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BACHELOR OF SCIENCE EDUCATION HONORS DEGREE IN PHYSICS

AN EXPLORATION OF THE PEDAGOGIC APPROACHES IN THE ADVANCED LEVEL PHYSICS TEACHING AT MZILIKAZI HIGH SCHOOL

BY

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DECLARATION

I, Mbongeni Sibanda, do hereby declare that this dissertation is my own original work and has not been submitted to any university or other tertiary institution for the award of a degree.

Signed:  Date: *12 May 2024*

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This dissertation is submitted to the Faculty of Science Education at the Bindura University of Science Education towards the completion of HBScEd Physics.

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RELEASE FORM

Title of dissertation: **An exploration of the pedagogic approaches in the Advanced Level Physics teaching at Mzilikazi High School**

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APPROVAL

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DEDICATIONS

This work is dedicated to my brother Bhekani Sibanda and Sazinkosi Sibanda, my wife Siphilisiwe Maphosa for their unwavering support during this programme.

ABBREVIATIONS AND ACRONYMS

NCERT - National Council of Educational Research and Training

PCK - Pedagogical Content Knowledge

PISA - Programme for International Student Assessment

CALA - Continuous Assessment Learning Activities

CDU - Curriculum Development Unit

SRCG - Syllabus Results and Component Grades

PCK - Pedagogical Content Knowledge

ALPT – Advanced Level Physics Teaching

ABL - Activity-Based Learning

CCE - Child-Centred Education

CCP - Child-Centred Pedagogy

CPD - Continuous Professional Development

DEEP - Digital Education Enhancement Project

ABSTRACT

This research focused on the pedagogic approaches adopted by the teachers in teaching Physics at 'A' Level; sampling with Mzilikazi High School in Bulawayo Metropolitan Province, Reigate District. The researcher had to get a confirmation letter from the supervising institution so that he used to acquire the mandatory letter from the School Head which will serve as a permissive document granting him permission for sourcing information from Mzilikazi High School needed for the research survey. The researcher used the result analysis table prepared by the school for year 2023 and the SRCG where he managed to extract a detailed A Level Physics pass rate breakdown by syllabus component, questionnaire and interviews to collect data from the teachers and learners. Different teaching methods were used such as exposition method, group work method and experimental method. The researcher also recommends that the science teachers should develop a tendency of using experimental method. Learning aids like charts, models, realia and equipment should be used properly and accordingly to suit learners' needs and ability, have a great impact in facilitating the effectiveness of learning-teaching process for efficient acquisition of useful scientific knowledge.

The researcher values the use of the Resource persons, panel discussion and field trips by the teachers to accomplish adequate pupils' understanding and attainment of syllabus objectives on various topics in Advanced Level Physics especially, "Modern Physics, Electricity and Magnetism, Oscillations and Waves and Electronics"

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1 CHAPTER 1: INTRODUCTION / PROBLEM ARTICULATION

1.1 Introduction

The researcher will focus on the background of the problem, the indicators of the problem (signs), sub-problems, and statement of the problem, experience and knowledge about the problem of the reasons of low pass rate in advanced level Physics subjects at Mzilikazi High School, objectives of the study and *definition* of the key words or terms respectively.

1.2 Background of the problem

After my relocation to an urban setup, when my transfer was approved from Gumbalo Secondary School, Insiza South District in Matabeleland South Province into Bulawayo Metropolitan Province in Reigate District I was deployed at Mzilikazi High School in May 2022. Unlike in rural areas where I used to teach where I used to formally teach Ordinary level science subjects and informally teach Advanced level Chemistry, Mzilikazi High became a centre of a new phenomenon in which I had to do formal Advanced Level Physics teaching.

I had a very serious challenge because I had no colleagues who had experience of A level Physics Teaching (ALPT) to whom I could refer to, even my colleagues with whom I trained at Hillside Teachers' College as most of them pursued other Degree programmes other than Physics. At times I had fear of that I might be asked some questions by the learners and I was subject to offer insufficient explanation to the learners who will in turn lose confidence on me leading to chaotic teaching-learning process. Since in 2022 I took the lower Sixth class, these learners were candidates for November 2023 (N2023) whose results were out in January 2024. I became so much worried when I was given the Syllabus Results and Component Grades (SRCG), I looked at the quality of results, I was not so much pleased. I just comforted myself saying, 'it's good for a starter,' however in the real fact I needed training because a sixty-nine percent is not enough. For the majority of the candidates did well in component 05 which is Continuous Assessment Learning Activities (CALA), which

helped some of the candidate to get to a passing symbol or better. The CALA component is the one which increased the average of my candidates, the need for balancing up efforts on all components when I introspected myself blames were vested on my pedagogy therefore, I felt that I have to carry out this study so that I may improve on myself and be able to help others to do well in ALPT in future.

Since A level students had already passed O level physics, I felt that it is possible for them to do serious parallel reading which might be a challenge to me in class during discussions, where I might fail to meet their questions' demands.

Since it coincided with the time at which I started my degree programme with Bindura University of Science Education (BUSE), the constraints became a springboard which made me to gain enough momentum to do ALPT with confidence with willingness to do more and find more about ALPT. When I began this module, 'Advanced Pedagogics in Physics,' I had a strong consolidation towards the exploration of the pedagogic approaches (PA) to the ALPT.

1.3 Purpose of the study

This study is aimed at making a road map towards proper, relevant and sound ALPT today and in future. It will be a very useful study even to the future Physics Classroom facilitators / practitioners in the educational fraternity. The educational fraternity is the pillar sustaining all other professions. Since education 5.0 is based on education with production, the young physicists should be given useful education so that when the knowledge of Physics is well imparted, at the point of exit the learners will be very useful to the industries they choose to enter. This study shall help to empower all the Physics educators in the educational fraternity to perform their duty effectively.

1.4 Statement of the problem

The mystery is that in ALPT at Mzilikazi High School is limited to certain methods of teaching methods it is not diverse, but the history of the centre says that, 'Mzilikazi High School has been known of being the centre of sciences.' The question is how is Physics in particular being taught if there are limitations or ceiling of the approaches to the PA, yet it should be limitless to avoid hinderances to the learners' capabilities and to the facilitators too.

1.5 Main research question / research aim

What are the viable teaching methods that will affect adequate grasping of physics concepts leading to acquisition of useful knowledge in physics in the following topics?

- Modern Physics,
- Electricity and Magnetism,
- Oscillations and Waves, and
- Electronics"

1.6 Sub-questions

a) How do Zimbabwean high school Physics teachers perceive inquiry-based science learning?
b) What is the extent of Zimbabwean Physics teachers' implementation of inquiry-based science practices in the classrooms?
c) What factors could be contributing towards physics teachers' investigation-based physics instruction classroom practices?
d) What other countervailing forces that constraint physics teachers in performing their duties?

1.6.1 Research objectives

The objectives of the study are to:

a) Identify the most effective, relevant PA in the ALPT.
b) Find out whether the very PA were existent and affectively implemented by the physics facilitators accordingly.

c) Formulate the effective and efficient strategies to ensure effective learning to the 'A' Level Physics learners.
d) Come up with the means to find all the A level Physics Facilitators (ALPFs) doing standard classroom activities when executing their duties towards the national educational goals.

1.7 Hypothesis / Assumptions

All ALPFs received enough training well aligned with the duties they should perform in class and Physics laboratories. The Physics classroom practitioners (PCPs) really know what to do during their teaching with respect to the individual topics that they teach at a time. In this study I will not focus on behaviour because all PCPs at this level know how to handle classroom situations with such level of learners, classroom management was covered earlier on in professional studies. This study is mainly centred on PAs.

I assumed that all PCPs are good syllabus interpreters hence are capable of identifying the materials needed for every concept being taught. As science philosophers born of Popper all PCPs are well versed with marriage of theory to practical and its importances in science education system.

1.8 Significance / importance of the study

The study explores the inquiry-based physics teachers' views, experiences and teaching practices. Findings from this study may enhance teachers' performances through sharing good practices and promote inquiry- based physics teaching and learning in Zimbabwe. The findings may also inform reality definers to revisit the Physics syllabus to align it with twenty-first
century global trends of inquiry-based science education paradigms.

