing curriculum content, warming up the brain for learning, promoting a deeper understanding of the content, making learning rewarding, building initiative and self- direction, offering differentiated instruction and capable of working in almost any classroom. However, at times, minimally guided forms of inquiry do not work, and learners may take longer to complete tasks, since no guidance is given to them (Bevins & Price, 2016). While learners are not all capable of carrying out self-directed learning without the teacher's assistance (Artayasa et al., 2018), open-ended learning environments are also challenging for teachers. The lack of support, inquiry-based teaching material, facilities such as laboratories, instructional time (Ramnarain & Hlatswayo, 2018; Gutierez, 2015) and overcrowded science classrooms (Ncala, 2016) contribute to the non-implementation of IBL in science classrooms.

2.4. Educational technologies that support IBL

In primary and secondary education, technology-enhanced learning applications are becoming an everyday practice (Smith et al., 2020). For instance, multiple e-tools (i.e. WebQuest, virtual laboratory, computer simulations) have been developed either as freeware or as commercial products that can be obtained for a monthly fee, which have changed the perceptions of learners towards natural sciences and have boosted their interest for science domains such as biology, chemistry, physics, mathematics and astronomy (Smith et al., 2020). Hakverdi-Can and Sonmez (2012) describe WebQuests as suitable for an environment where learners are expected to solve a problem, which allows learners to go beyond collecting information and requires them to synthesise information and draw their own conclusions.

Similarly, Singhai (2018) suggests virtual laboratory (V-lab) be used to save schools from time and resources in setting up science laboratories, which most schools cannot afford. In fact, studies showed that V-labs can be efficient tools for engaging STEM learners in authentic learning experiences, fostering conceptual understanding, stimulating self-paced learning, and offering practical problem-solving experience (May et al., 2022; Brinson, 2015). On the other hand, computer simulations, computer-generated dynamic models, present theoretical or simplified models of real-world phenomena, components, or processes (Abdullah et al., 2021). They can include visualisation, animations, and interactive laboratory experiences enabling users to change particular sets of variables or parameters, which then builds a virtual environment using those variables or parameters (Wilson, 2016).

In a study conducted by Abdullah et al. (2021), the inquiry-based computer-simulated lesson in Physics allowed learners to review the concepts and see relationships between the variables in graphical forms when a selected independent variable was manipulated and all the corresponding values were keyed into the Excel table. Computer simulations have been very engaging for learners, provided the learner is the one asking questions and driving the investigation (Wilson, 2016). It also provides a viable alternative to physical science laboratories that exist in only a small proportion of South African schools (Dunn & Ramnarain, 2020). Through visualisation, learners acquire an understanding of such phenomena.

3. Methodology

The study's data collection process was guided by interpretivism research philosophy, which is viewed by Creswell (2014) as appropriate for qualitative research. Unlike positivism, interpretivism aims to include richness in the insights gathered rather than attempting to provide definite and universal laws that can be generalised and applicable to everyone regardless of some key variables and factors (Saunders et al., 2012). According to Kivunja and Kuyini (2017), the central endeavour of interpretivism paradigm is to understand the subjective world of human experience. This made it possible to get the viewpoint of participants in Ekurhuleni schools about how educational technologies could be used to support IBL in NS. It also enabled the researcher to use a qualitative research approach whose goal is to have a deep understanding of the phenomenon, describe and interpret it systematically from the point of view of individuals being studied (Haradhan, 2018).

A case study design made it possible to focus on four selected schools and collected rich and detailed information from participants' natural settings in schools (McMillan & Schumacher, 2014). Four NS Heads of Departments (HODs) and three NS teachers were interviewed while other four NS teachers participated in focus group discussions. A total of eleven purposively selected participants who implement IBL in NS took part in the study. Data were analysed in a narrative format under themes that emerged from data interpretation (McMillan & Schumacher, 2014).

The ethical guidelines were upheld in this study. The participants' names and identities were not disclosed, and participation in the study was voluntary and through informed consent (McMillan & Schumacher, 2014). Code names were used to protect the identity of participants and schools. Similarly, participants signed consent forms with ethical guidelines before taking part in the study. Data were kept safe and used for a comparative study that will be conducted on the same topic in Eswatini. After finalisation of the comparative study, data in hard copies will be destroyed through shredding and data in soft copies will be deleted. Permission to conduct the study was granted by Gauteng Department of Basic Education.

4. Findings and Discussion

4.1. Inquiry-based learning

Though some participants struggled to give an overview of IBL, most participants managed to.

> *For me inquiry-based learning is where the learner is asking questions based on their knowledge and experiences so that they learn more from their experiences* (HOD 1 from school C).
>
> *Inquiry-based learning happens when learners use their initiative to find information about a topic* (HOD 2 from school C).
>
> *Inquiry-based learning happens when learners learn through experimentation* (HOD school B).
>
> *Inquiry-based learning is hands on. It is a learner-centred approach where learners are actively involved in inquiry rather than a teacher-centred approach where information is transferred by the teacher to the learners* (Teacher 1 school B).

Participants' responses show that they understood that in IBL, learners play an active role in their learning through experimentation and seeking information on a given topic than only relying on information from the teacher. As an instructional practice, learners are at the centre and take ownership of their own learning by posing questions, investigating and answering questions (Suarez et al., 2018), enabling learners to conduct research to solve problems that they encounter (Korkman & Metin, 2021).

4.2. Types of IBL teaching and learning methods used in science

Findings revealed that most teachers used experiments as an inquiry-based method in the science classroom. Though some participants said that they used field trips, individual and group research, experiments seemed to dominate other inquiry-based methods.

> *We use experimentation to support knowledge that learners are taught in theory. Experiments help learners to have a practical view and experience of what they learnt on theory. This helps them to see it in practical form than in text form. Some of us knew the test tube through text books. Learners of today are privileged because they see the actual test tube in the laboratory. They conduct experiments using apparatus in the laboratory and see actual results than being told. Some learners are textile and visual, they understand concepts better through practically participating in experiments and seeing results (*HOD School B*).*

> *Mmm! We have practicals. After teaching 2 or 3 topics we do practicals so that learners can see what is taught in a practical way. For example, when teaching about density you can pour substances like sunlight liquid, spirit and sun flour liquid inside the cylinder. The one that goes to the bottom indicates that it is dense than the one that remains at the top. If learners see this practically they tend to understand it better than when it is explained to them in theory (*Teacher 1 School B).

> *We use practicals to investigate scientific concepts, and students use normal lab equipment. This is hands on. They manipulate and collect data of their own. They develop hypothesis and aims and manipulate the equipment to see whether the results match the hypothesis. If the results do not match they have to explain* (HOD1 School C).

As primarily used by the teachers, experiments are vital instructional delivery method as they enable learners to manipulate objects, test hypothesis, and work together to solve a problem or to prove something exciting (Shamsudina et al., 2013). Similarly, they are perceived as an enlivening element in physics lessons, and they help with understanding the subject matter and are also an interesting complement to theory (Marounova & Kacovsky, 2024).

Some participants said they used field trips and also allowed learners to conduct research themselves about a given topic.

> *As learners go about their research, other topics and questions open up. This results in enrichment and better understanding of concepts by learners* (HOD 2 School C).

> *After covering a topic, I give learners work sheets with questions that require them to carry out research individually or as a group. After researching they present their findings to the whole class followed by discussions* (Teacher 4 School A).

The group research and presentations are encouraged in social constructivism, which could be achieved through team work, group discussion or any instructional interaction in an educational setting, according to Kapur (2018). This also includes variety of groupings and interactive methods, namely class discussions, small group discussions or learners working in pairs on given tasks (Akpan et al., 2020). In addition to the methods identified by the participants, literature shows some inquiry-based teaching and learning methods such as project-based learning, demonstrations, problem-based learning and case studies (Joseph et al., 2022; Shamsudina et al., 2013).

4.3. Benefits of IBL

Participants shared that IBL teaching and learning methods have vast benefits.

> *Inquiry-based learning and teaching methods help learners to gain interest and understand concepts better when they see or do things practically in the field than being told in theory. When learners are taken to the field to be shown what they have been taught in class, they become interested and start asking questions. Learners' confidence is boosted if they understand what they are learning* (Teacher 2 School D).

> *Inquiry-based methods connect what is in the book with the outside world. This promotes self-study and helps learners to understand and remember the topic and the content* (Teacher 3 School A).

> *When using inquiry-based methods learners do not only hear, but they also see. During experiments when substances are mixed, they practically see this instead of being told. They see the effect of temperature on the rate of reaction and record their observations. They can observe and record the reaction of acid, metals and materials. Seeing sticks in the learners' minds and enables them to understand what is being taught better than when they are told by the teacher* (HOD School B).