I am doing research so that I may be able to come up with some major PAs, which are suitable for teaching 'Advanced' Level Physics. Other than the well-known or common teaching methods which had been frequently used by teachers and mentioned by other researchers the way they did. This will bring across an awareness to all physics teachers based on the other factors leading to ineffectiveness of applying the PAs in the execution of their duties. By so doing

many ideas will be triggered which will be aiming towards resolving the issues associated with under exploitation of some of the teaching approaches.' This research will be helpful to the teachers' training colleges, teachers in schools and the ministry because, the student teachers will be equipped with diverse factors which affect their competences and pupils' effort and nullify their enthusiasm at schools. The teacher training institutions will be able to prepare skills to give to the new teachers on how to destroy psycho-social disruptions invading the pupils and depriving them of their wisdom and determination making them to focus with sufficient determination on what is brought forth by their facilitator.

To the student teachers practicing the teaching profession this research will keep them aware of the obstacles, pebbles and cobbles which might take them off their road, delaying the accomplishment of the educational goals, particularly the lesson objectives attainment in Physics topics they teach.

1.9 Delimitations of the study

The researcher is sampling using Mzilikazi High School, focusing on the Advanced level Physics learners only because they are the only target population and the school has been known and is today is known of being a centre of science learning, endeavour collecting the detailed data on the pedagogical approaches leading to the effective teaching-learning processes in the Advanced Level Physics.

The organisation involved is Mzilikazi High School where the researcher is stationed, doing his teaching duties having started teaching A level Physics teaching. The area of the researcher's interest is the Bulawayo Metropolitan, Reigate district where he is stationed focusing on the Advanced Level Physics results analysis and topical performance analysis as source of the evidence of the problem. As a result, the key criteria strongly become the science department of the station, subject area "Physics." This saves time and makes it easy to attain the objectives of the study.

1.10 Limitations of the study

I am bound to encounter challenges in the collection of data. This might seem difficult especially when the choice of collecting data is not diverse for example the use of closed ended interviews might be effective for pupils / learners because the pupils might not understand the instructions and as a result, they are subject to disclosure of their teachers' names and some confidential information which might sound unnecessary / irrelevant for the research question. Upon interviewing the teachers bias information might be given because of fear to give real responses as they doubt me.

I will try all means to monitor and guide the pupils during the questionnaire answering, whereas upon interviewing the teachers I will use an indirect approach. In this way the interview has to be like a simple conversation and open ended.

Open ended interviews will be done after the closed ended so that more of precise and detailed information answering the research question could be collected

1.11 Definition of key operational terms

The terms defined in the study are: exploration, advanced-pedagogics, psychosocial factors.

1.11.1 Exploration

Refers to the ratio of pupils getting passing symbols to the total number of candidates or pupils sitting for an examination paper per Science subject, multiplied by *100%*

1.11.2 Advanced-pedagogics

(Entz, 2006) defines pedagogy as the science of teaching. The word originates from Greek word '*paidagogas'* meaning to *lead ensuring good behaviour in public.*

Advanced refers to the progressive views at a higher level in training or knowledge or skill, (Bloomsbury, 2001). Therefore, *advanced pedagogics* is etymologically defined as the process of scientifically leading ensuring good

behaviour in subject of concern using progressive views at a higher level in training or knowledge skill.

In line with this research *advanced pedagogy*, refers to the set of educational informative subject specific approaches or strategies used by advanced level teachers to ensure the understanding and concept grasping by the learners meant to constitute favourable behavioural change in favour of subject matter. In this dissertation advanced pedagogics refers to the teaching methods well suited for ALPT.

Advanced pedagogy in Physics is defined as: **'the innovative and evidence-based teaching methods and strategies used to enhance student learning and understanding of physics concepts. It involves using cutting-edge approaches, technologies, and research findings to improve physics education.'**

Some examples of advanced pedagogy in physics include:

- Active learning: Encouraging students to engage actively with course material through discussions, problem-solving, and hands-on activities.
- Inquiry-based learning: Fostering curiosity and critical thinking through open-ended questions and investigations.
- Technology-enhanced learning: Utilizing simulations, virtual labs, and multimedia resources to visualize complex concepts and promote interactive learning.
- Flipped classroom: Reversing traditional lecture-homework format, delivering instruction at home and reserving class time for collaborative activities.
- Problem-based learning: Presenting real-world scenarios or case studies for students to analyze and solve, developing problem-solving skills.
- Collaborative learning: Pairing students to work together, promoting peer-to-peer teaching and learning.
- Formative assessments: Regularly monitoring student progress, adjusting instruction to meet diverse needs.
- Contextual learning: Connecting physics concepts to everyday life, making learning relevant and meaningful.

These advanced pedagogical approaches aim to increase student engagement, motivation, and understanding of physics, preparing them for careers in STEM fields.

1.11.3 Inquiry-based science

Refers to the science which is based on the study / exploration / investigation / scrutiny as a way of executing the teaching-learning processes in order to reach attainment of educational goals. This type of science has a lot of learner of students involvement in order to enhance and maximise the higher level of acquisition of useful scientific education equipping the learner with adequate productive knowledge for good future positioning which is industrial or technical, intellectually academic.

1.12 Organisation of study

This chapter, which is an introductory chapter, has outlined the background to the study, the purpose of the study, its research objectives and critical research questions, the statement of the problem and the location of the study.

Chapter 2 is a review of literature related to the study. It reconnoitres literature dealing with the instructional approaches in teaching Advanced Level physics.

Chapter 3 reconnoitres the research methodology guiding the research. covers the research paradigm / philosophy, research design, strategy, population and sampling data collection methods/instruments data analysis methods, reliability and validity, ethical issues. This includes the research paradigm, type of data collection techniques, sampling and sample size.

Chapter 4 discusses the key research findings focuses on data analysis and interpretations of the research findings.

Chapter 5 Gives the conclusion of the study.

1.13 Summary of the chapter

This section focused on the background of the study, statement of the problem objectives of the study, significance of the study, delimitations of the study, limitations of the study, definition of key words and organisation of the study. In the next section the researcher will focus on the population sampling, instruments used to gather data and the intervention strategies used.

2 CHAPTER TWO: REVIEW OF RELATED LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to scrutinise some of the theories brought by other researchers as major approaches to the advanced level physics teaching. There are several references that have been written on this topic with the majority of review or theories written and developed in developed countries. The researcher has realised that even though these authors are from developed countries, some of their findings or analysis bear strong relevance to situations in developing countries Zimbabwe, thus in the Bulawayo Metropolitan Province in Reigate district.

I am seeking to establish and analyse the knowledge that have been raised by authors, that is related to my main research question. The main aim of this chapter is to find and highlight the theories and perspectives which some authorities who have made a significant contribution largely through books, journals and articles published or unpublished research finding on how they had explored the pedagogic approaches in Advanced Level Physics Teaching in high schools and its effects. Efforts were made to establish from literature review the extent to which family background, teacher ineffectiveness, inadequate facilities, poor administration focuses and many other factors contribute to poor performance in schools.

2.2 Origins of the pedagogy in science, Advanced Level Physics in particular

Effective teachers need to be well-grounded in pedagogical content knowledge (PCK). (Munikwa & Gherda, 2019) argue that PCK represents the coalescing of subject matter and pedagogy creating a consciousness of how explicit concepts are structured, portrayed, and adjusted to the varied interests and capabilities of learners, and availed for instruction. The stance on PCK is supported by (Jang & Tsai, 2012) who purport that PCK should embrace the knowledge of the discipline, learners' difficulties, effective instruction approaches for a particular concept and assessment techniques. PCK could be considered as the integration of what is to be taught and how it should be effectively delivered and assessed. (Munikwa & Gherda, 2019) suggest that PCK is the knowledge that is more credible in terms of distinguishing the scientist from a science teacher. This

indicates that PCK distinguishes a discipline expert from a practitioner who has the skills and capacity to facilitate learning and create an enabling environment.

2.3 Pedagogic approaches well suited for electricity.

(Kriek & Kotoka, 2023) are of opinion that, "the TPACK framework is a complex interaction between the different types of knowledge domains. The interaction of these knowledge domains is needed to integrate technology successfully into teaching.