The narratives shared by the teachers are congruent with empirical evidence. For instance, Zalloum (2018) and Ncala (2016) state that IBL increases retention of scientific knowledge by learners in all science disciplines. Learners who are involved in inquiry learning recall the activities that they practice with their peers. This is also similar with the study of Shana and Abulibdeh (2020) that there is a positive correlation between practical work and the academic attainment of most learners in science. Learners understand concepts better when they are practically involved and see things for themselves than when they are told theory by the teacher. Congruent with Raymond and Wong (2018), experiments provide learners with firsthand experience and are effective in stimulating learners' interests and improving their understanding of concepts.

> *Inquiry based methods make the lesson interesting and less boring. It stimulates interests and discussions on the part of learners. This promotes learner engagement and consolidation of concepts* (teacher 1 School B).

> *If inquiry methods are well used, learners are not supposed to be left behind, because these methods ignite interests, debates, and questions that compel all learners to be involved and participate* (HOD1 School C).

These assertions by participants are explained by Ramnarain and Hlatswayo (2018) that IBL motivates learners and help them understand abstract scientific concepts. In a similar study by Minner et al. (2010), IBL stimulate learner interest during the lesson and it promotes deeper understanding of content through offering differentiated instruction (Guido, 2017). Gardner's Theory of Multiple Intelligences sees the necessity of acknowledging the diversity of learners' intelligences and not confining learning to specific profiles (Julita, 2022). This way no learner is supposed to be left behind when diverse IBL methods that cater for learners' different intelligences are used.

> *Inquiry-based methods enable learners to develop critical thinking skills which are high order in Bloom's taxonomy. This makes entry from school level to tertiary level much easier. Experiments that we did at university were the same as those we did at school. This assisted to smoothly move into tertiary level. Practical assessments account for 60% high order questions which is investigative high order learning, and 40% is low order learning. This happens at both external and school based assessments* (HOD 2 School C).

> *Inquiry-based teaching methods stimulate learners to ask questions than to take things at face value. This allows them to think out of the box* (HOD1 School C).

These assertions are supported by Gholam (2019) that IBL emphasises critical thinking and problem solving as well as Duran and Dokme (2016) that learners instructed through IBL methods improve their critical-thinking skills and achieve better.

4.4. Challenges of IBL

Participants noted that though inquiry based learning has benefits, it also faces some challenges in the science classroom.

> *The first challenge is that inquiry based teaching and learning methods are time consuming. Some few learners do not pay attention or participate in given group tasks, while some ask irrelevant questions (Teacher 1 School B).*

> *The number of children in class makes it impossible to discuss and to give individual learner attention* (Teacher 1 School A).
> *Learner teacher ratio is supposed to be 20 – 25, but on the ground it is 30 – 40. In some schools it is even 60 learners in one class* (Teacher 2 School A).

> *The Department of Basic Education emphasises on writing exercises and does not take note of teaching. They interpret writing of exercises as teaching and lack of written exercises as lack of teaching. They demand 5 exercises a week. This consumes more time for lesson delivery. The teacher sometimes is supposed to see learners 4 times per week and administering 5 exercises a week becomes impossible. There are other activities that consume time e.g. sports and other administrative activities. In addition, due to power outages and water shedding*

> *children end up being sent home instead of learning. This consumes instructional time and makes the use of inquiry based methods difficult, because they require more time* (Teacher 2 School A).
>
> *There is no enough time to complete the syllabuses. A topic which is supposed to be covered in 3 weeks ends up being squeezed in 2 or 1 week, because of time constraints* (Teacher3 School A).
>
> *Exam time is not factored into the Annual Teaching Plan (ATP). Then exams in May infringe on instructional time. During exam period learners stop learning as you can't teach when children are writing exams* (HOD School A).
>
> *Due to time consumed by exams, you are forced to have afternoon, evening and weekend lessons to catch up with the syllabus. Lack of time therefore affects inquiry based learning which needs more time. You also need time to deal with challenged learners through coming up with interventions, while at the same time enriching fast learners. In addition, the Department of Basic Education expect teachers to do extra mural activities e.g. ruby, netball and the like which also consume instructional time* (Teacher 3 School A).

All the assertions by participants point to lack of adequate time and high learner teacher ratio as major challenges encountered in the implementation of inquiry-based teaching and learning methods in the science class. It was highly characterized in the empirical studies that South African schools have high learner to teacher ratio (Samuels & Dudu, 2017), overcrowded science classrooms in townships public schools (Ncala, 2016) and lacks teaching time completing the curriculum (Ramnarain & Hlatswayo, 2018). Since the school has numerous activities including examinations and core-curricular activities, the use of inquiry-based methods that require a lot of time in most cases ends up posing a challenge to teachers.

> *Lack of resources needed for practicals e.g. lack of a school laboratory, chemicals and apparatus prejudices learners from conducting practicals* (Teacher 2 School D).
>
> *Large numbers of learners result in class result in recycling of apparatus that need to be washed when you go to another class. When the apparatus are not properly cleaned and remain with traces of acid they tend to give different results that are not expected. The teacher has to explain and repeat the experiment. If*

> *results are not accurate because of improperly washed apparatus they tend to contradict what is in the text book. The teacher has to be alert, because if experiment results contradict what is written in the text book learners would start doubting the teacher* (HOD School B).

These assertions show that resource constraints in schools act as another barrier to the implementation of IBL. This was characterized in the empirical studies that most schools lack support, inquiry-based teaching material and facilities such as laboratories (Ramnarain & Hlatswayo, 2018; Gutierez, 2015). Hence, IBL is only possible when schools provide the necessary resources, time and assistance (Joseph et al., 2022).

> *There are some primary school teachers who are not qualified to teach Natural Science (NS), and they don't know how to use inquiry based methods. This creates gaps when learners progress to high school as they will not be familiar with inquiry based methods. The Department of Basic Education should provide training programmes for such teachers to equip them with modern teaching methods* (HOD 1 School C).

This assertion is supported by Barrow (2006), identifying limited teacher preparation as a challenge to the implementation of IBL. The open-ended learning environments are challenging for teachers (Inoue & Buczynski, 2010), especially to those who do not have proper training. Participants also noted that untrained teachers did not know how to use inquiry-based teaching and learning methods in class.

4.5. Educational technologies used to support IBL in schools

Some schools had inadequate technological resources while others were better equipped. Participants noted other educational technologies not available in their schools, but were of the view that those technologies were essential for instructional delivery in science.

> *Ya, we use quite a lot of technology in Natural Science in our school. It is difficult to teach other topics without technology. In our school there are projectors in every science class so that visuals are used. Learners are used to technology. If you give them a piece of paper, black and white it won't interest them. They need visuals. One visual can teach the whole lesson. Other schools have interactive boards and children can come and work on the board, but we don't have that in our school* (Teacher 2 School A).

> *We used to have tablets, but children stole them, or sometimes they were off battery. The tablet needs learners to scroll around as it shows a piece of the page unlike the textbook that shows the whole page and picture. This is an inconvenience especially on diagrams where you are supposed to go up and down. Students play games on tablets and sometimes they break the tablet or steal each other's tablets* (Teacher 3 School A).

> *Learners can be given gadgets like tablets, but this was tried by the Department of Basic Education and failed because gadgets got stolen and some got broken. There were different stories about tablets (Teacher 1 School B).*

> Despite challenges associated with some types of technologies like tablets, Secore (2017) spells out that in social constructivism learning technologies are preferred in instructional delivery. These types of technologies allow learners to use their sense of sight and sense of hearing during the learning process. This leads to better understanding of the information being taught.

> *In our school we do use technology. We are moving towards technology in the classroom. Teachers use lap tops that are connected to the internet in the classroom to access information, and we are able to display accessed information using smart boards and projectors* (HOD 2 School C).

> *There is free Wi-Fi for all educators. Laptops are provided to educators by the school. These laptops however remain the property of the school* (HOD School B).

> *Primary level has virtual reality (VR) Google. It uses applications that show videos of information being taught. It can walk the learner through the museum* (HOD 1 School C).

> *The challenge is that the VR google does not have enough information for all the topics taught, so the teacher factor cannot be underestimated. We have a lot of videos and teaching content, but abstracts of what is taught cannot be done effectively through the use of technology only (HOD 2 School C).*

Some participants also revealed that their schools did not invest much in educational technologies. As a result, they had inadequate technologies that support IBL in the science classroom.

> *Our school does not place importance of the use of educational technologies in class. They only talk about its use in theory, but practically there is nothing available. The school only allows learners to use their cell phones, but this has its own challenges as learners tend to do other things on cell phones during the lesson. This disturbs their focus on the lesson and not all learners have cell phones* (Teacher 2 School D).
>
> *The school has only one projector, interactive white boards are expensive and prone to theft. Internet at the school is localised to one point at the admin side. In other places like classrooms and at staffrooms there is no internet. This makes it difficult for teachers and learners to use technology in class that requires internet connectivity* (Teacher 1 School D).