This differs from the previous research results and therefore invites further research in this area to help provide conclusive results. Secondly, even though there was a positive correlation between the learners' achievement and their teachers' TPACK, the correlation was not statistically significant. Further research is therefore needed as the current study did not prescribe any specific technology during the teaching of electricity. As the TPACK paradigm offers a framework for both in-service and pre-service teachers to integrate technology into the classroom, it also provides the opportunity for metacognition with regard to these teachers' own learning and professional development. The findings have further expanded the TPACK research, as these findings can influence investments into the nature of teachers' professional development. This study provided answers with regard to the influence of teachers' TPACK and their learners' performance as well as how the teachers 'evaluate their own use of technology and therefore the future use of technology in education in South Africa, Africa and the world over.

2.4 The impact of ICT in the teaching of A level Physics.

The Physics teachers worked in isolation with limited ICT skills and insufficient awareness of the potential of ICT in their teaching. Few sought helps from the CS. In view of the findings in these case studies, both the teacher and the CS should play crucial roles in the division of labour within the community of the Activity system where ICT is used in the teaching and learning of Physics. Drawing on the examples of some aspects of good practice from the computer specialists (CS3 and

CS5) at two of the schools and from the literature, an ideal computer specialist (ICS) is proposed for schools that may want to see Physics teachers and other subject teachers begin to use ICT for teaching and learning. (Mlambo, 2007)

The ICS can mediate the transition from the current situation where the computer is taken as an object of study to where it is viewed as a tool for teaching and learning. Based on the findings in this study, there is a need for training to raise the Physics teachers' awareness, ICT skills level and the philosophy of teaching with ICT. The ICS should be able to organise such local training initiatives on-site and off-site. Particular attention would need to be given to the integration of ICT within Physics lessons where students are required to use the computer to attain particular learning outcomes. This would enable the teachers to make optimal use of the skills that students already possess or could learn quickly. Constructivist-learning affords students opportunities for learning by discovery and to "build and apply their own knowledge" (William, 2000:188) cited in (Mlambo, 2007). The teacher dominates in the teacher-centred lesson. In pupil-centred methods, students are actively engaged in interacting with the Physics content and processes.
(Makonye, 2019) vests the emphasis on critical thinking in physics and mathematics teaching. However, critical thinking is born of the other process known as scientific presentation of scientific concepts characterised by a variety of learner centred instructional methods commonly known as scientific pedagogic approaches.

The need to teach critical thinking for young learners to solve problems was also realised through observation of mathematics lessons and mathematical activities. The finding of this research study concurs with a Columbian study conducted by Melo (2015) cited in (Makonye, 2019) which established that application of what is learnt indicates some degree of critical thinking. Based on the aforementioned research, the present research study therefore acknowledges that fostering critical thinking skills in young learners during the teaching of mathematics may enable learners to apply what they have learnt beyond the classroom context, that is, mathematical literacy.

ICT provides an alternative way when equipment for doing experimentation is not available, making it easy for the learners to access some application which will portray a laboratory in a virtual system of a computer. Animations provide a picture of what a system is like showing how a system operates. A computer simulation gives the learners the capability to explore what exactly would transpire in the real world of experimentation.

2.5 The impact of the indigenous knowledge systems in advanced level physics learning and teaching.

In order to improve access, achievement and relevance in physics, researchers such as Barton (1998), Shava (2005), Shava (2016) and Handayani et al. (2019) cited in (Mudzamiri, 2019) proposed the integration of IK artefacts in the teaching of physics. In this regard, (Battiste M. A., 2002) had indicated that academic failure in science among learners from indigenous communities could be attributed to the learners struggling to understand, gain access to, and find relevance in the culture and practice of science as framed by the school. A publication from UNICEF (2004) contends that every child has the right to education, and to a system of education that values his or her culture, language and community, and access to and participation in schooling without discrimination or hindrance. These rights are enshrined in the 1989 Convention on the rights of children. Participation in science is accordingly taken to be a human right (Banks & Banks, 2005) quoted in (Mudzamiri, 2019).

Fensham (2000) as cited in (Mudzamiri, 2019) has identified three dimensions in access to science. The first dimension is about physical access, which involves access to teachers, facilities, courses. A second dimension of access is about outcomes that demand that access should involve both effective and meaningful learning. In this dimension, issues of purpose of learning and the content of learning are valued. Questions like „Which science? Whose science? and why? “ Are asked. The third dimension is about pedagogy. The pedagogy should enable different learners to learn effectively, taking into consideration their backgrounds, context, learning styles and aspiration. The are many opportunities that are inherent in the use of IK artefacts in physics instruction as observed by Shava

(2005). Among such opportunities Grenier (1998) included benefits of adopting methods of imparting content knowledge (for example the use of indigenous games, storytelling, use of artefacts in demonstrations), pedagogical content knowledge and aspects of subject matter content. Mudzamiri, (2019) argue that the integration of IK in instruction started very long ago in Zimbabwe. In primitive societies people would use the knowledge they had already acquired and pass this on along with new information or ideas to their fellows.

Social constructivists believe that learning occurs when individuals are engaged in activities such as interaction and collaboration (Doise, 2015) cited in (Mudzamiri, 2019). In view of this, a young learners' mental agility or functioning is likely to be stimulated through critical thinking and, in turn, improve their mathematical literacy through interacting with teachers and engaging in activities with their peers. The present research study established through interviews that critical thinking is an essential asset for further education and even for the future. The finding of this research study is consistent with an American research study conducted by Crockett (2016) who established that critical thinking skills are invaluable because they allow young learners to deal practically with problems of a social, mathematical and scientific nature. In the aforementioned research study, it was also emphasised that it is easy to see why critical thinking skills are important to success beyond school because young learners are empowered to make effective and well-informed decisions in their lives. Draper (2013) cited in (Mudzamiri, 2019) argues that the social constructivist approach does not see a classroom as a place where the teacher pours knowledge into passive learners but emphasises active involvement in which young learners interact to create knowledge and acquire skills for everyday use and these may include mathematical literacy.

2.6 Role of the teacher in teaching Advanced level physics.

NCERT (2013) gives the role of a teacher as follows:

- Promote collaboration and stronger connection between different classes of the school, various schools, with other educational institutions and in general with communities to help develop a healthier society.

- Use diverse pedagogical practices in teaching-learning of science. Care should be taken to remove discrepancies against students on the basis of learning difficulties, identity, gender, caste, religion, etc.

- Science exhibition, science club, science drama, field visit to various places and out of the school activities should be promoted to foster social values along with enrichment of educational experiences. Knowledge of science should not breed a culture of arrogance and superiority. Team spirit, respect for other's idea and collaborative work culture should be developed in students.

- Social climate of the school and classroom has a deep influence on the learning process of the learners. An atmosphere of trust would make the classroom a safe space where students can share their experiences, where conflict can be acknowledged and constructively questioned, and were resolutions, however tentative, can be mutually worked out.

- Collaboration in all forms rather than competition should be promoted. Ours is a democratic country were people of different caste, creed and gender live together. Teacher should value, elicit and try her best to incorporate experiences of all students in teaching-learning of science. Students should be made aware that their experiences and perceptions are important for further enhancing their understanding of science.

- Science teacher should be fair and scrupulous to all and not act out of her vested interest. She should be appreciative of our composite culture and national identity from an international perspective. Teacher should keep herself up to date in the area of latest

- development in science, technology and their impact on the society. Developing scientific attitude in students is one of the important obligations of science teacher. Teacher must develop warm and supportive relationship with students and colleagues and must collaborate with other

teachers especially with science teachers in designing and sharing experiences of teaching-learning of science.

2.7 Modelling

Modelling of concepts is an aspect of pedagogical approaches which extends beyond guided practice. When Mostafa (2018) define PISA as teacher-direct learning, the central aspect is the modelling of the concept by the teacher, with (Bartlett L & Vavrus F, 2012). attributing this to it being so effective when utilised in UK classrooms. Modelling was a key theme which ran across observations from the exploration section and was mentioned by 2 of the learners during interview. Due to the need to support the class teacher during the engage and explain sections of the lesson, I could not make any observations, meaning no data was collected for body language of learners. But from observations during the other parts of the lesson, some information can be gained about their engagement and aspects taken from the model to support their development of concepts from their initial misconception.

The learner has shown good comprehension of the model in their ability to extend the knowledge beyond the tray to the object they are exploring. When articulating this to their peer, they showed confidence, pointing towards the cupcake trays and modelling with their hands how the surface texture was impacting the direction of light. Without the reference point of the model to bring their learning together, then the learner would not have been able to visualise an abstract concept before extending this knowledge.

Whilst child A did not explicitly refer to the model, as they explored foil, which prior to the lesson had always been perceived as a 'shiny' surface, they explained to their partner:

> *'when you screw it (the foil) up, it's not really shiny anymore so the light doesn't look as bright as it's reflecting everywhere but it is still reflecting, look,' (handing the other learner the torch).* (Child A, 2023)

Child A had been shining the different torches at the foil for around 3 minutes, they then sought another piece of foil, which they then scrunched up and tried out with 2 different torches before screwing the foil up even more, again unfolding and testing. They compared the two surfaces, this child then left their seat to go

and look at the baking trays, feeling the surfaces before returning and repeating. Observing during this period showed the child become more relaxed and their confidence building in what they were observing, nodding and brief smiles to themselves as their ideas came together. After around 8 minutes of exploring, they articulated their findings to their peer, as above, showing them what they had found. Similar to Child D's exchange, the other child then repeated these themselves, showing agreement.

Child A and D both showed through their exploration a direct link to the model which they had witnessed during the engage section of the lesson, bringing in the knowledge from the explanation. Child D using the foil to link between their misconception, that the foil would need to be shiny, to now confidently explaining to their partner that it still reflects, even though it is now not clearly shiny, shows a balance between their misconception and the correct scientific concept which Mason and (Battiste, Indigenous Knowledge and Pedagogy in First Nations Education. A literature review with recommendations, 2002) have evidenced is how our learning process needs to form, bridging the misconception to the correct concept.

Moreover, this interview extract corroborated what I observed through their learning. By re-visiting the model, they were building their learning whilst using the model as a reference point to explain what they were seeing. Child D stated:

> *'The explanation at the start helped me to understand why it's not just shiny things but also why I thought that. I now know how it happens. It makes sense when you see the trays and how different surfaces reflect the light differently.'* (Battiste, Indigenous Knowledge and Pedagogy in First Nations Education. A literature review with recommendations, 2002)

Models used as a pedagogical approach alone have yielded varying results. Sari and Cahyo (2020) showed positive results using a direct model in their guided practice approach, as the concept was biological, the learners could explore visually the actual concept and the misconception be bridged. Whereas (Chiromo, 2010) showed mixed results, the lack of specific planning for the misconceptions needs to be considered as a factor in these results, instead focusing on too many

and presenting a more generalized model. This study used a model specifically designed to address the misconception identified from the pre-assessment, ensuring that these classes preconceptions were valued and fed into the lesson's model (Westbrook et al, 2013)

Using models to explain to learners why they may have perceived their misconception, bridging that understanding. Though it is noted that only half of the case-learners had codes mapping to the theme 'modelling', from the learner's views and on balance of the previous studies, a specific targeted model seems significant for learner's experience of guided practice, providing not just a visual but also a transferable model for the concept to start to balance the co- existence of conceptions (Mlambo, 2007).

It is important to consider that this lesson was intended to be conducted by the class teacher solely, even after being part of planning and having rehearsed the lesson, the class teacher doubted herself when having to make such specific links between the model and the scientific concept. Had I not been there, questions surround how the class teacher would have proceeded with the lesson. This is a key factor discussed in literature, teachers often lack confidence which can lead to misconceptions being compounded or further ones generated (Bianchi et al, 2021), or else deviating back to more teacher-led or lecture style approaches (Murphy et al, 2021). Stepping in to support and deliver the engage and explain sections of the guided practice was a positive move as it ensured the knowledge was succinct and clear for the learners, facilitating the model to bridge from pre-assessed misconceptions to the current scientific concept to apply in the explore sections, this ensured the integrity of the guided practice model and in turn the study itself.

2.8 The impact at teacher training on child progress in schools

Five interventions designed training to fit specific pedagogies to specific contexts, such as activity learning or Schools for Life for rural communities and marginalised students, or use of technology to support the curriculum, or, as in the study by Hussain et al., addressing the subject and pedagogical content

knowledge and reflective skills required for teachers being trained as mentors (Westbrook J, Durrani N, Brown R, Orr D, Pryor J, Boddy J & Salvi F, 2013).

These reported that teachers implemented the training received and lessons were more interactive and enjoyed by students. Jang & Tsai (2012) reported that the training was also cost-effective, although no evidence was given to support this. Teacher manuals with scripted lessons were cited as supporting the translation of newly acquired theoretical knowledge into concrete practice in three studies, by (Jang & Tsai, 2012) and (Chitate, 2016), and (Entz, 2006) have seen earlier how such teacher guides support teachers in teaching a more varied lesson sequence. This may also reduce the need to recall large amounts of unnecessary information, which these unqualified teachers may find challenging (Abadzi 2006). The expertise of the teacher educator in teaching or modelling the promoted strategy made a considerable difference to the quality and outcome of professional development in two studies as reported by the mentors and students who were the beneficiaries, as reported in (Battiste, 2002) as cited in (Mudzamiri, 2019). If teachers have not seen or experienced a different way of teaching, they cannot be expected to implement it themselves, alone, in their classroom. The limited teaching experience and cultural differences of teacher educators were a stumbling block, however, for example where teacher educators selected only the pedagogy they understood and taught using rote learning, as observed by (Battiste, Indigenous Knowledge and Pedagogy in First Nations Education. A literature review with recommendations, 2002) or where teacher educators' limited capacity to teach multigrade teaching prevented a greater spread of student improvement, as described by (Entz, 2006). In the study by (Bartlett L & Vavrus F, 2012) asserts that teacher educators' morale was low because they felt their skills were undermined by the school-based structure of the Malawi Integrated In-service Teacher Education Programme (MITEP) programme.

This model of teacher education sharply contrasted with more traditional ITE where there was misalignment between the curricular intentions of ITE and the realities of the contexts in which teachers have to practise, including misalignment with the school curriculum itself. Such ITE curricula were

overloaded, outdated, still influenced by a behaviourist approach focused on content knowledge or methods rather than pedagogical content knowledge and mostly directed towards upper primary schools. This was seen in six studies (Chiromo, 2010) as sited in (Westbrook J, Durrani N, Brown R, Orr D, Pryor J, Boddy J & Salvi F, 2013). These studies were mostly of reforms or existing conditions in East Africa, where often there were too many trainees crowded into small classrooms with few resources. Under these conditions, teacher educators, themselves strangers to more interactive practices, used expository methods with basic group work and advocated a prescriptive teaching sequence with little emphasis on critical and independent thinking for trainees (Dyer, 2008 M/M EC; Kunje, 2002 M/H Int; Lefoka and Sebatane, 2003 H/H EC; Pryor et al., 2012 M/H EC). Akyeampong et al. (2013 M/H EC) observed that where there were simulated classroom activities, these did not 'prepare trainees for the kind of responses and challenges real children are likely to face' (p. 276). These trainees, as NQTs, used their college notes and similarly taught in transmission-oriented ways, neither seeing nor experiencing any other way of teaching, (Westbrook J, Durrani N, Brown R, Orr D, Pryor J, Boddy J & Salvi F, 2013)

says, teacher's training was found to be important in producing teacher behaviour changes- teaching methods and improving in skills necessary for effective teaching for any education system to stand" it should be supported by qualified teachers who by virtue of their training are capable of identifying children's individual reeds. Nyagura noted that a qualified teacher is not only creative or innovative but also sensitive to the needs of the pupils an in the nation at large. Teacher in Zimbabwe of October (1993) indicated that rural school s have is opportunities to qualify education compared to urban school s since most rural schools mostly staffed by incompetent untrained teachers who have not been exposed to proper methods of teaching.

Dove (1985) argued that, the fact that classes contain pupils of various ages. ethnic and social backgrounds mean there is need to employ trained teachers to look after the children. Dove (1986; 73) says,

> At primary level in particular and in small, one or two teacher schools, individualised and small group teaching methods are necessary to accommodate the range of pupils in any one class.