Participants viewed lack of management commitment in investing on technological equipment and budget constraints as inhibiting the use of educational technologies in their schools. From participants' narratives, it can be noted that some schools placed importance on the use of educational activities in science while other schools invested less in the use of technology in the science class. There are however other technologies that can be used in the science class such as WebQuest application, virtual and online laboratories (Hakverdi-Can & Sonmez, 2012; May et al., 2022) and V-lab (Singhai, 2018; Brinson, 2015).

4.6. The use of educational technologies to support IBL in science

> *If practical experiments do not work you google and use YouTube experiments so that learners can see the results of experiments. Schools that do not have laboratories and apparatus like township schools are encouraged to use YouTube experiments. Suburb/model C schools that have well equipped laboratories can use both practical experiments and YouTube experiments. Township schools have one beaker, one Bunsen burner. Once these break, they are not immediately replaced. Maybe they are replaced after 3 months. In model C schools replacements are done after 2 days* (HOD School B).
>
> *The teacher can take lessons from YouTube and show them to learners while he/she facilitates the lesson* (Teacher 1 School D).
> *Projectors and laptops can be sued to project YouTube videos, and other useful text and visuals* (Teacher 1 School B).

The use of projected YouTube videos in class has been supported by empirical studies (Pratama et al., 2020; Almurashi, 2016; Pratama et al., 2020; Madlela & Ngakane, 2024).

> *Simulations of concepts can also be used e.g. when teaching about the engine or gears, you can use the software that simulates the changing of gears. Practicals can also be simulated and results shown. This brings the laboratory into the class. The drawback is that it is not as perfect as doing an actual experiment and it doesn't promote psychomotor skills and affective domain. It doesn't give learners a chance to touch, feel and smell the chemicals, and get skills of performing those practicals physically* (Teacher 1 School D).
>
> *We use simulations if the experiment is time consuming or dangerous, but most practicals are not dangerous. At times due to time constraints you leave out practicals and try to push the syllabus* (HOD1 School C).
>
> *Simulations reduce expenses needed for physical resources, laboratory material and stationary, because of the use of software copies. Time for the preparation of experiments is saved. The teacher also learns from lessons and simulations presented on videos. There is a large pool of e-resources. Learners can always refer to the video or recorded lessons at any time and space as per their convenience (Teacher 1 School B).*
>
> Participants viewed the use of simulations as a way of mitigating lack of time and non-availability of resources needed to conduct practical experiments. Wilson (2016) argues that computer simulations are engaging for learners especially if learners are the ones asking questions and driving investigation. Dunn and Ramnarain (2020) spell out that computer simulation may provide a viable alternative to physical science laboratories that exist in only a small proportion of South African schools. Simulations enable visualisation of the phenomena, and through visualisation learners acquire an understanding of such phenomena (Dunn and Ramnarain, 2020).
>
> *I ask learners to come up with Tiktok videos of what has been taught* (HOD 1 School C).

Asking learners to produce and present Tiktok videos of what has been learnt consolidates their understanding of concepts and enhances their creativity. In constructivism, actively involved learners can build their own knowledge structure based on their cognitive level (Rohman & Fauziati, 2022).

> *Assignments can be sent through WhatsApp groups where parents are also there. So parents can monitor and check the learners' progress* (Teacher 1 School D).

> *WhatsApp can be used for communication and sending video links and home work* (Teacher 2 School D).

The use of WhatsApp for communication and sending assignments, can also be extended to sending videos, text and audio to learners (Ngakane & Madlela, 2022). Learners, under the guidance of the teacher, can use WhatsApp to collaborate, interact and share learning material and findings of their investigations. As learners collaborate and interact, they tend to create new knowledge through dialogue and interaction with others (Churcher et al., 2014). Constructivism believes that learners can collaborate with the teacher or peers to construct knowledge and understanding (Akpan et al., 2020). Hence, the use of WhatsApp and other educational technologies like LMS enhances collaboration of learners with their teachers and peers.

> *Technologies can be used to make emphasis after teaching e.g. playing a video to emphasise and summarise content that have been taught. Some learners understand better when they watch a video or videos after the actual teaching. The teacher should not rely much on the video, but should use it to emphasise and summarise, and to pin point certain concepts. This should be done after the teacher has taught the topic* (Teacher 2 School B).