For effective teaching to take place, teacher training should be a pre-requisite. The teacher has to develop skills of assessing individual children and establish their individual problems a skill that is acquired during teacher training. The researcher feels that poor performance in Binga schools is mostly caused by the large numbers of untrained teachers whose instructions might not be effective whose instructions may not be effective. Gamira & Firomumwe, (2021) who analysed the Grade seen results from rural and urban schools established that, primary school pupils taught by trained teachers obtained better results in the two subjects, mathematics and English. They concluded that ford taught by trained teachers had an average achievement that is different in both English and Mathematics, compared to classes taught by untrained teacher.

Zimbabwe just like Malawi has a programme known as an in-service teacher training which is aiming at equipping the facilitators with adequate skills and knowledge suited for imparting knowledge to the upper high school learners. (Mudzamiri, 2019) laid it down as in the paragraph below:

> Currently the Advanced Level physics classes are taught by teachers with little knowledge of the integration of indigenous artefacts in the teaching of physics. However, most of the teachers have some pedagogical skills, which they acquired either through their initial training at teachers‟ colleges or through workshops and in-service training courses. This means the teachers are able to work effectively as mentors while learners explore some new areas. The teachers bridge the gap that exists between the learners‟ daily experiences and their physics classroom experience. The teachers, as „cultural brokers‟, guide the progress of learners from their familiar zone of home across the ZPD into the unfamiliar zone, which includes classroom physics concepts and their everyday applications.

The equipment in laboratories, which is dominated by artefacts derived from western indigenous knowledge systems, is often unfamiliar to both teachers and learners in Zimbabwe. These artefacts are ubiquitous as instructional aids and instructional technologies used during practical demonstrations, as textbook illustrations and are also given as examples by the teachers in every section of the content. Mudzamiri, (2019) puts his emphasis on the use of indigenous knowledge artefacts which is born of indigenous methods of imparting knowledge.

2.9 Influence of CDU and leadership in physics teaching methodologies

The competency-based curriculum, criterion referenced curriculum, and mastery learning and programmed learning are all based on behaviourist theories of learning (NCERT, 2013). These approaches assume that large/complex tasks can be broken down into small/simpler tasks and these can be sequenced in order from simple to complex. The competency-based and programmed curriculum use these assumptions. In competency-based curriculum, terminal competencies are defined in behavioural terms. These are then sub delineated into sub competencies. Competency-based curriculum (minimum levels of learning) has been developed in India and some other countries. One example of breaking down the complex task into simpler learning tasks are given below:

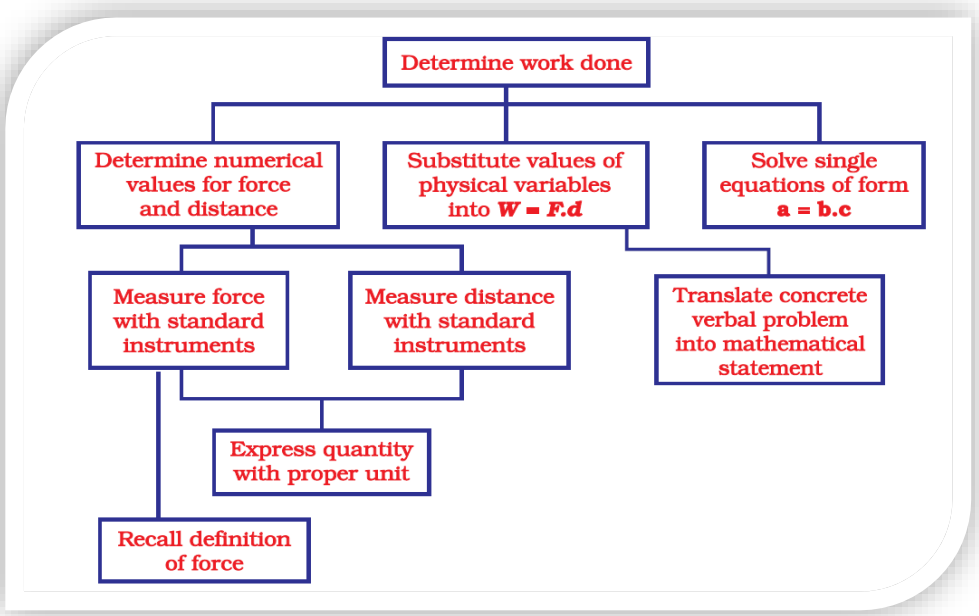

Figure 1: Breaking down the complex task into simpler learning tasks in competency-based curriculum

In behaviourist curriculum, teachers are instrumental to implement curriculum developed by curriculum developers. Teachers do not question 'ends or means of curriculum.' (Entz, 2006) cited in (NCERT, 2013) posits that, The behaviourist curriculum does not take into consideration the learner's experiences, context and cognitive predispositions. Learners are treated as passive receivers of knowledge and teacher as transmitter of knowledge. Chalk and talk are the common method of teaching. Learners memorise, recite or study their lessons silently without questioning. Childhood is viewed as preparation for adulthood within society. The education aims at developing such knowledge and skills which will be helpful for students to serve society in their adult life. Critiques of subject-centred and behaviourist approaches say that these curricula do not help in achieving the aim of all-round development of the learner.

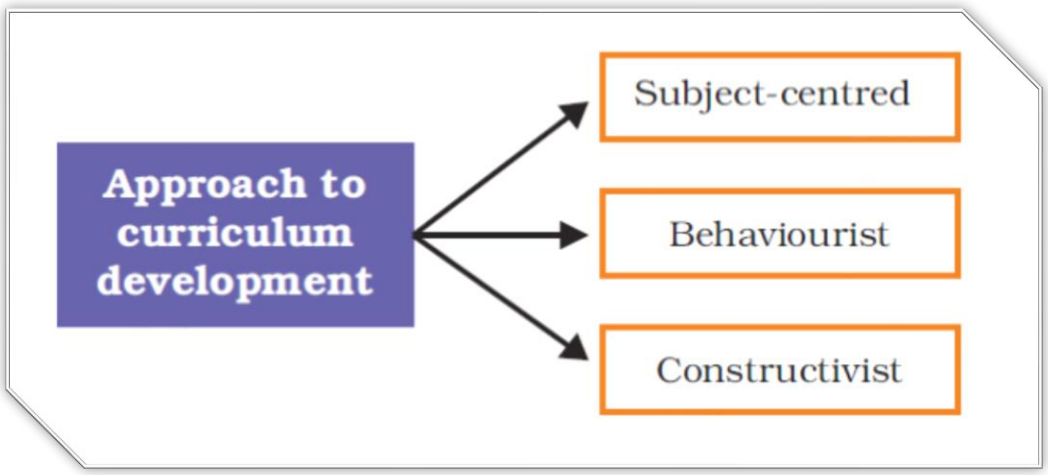

Figure 2: Approach to curriculum development

These three syllabi require different teaching-learning approaches and curricular materials. The role of teacher and learners also change in these classrooms. The nature of learning experiences and also the outcomes and evidences of science learning will be different in each case.

The aim of learner-centred curriculum is to stimulate and nurture growth of learners. The learner-centred educators stress that aim of education is growth and development of the learner and the orientation of the entire school should be towards the learner. Learners create meaning and thus, construct knowledge by engaging in stimulating experiences when they interact with their environment. Learners are innately curious and predisposed toward exploration.

The role of teacher is to provide learning environment and stimulating experiences to learners. From the learner-centred viewpoint, teachers must trust in the innate abilities of learners; in their capacity to direct their own exploration and learning. *Learner-centred curriculum views learning from a constructivist perspective. Learning takes place when learners engage with stimulating environment, get involved in inquiry and make meaning for themselves out of interactions with environment* (NCERT, 2013). Learner-centred educators are interested in knowing, 'what is happening within' the learner between stimulus and response. The learner-centred educators are interested in parameters such

as the state of learner's cognitive structures, her meaning-making abilities, and her creative spirit.

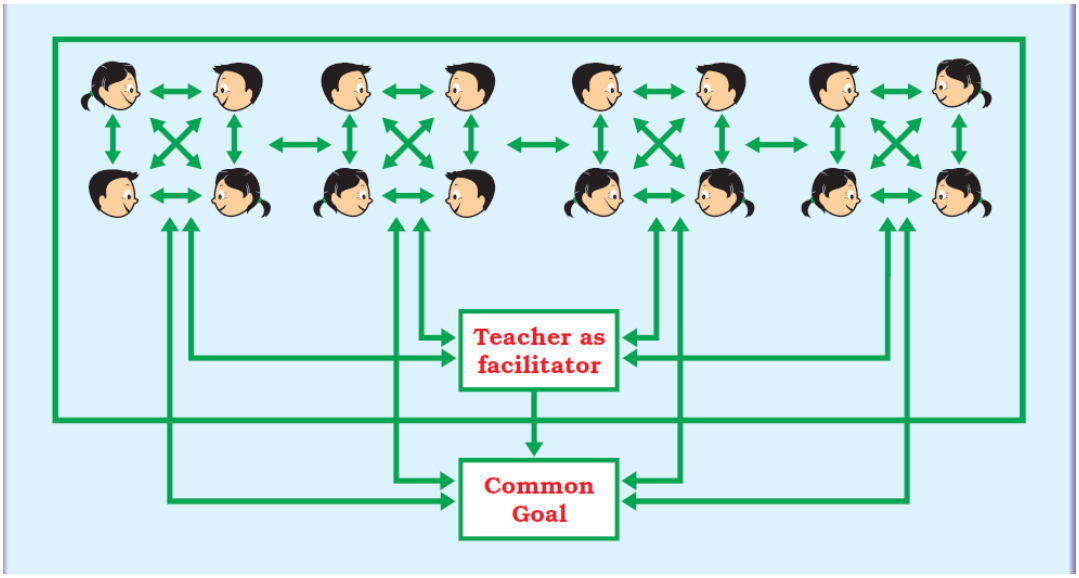

Figure 3: teaching and learning process showing interaction and teachers' role.

For 'constructivist curriculum' developers, it is the learning environment and experiences, that are of crucial importance and can be generated by taking into consideration the context of learner as well as teaching-learning environment (NCERT, 2013). The curriculum must engage learners with stimulating experiences by arranging suitable learning environment. 'Constructivist curriculum' is based on the following assumptions:

- Knowledge is actively constructed, invented, created, or discovered by learners. It is not passively received and stored by learners.
- Knowledge cannot be separated from the process of meaning making or knowing or learner's experiences. It is based on learner's conceptual structures and prior experiences.
- Learners are constantly constructing and reconstructing their cognitive structures, both as a result of newly acquired knowledge and as a result of their reflection on previously acquired knowledge.
- Social interaction with peers and adults in a cultural context is extremely important in individual's construction of knowledge.
- Concept formation progresses from concrete to abstract slowly.
- Learners have different learning styles, and teaching–learning should accommodate these.

- The teacher in constructivist curriculum is provider of the learning environment and a facilitator of learning.

2.10 Pedagogical Shift from science as fixed body of knowledge to the process of constructing knowledge

Earlier, nature of knowledge in general and nature of knowing in particular was considered as a fixed entity. However, in the contemporary understanding of nature of knowledge and nature of knowing, these are dynamic entities. *Thus, the pedagogy which we use to construct knowledge through diverse learning strategies includes previous experiences of the learner, their sociocultural and economic background along with the content knowledge rather than overwhelming emphasis on the psychological characteristics to the individual learner* (NCERT, 2013). Till recently, the main purpose of studying science was perceived as 'acquiring' scientific knowledge.

Now, there is a shift in perception regarding this purpose. This shift is tilted towards 'construction' of scientific knowledge, not the passive acquisition of factual knowledge. Construction of scientific knowledge concerns knowledge of 'how to do things' scientifically (here, doing is not confined to manual activity only, it could be mental activity also) and, perhaps, that is why scientific knowledge is always the result of a constructive activity. Therefore, the fundamental difference between the acquisition and the construction of scientific knowledge is passive receipt of the knowledge, and active involvement and critical examination based on critical thinking on the part of the learners. Shift in pedagogy of science from a fixed body of knowledge to the process of constructing knowledge has many dimensions. It includes a shift in our understanding of nature of science; nature of knowledge; learners, learning and teachers; assessment; science curriculum; scientific method and scientific inquiry; importance of critical pedagogy; approaches to planning; various aspects of inclusive education etc.

In order to understand pedagogical shift in physical science, it is important to have a brief overview of all these aspects related with teaching–learning in science.

2.11 Pedagogical shift: Knowledge

Science is an enterprise that has evolved over many thousands of years and continues to evolve. We have discussed that our understanding of knowledge has shifted from a 'static entity' to a 'dynamic entity.' Considering knowledge as a static entity to be transferred to learner's mind, makes her passive receiver of knowledge without engaging in thinking and questioning. We understand that knowledge is actively constructed by learner and cannot be passively received. So learning is something done by the learners and not something that can be imposed on them. Knowledge can be conceived as experiences organised through language into structures of concepts, thus creating meaning which in turn helps learners to understand the world they live in. Scientific knowledge can be represented in the form of conceptual structures and they can model these structures to describe them. Fig 3, Shows how growth of scientific knowledge takes place.

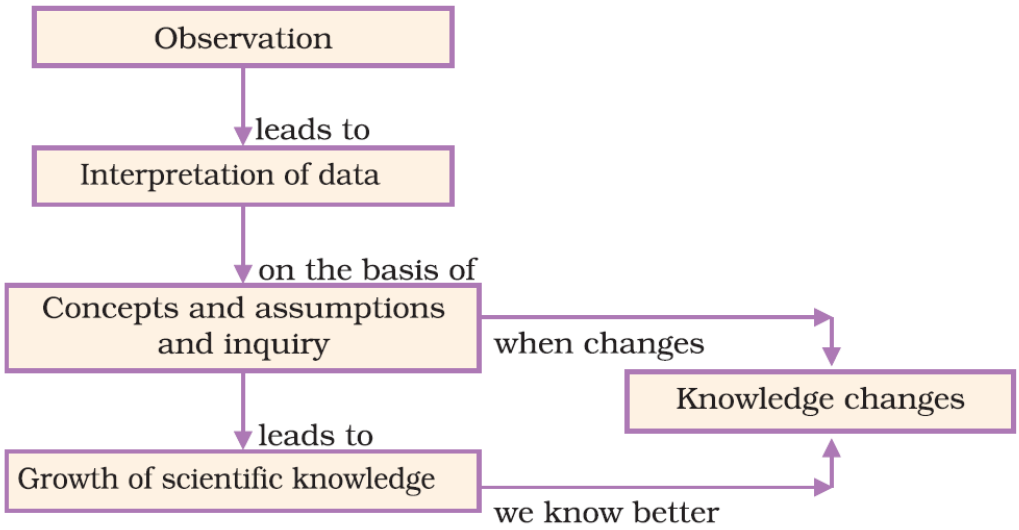

Figure 4: Growth of scientific knowledge

2.12 Research gaps

None of the studies evaluated the impact of interventions/reforms using control and treatment schools. There was a little bit on electricity but it was not in detail but was just general and shallow. There was no study which focused on ALPT

based on the suitable pedagogical approaches for the following topics: electronics, modern physics, Oscillations and waves.

A small number of studies used inferential statistics to correlate specific practices with student cognitive attainment; however, they missed details of pedagogic practices. Observation-descriptive studies that drew on mixed methods and used standardised tests or national tests to measure the impact of interventions did not always use baseline tests. Qualitative studies that looked at reforms or existing conditions gave significant details of students, teachers, contexts and practices, but did not systematically assess students' learning. Future research designs should be of a *larger scale* combining *qualitative and quantitative methods*, with both *baseline and post-tests* measuring student attainment as a result of an intervention or reform and systematic, structured classroom observation. The *indicators and measures* used should include students' perspectives and experiences of school and classroom life, teachers' understanding, student discourse and immediate understanding of a concept taught, student participation in class, use and frequency of teaching and learning materials (TLMs) and attendance patterns over time. Longitudinal studies looking at long-term impact over more than three years would show how reform or interventions work (or not) in altering practice in situ. *Randomised controlled trials* are more difficult and costly but will give more precise findings of 'what works. Assessing *teachers' content and pedagogical content knowledge* via questionnaires using classroom-based scenarios and tests, and comparing this to the assumed knowledge in the curriculum and as indicated in teachers' actual practice would also be useful.