Videos benefit learners a lot if they are properly chosen and used in class. They serve as dynamic medium of delivering information to learners because of combined several elements such as text, audio and visual (Syaripuddin et al., 2019). While the video is suitable for application in the teaching process, its selection should be match with the learning goals, content, classroom environments and infrastructure facilities. Although the participants alluded to the use of the video only to emphasise and summarise the lesson, it should be noted that the video can be used in all stages of the lesson.

Participants also suggested some technologies that schools should use to support IBL.

> *Schools can also use clickers. These can be used by learners to answer questions on the digital board. Doing so encourages learners to concentrate. The digital boards can be linked to the application which can personalise learners. Then after answering questions through clickers each learner's work is digitally marked, and*

> *marks automatically added to their student portal. This gives instant feedback to learners and teachers, and improves learner motivation* (Teacher 2 School A).

Since IBL is time-constrained (Ramnarain & Hlatswayo, 2018), the expanded use of clickers by learners to answer questions on the digital board where work is digitally marked can mitigate this challenge. As tasks would be marked automatically by the system, teachers will then use the allotted time to prepare and do other activities with the learners.

> *In mathematics they have visualisers. The teacher writes information on paper and the visualiser camera projects it on the board through the projector. This technology can also be used in science. The teacher can record the lesson on the visualiser and post it to learners through WhatsApp groups* (Teacher 2 School A).

> *Lessons can be conducted through Google classroom. Such lessons can be recorded and learners can refer to them at their convenient time as necessary* (Teacher 4 School A).

> *Google classroom lessons should be recorded because of data issues. Not all learners have data at the same time. Having lessons recorded enable learners to access them at the time when they have data and network availability* (HOD School A).
> *Digital measuring probes can be used to measure for example temperature, heart beat and blood pressure. This kind of equipment is expensive, and it is difficult to have it due to budgetary constraints* (HOD 2 School C).

Participants noted that although they needed to use technological gadgets in their schools, budgetary constraints were limiting them. As this has been raised in the previous studies (Ramnarain & Hlatswayo, 2018; Gutierez, 2015), Ebri and Oben (2022) suggest public schools to embark on fundraising and income generating projects to raise resources to fund some of their operations. If schools can fundraise, they can supplement their budgets and manage to buy materials and technological equipment necessary for the implementation of IBL.

> *Solar energy can be used to support the use of educational technology* (Teacher 4 School A).
> *Kids learn differently. If electricity goes off and the projector is off you lose learners' concentration. As you write on the board they start misbehaving because you are no longer facing them* (HOD School A).

Investing in solar energy can help schools during load shedding when there are electricity outages. Solar energy can power projectors, internet and computers if electricity goes off. Hence, Madlela (2022) suggests investing in solar energy to enable the use of educational technologies even without electricity.

> *Schools that are not well equipped can go to schools with apparatus and technology to use them for a day or two days. These schools can also turn certain text into a song and record it. Learners like songs. They are able to memorise songs. Learners can rap certain scientific definitions and concepts and have them recorded using available technology. This can help learners to learn through songs* (HOD School B).

As suggested by the participants, collaborations and sharing of resources between schools is a progressive strategy. Schools with lack of educational technologies can collaborate to visit schools with access to technology (Madlela, 2022). They can also collaborate with centres and libraries that have technology. With the available technology in other schools, the learners will not be deprived of the use of latest technology in the classrooms. However, school leadership is necessary to come up with the proper agreement on the collaboration.

5. Conclusion

The implementation of IBL in schools is constrained by the lack of time, materials and facilities like laboratories, as well as deployment of unqualified and unfamiliar teachers with inquiry-based teaching and learning. Despite these challenges, IBL has vast benefits such as enabling learners to grasp and understand concepts better through active involvement in their own learning. While some schools place importance on the use of educational technologies that support IBL, other schools are deprived. Meanwhile, aside from practical experiments, the schools can also use commonly available technologies such as computer simulations and YouTube videos, WebQuest, V-lab and open source LMS. While the schools raise concerns on time constraints, the use of online laboratories, LMS and clickers to deliver instruction and administer assessments can mitigate this challenge.

Since IBL is constrained by lack of resources and time, the Department of Basic Education and schools should support mobilization of needed resources for the implementation of IBL. There should also be training for teachers on the use of different methods and technologies to implement IBL. In order to generate funds to support the purchase of necessary technology, schools can embark on fundraising and income generating projects. With the current lack of available technology to support IBL, the schools are encouraged to make use of free and available technologies. They can also initiate collaboration with other institutions on the use of available technology.

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