2.13 Chapter summary

This chapter is a review of literature of what some authorities have written or explored the pedagogy in Advanced Level Physics. However, the authorities I have just reviewed have explored the science pedagogy at different levels. Some authorities have been specific to certain topics and some researchers looked into pedagogical determinants. However, from the overall review I have summarised the general concept or sense as follows:

A good understanding of curriculum also facilitates the teacher to get insight into general principles of teaching-learning approaches and evaluation, criteria for

a good teaching-learning materials, providing equal access to all children in the activities, experiments and all classroom transactions in an equitable way.

It is important to recognise that education is a process and experience is a significant part of this process. Unless the learner can locate her standpoint in relation to the contexts represented in the classroom experiences and relate the knowledge with her everyday life experiences, knowledge is reduced to the level of mere information. Therefore, all curricular experiences have to be designed to ensure that learners with varied needs enjoy and relate to teaching-learning processes. Teacher should make science curriculum accessible to all learners by bringing flexibility at suitable points of interaction.

3 CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In the previous chapter the I focus on the theories and findings by other authors which may bear strong evidence to the current instructional or pedagogic stance at Mzilikazi High School, pertaining the suitable pedagogic approaches relevant to the ALPT yielding desirable results in proving constructivist knowledge in physics. However, in this chapter the researcher focuses on own proposed approaches towards the findings. Since the research is of traditional design for attaining information the researcher uses the interviews, questionnaire, case-study. I will prepare interviews and questionnaire to the pupils and to the Physics teachers, and the Syllabus Results and Component Grades I received from the Deputy-Head after requesting for it. Presents constructivist philosophies that are grounded in qualitative research paradigm and *unhu/ubuntu* as hypothetical supports of my research. This interactive research framework respected the importance of relationships and the context of the study. It also clarified the location of the problem and the research focus.

3.2 Research design

3.2.1 Research paradigm / philosophy

For a research study to fit within the physics pedagogical paradigm, it should be guided by the assumptions of that paradigm, and must relate to indigenous methodologies and indigenous ethical practices. Qualitative research emphasizes the understanding and carrying out of study from the standpoints of people whose ways of knowing were previously relegated and, therefore, should accord due regard to cultural etiquettes and values as an integral part of the methodology (Vavrus, 2009). It is participatory in nature and respects the well-being of the participants and provides a platform for the less powerful to be heard. The values, beliefs and customary practices of indigenous communities should be embedded into the research, be thought about, be declared openly as part of the research design, be discussed as part of the final results of a study and to be scattered back to the people in culturally apt ways

and in a language that can be understood by them. Constructivist or pragmatic methodologies fundamentally recognise the importance of engaging, participative learner-centred approaches in inquisitive teaching-learning environment. The pedagogic paradigm views relationships as being central to the curriculum design, (NCERT, 2013).

As outlined at the beginning of the previous chapter, my ontological perspective is that reality is constructed based on how an individual interprets and experiences the world around them, embracing multiple, dynamic realities (The Open University, 2020). Dilthey distinguished natural science from social science, stating natural phenomena can be explained by cause and effect, but human mind and realisation are not determined by natural laws (Gamira & Firomumwe, 2021) as cited in (Muir, 2022), hence cannot be perceived or measured through the same means. Though it is debated whether natural and social science ontological views should be distinct in their terms of laws of nature (Kotoka & Kriek, 2014)cited in (Muir, 2022)**,** it is my view that social phenomena cannot be generalised. This is the essence of preconceptions, individuals will come to the classroom with a unique set of experiences, views, and knowledge of the world, and therefore reality cannot be presumed to be analogous. Through the process of learning, the perceptions and knowledge which learners possess will change and adapt. Through teaching, learning allows reality to be in a constant state of revision (Grix, 2002). In this chapter, I will outline how my literature review, guided by my ontological and epistemological positions, has shaped the choice of methodology, and in turn research methods for this study.

To explore an individual's experience and reality, we needed to explore how a specific approach could shape a learner's learning and how this learning could be experienced. The specific approach of 'guided practice' was identified from literature as a pedagogical strategy showing promise for addressing misconceptions in learners (National Council of Educational Research and Training (NCERT), 2011) but all current research focuses on quantitative conclusions of whether it works, with little information on the nature of learning. This informed my decision to focus on a qualitative approach, to

understand the process rather than the outcome. Knowledge and learning are not as simple as right or wrong, learner perception and experience need considering to comprehend what aspects of a pedagogical approach support learning and what does not. With misconceptions being unique to each learner, and with the constant revision of knowledge (Grix, 2002), this cannot be measured quantitatively.

To address the research question, I am assuming a descriptive-interpretivist position. This will allow description of the learning experience from the perspective of the learner. By adopting this approach, the research question is open-ended, with a focus on learner experience, rather than merely the overall success of the approach. This is important to understand what about guided practice has the impact, allowing focus and planning on how to further develop and explore it as a pedagogical method for addressing misconceptions, which is a gap from previous research. The study aim will gather qualitative information from observations and verbal expressions about the experience, aiming to look at not just how the individual realities are constructed but how they are experienced (Moodley, 2017). This information will be represented through organising, theming, and linking information, striving to understand learning by representing learner experience through these themes (Chitate, 2016). There is no fixed reality, how one learner perceives their experiences will be unique, these cannot be generalised (Oxford Cambridge and RSA, 2023), but a rich plethora of information can be gained on learner experience through this approach which can feed into further research and refining of this approach. Understanding the contribution of each section of 'guided practice' to the overall process of learning, knowing which aspects support understanding the knowledge and looking specifically at bridging and balancing the concept to their initial misconception is central to development of this pedagogical approach.

3.2.2 Research methodology

The study adopted the convergent parallel design. According to Creswell and Plano Clark (2011) and Fischler (2014) as cited in (Munikwa & Gherda, 2019). The convergent parallel design is orchestrated through the researcher

soliciting for quantitative and qualitative data concurrently, analysing the two data sets separately and mixing the two data sets by merging the results during interpretation. From this perspective it can be argued that the mixing is on data collection methods and data interpretation. Hence, it may be argued that the main thrust of the convergent parallel design is on gathering different but complimentary data on the research problem.

3.2.3 Research strategy

Burns and Grove (2003:195) define a research design as "a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings". Parahoo (1997:142) describes a research design as "a plan that describes how, when and where data are to be collected and analysed".

Polit et al (2001:167) cited in (Mudzamiri, 2019) defines a research design as "the researcher's overall for answering the research question or testing the research hypothesis". This study focuses on the factors leading to a low pass rate by the Ordinary Level candidates at Mzilikazi High School which is situated at the Bulawayo Metropolitan Province. The research approach is non-experimental, qualitative, exploratory-descriptive and contextual.

Therefore, *research design* is the overall plan for connecting the conceptual research problems to the pertinent (and achievable) empirical research. In other words, the research design articulates what data is required, what methods are going to be used to collect and analyse this data, and how all of this is going to answer your research question. Both data and methods, and the way in which these will be configured in the research project, need to be the most effective in producing the answers to the research question (taking into account practical and other constraints of the study).

In this case the researcher decided to use a Traditional Qualitative Research Design and focuses on a particular population or group pupils from which he will source information towards answering the research question however to the teachers there is no selection because all science teachers do teach all levels. The researcher had proposed to use some information gathering strategies

known as *instruments* these involve the following: oral interviews, questionnaire directed to both the science teachers and the, "science learners who are already at Advanced level."

3.3 Population and sampling procedures

3.3.1 Population and sampling

Population refers to the collecting of units or individuals about which the researcher wants to make a qualitative or quantitative evaluation statement (Koh, Chai, & Lim, 2017). Awoniyi (2009:29) defines population as "all members of a well-defined class of pupils, events or objects understudy." The objects within the population show commonness in terms of characteristics desired for a study thus will make the findings in a sample generalized and justifiable. The population understudy was the L6th and U6th classes at Mzilikazi High School who are the Advanced Level Physics learners. It comprised of twenty-five learners, and the Physics teachers in the district.

The study participants were drawn from physics teachers from the 16 High schools in Reigate District of Bulawayo Metropolitan Province, there are 20 Physics Teachers because some double session schools have two physics teachers. Because of accessibility, the 25 A level Physics learners at Mzilikazi High School will represent all learners in the district.

3.3.2 Data collection methods / instruments

The study employed used a closed survey questionnaire with 11 items, an interview guide, a lesson observation guide and document analysis guide. The survey questionnaire was deemed most appropriate for soliciting for technical data addressing the research questions. The interview guide was used to solicit for deeper information pertaining to the preferred teaching practices to corroborate survey responses. The document analysis guide targeted 30 schemes of work for one school term and nine practical paper 4 examination questions. The lesson observation guide was used in the 20-lesson observed. The data gathering methods complied with the requirements of the mixed

methods approach through facilitation for data triangulation and comparability.

3.3.3 Data analysis methods / instruments

According to James (2008), research instruments are tools that are used for gathering data. Hopkins (1993:73) says, “Research instruments are strategies or ways used in data collection process that assist in finding solution to the problem.” In this action research, the researcher used instruments such as a questionnaire, interviews guide and focus groups guide.

Interviews

An interview is an oral conversation between an interviewer and the interviewee. Barbie (2001) says, “An interview is a two-person conversation initiated by an interviewer for specific purposes of obtaining research information.”

I used the interview method to obtain data from both pupils and teachers at Mzilikazi High School. This helped the researcher to have knowledge on the teaching, learning methods the challenges by the learners and teachers in the teaching and learning of A level Physics, the most approaches used by the teachers to teach science which seemed more comprehensive, most preferable ways to prepare for the examinations and other additional factors which might not be associated with the school environment. The researcher used open-ended interviews which are also called semi-structured interviews.

Open-ended interviews

These types of interviews are also called semi-structured. Barbie (2001) cited in (Chiromo, 2010) says that open-ended or semi-structured interviews allow broad questions to be asked in a predetermined manner allowing for a free following conversation. This type of an interview is characterized by flexibility.

Advantages of interviews

In order to get more responses and information, the researcher altered the interview. With open-ended interviews, the interviewer obtained rich details and new insights. Open-ended interviews allowed the interviews to ask the respondent for additional information. The researcher was be able clarify the questions to the interviewee. This helped the interviewee (pupils) to understand how they should respond to the questions asked by the researcher.

There was freedom of expression and data collected could be cross checked and be strategized as it provides immediate feedback.

Disadvantages of interviews

Data could be easily biased and misleading. Pupils could respond positively to the questions asked to please the researcher. Limited information is gathered if the responded or interviewee is unwilling to participate. Wenzel and Brill (1998) say those open-ended interviews maybe expensive and time consuming to conduct and transcribe.

Focus Groups

These are excellent research tools. Focus groups are forms of group 'interviews' – but there are differences. You will probably be familiar with the term 'focus group' from market research reports as they are used often to test reactions to new products or new politicians. A focus group usually consists of 6-15 people. (If the group is too large, then it tends to break up into sub-groups and control is difficult). The researcher acts as a facilitator rather than an interviewer. The facilitator starts with a clear theme communicated to the participants and a set agenda of items.

The group then works through the items, but the facilitator should also be prepared to pursue novel issues as they arise. Focus groups should be taped

(audio) or videoed. Videotaping can be more difficult and intrusive but is often worthwhile. Permission of the participants should always be sought for taping/ videoing. It is vital to make sure that everybody talks. If you wish to use focus groups across an organisation as a primary method of research, then a 'pilot' focus group should be tried first – learn the problems. Some of the advantages and disadvantages to the researcher at during this research are summarised in the table below:

Advantages of focus groups

- A dynamic focus group will generate many ideas, helping to explain or explore concepts. They will help to tell you why the organisation is as it is.
- Bottom-up generation of concerns and issues, which can help to establish survey variables.
- Can offer credibility to research where issues of bias are associated with interviews.
- Relatively quick and easy to organise. Cheap on time compared to participant observation, etc.
- A snowballing effect can occur as participants develop ideas triggered by other participants.

Disadvantages focus groups

- High level of skill of group leader/researcher is required to facilitate and manage the discussion. Otherwise, the discussion degenerates into 'waffle'.
- Where focus groups are conducted within an organisation, participants may be concerned about confidentiality.
- Dominance by one, or some, participant(s) of the discussion.
- Some participants may be inhibited because of the group.
- Problem of 'groupthink' – tendency to express views that satisfy others in the group, but which may not be valid outside the context.

3.4 Reliability and validity

In qualitative research, notions of reliability and validity have different meanings to those adopted in quantitative research. Quantitative research assumes the possibility of replication where, if the same methods are used again with the same sample, then the results should be the same. By contrast, in qualitative research reliability does not require such replication in generating, refining, comparing, and validating of constructs. Moreover, LeCompte and Preissle (1993) cited in (Mudzamiri, 2019) argue that such replication would be difficult, if not impossible, in qualitative research since it would require the researcher to repeat his status position, choice of respondents, social situations and conditions along with methods of data collection and analysis. Some qualitative researchers have argued that the concepts of validity and reliability are not applicable to qualitative research, but rather they are terms used in the quantitative paradigm (Altheide & Johnson, 1994; Golafshani, 2003; Leininger, 1994). The quality, rigor and trustworthiness have been suggested by Lincoln and Guba (1985b) and Stenbacka (2001) as being more suitable for (Golafshani, 2003). The idea of trustworthiness or rigor contains aspects of authenticity or credibility, transferability, dependability, and confirmability. Without rigor the research is worthless; it becomes fiction, and loses its utility (Golafshani, 2003). The concepts of authenticity and transferability set the standards by which I tried to ensure that the research was of high quality. I promoted authenticity by building a rapport with the participants and making the climate for the interviews and focus group discussions as natural as possible. This made the study authentic, naturalistic, and ethnographic. Holloway and Wheeler (2002a, p. 255) note that transferability means that findings of a research project could be applicable to similar situations or participants. This implies that the knowledge that was acquired in one context would be applicable in another similar context and researchers in that other context would be able to apply findings that from the original research. To improve transferability or generalizability of findings, I tried to give detailed or thick descriptions of the discussions. Thick description refers to rich, thorough descriptions of the research setting and the transactions and processes observed during the study (Polit, Beck, & Hungler, 2001, p. 316). Data was collected in different forms from physics 6032 teachers and learners to ensure trustworthiness

of the data and the study in general. The use of multiple sources of data or information (data triangulation method) enhanced the rigor and trustworthiness of a qualitative research (Johnson, 1997, p. 289). Similarly, Jick (1979) asserts that a multiple research approach is one way of ensuring trustworthiness of qualitative research. Triangulation is a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2000, p. 126). Creswell and Miller (2000) cited in (Mudzamiri, 2019) posit that triangulation is used to increase credibility and check dependability by sourcing information from different sources to form themes of the study. In this study validity and reliability because learners and their teachers were interviewed and the findings are analysed before compilation.

3.5 Ethical issues

The researcher prepared and used a research guide to channel all the conversation towards planned objectives. This eliminated extremes and lack of purpose as the interview was a semi-structured one. The researcher explained the purpose of the interview to the interview to the interviewees. Issues of ethical consideration, confidentiality and privacy of the research participants and respondents had to be taken into account. Research participants such as the teachers and school heads were at liberty to participate in the research without being coerced. Those who felt that they did not want to take part in the study were respectfully left alone and the researcher took every effort to protect the personal privacy of all respondents used in the research project. The objective of the research was explained verbally and participants were assured that the information obtained during the research would be kept confidential. The researcher interviewed three qualified A level Physics teachers. The purpose was to share their experience in teaching science generally and the topic modern physics; electricity and magnetism; oscillations and waves, and electronics specifically.

3.6 Chapter summary

This chapter the research design, the population, sampling and instruments have been presented. This was meant to specify or clarify the researcher's methodology to gather information towards answering the research question so as to meet the objectives of the study, however some questions may not be written since they might arise during the interviews hence oral face to face interviews are conducted. The next chapter is going to focus on data presentation, analysis and interpretation.

4 CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

4.1 Introduction

The previous chapter focused on instruments used as means of collecting data, the strengths and weaknesses or limits per instrument. In this chapter, the I will focus on the data presentation, analysis and interpretation. I will use the tables, pi-charts, line graphs and bar graphs.

4.2 Data Presentation, analysis and discussion / interpretation

As shown below this are the results, I compiled from my findings of the frequency of the learning methods that are used by the teachers at schools. The results are obtained from the learners.

LEARNING METHODS RECORDED BY THE LEARNERS	**Modern Physics**	**Electricity And Magnetism**	**Oscillations and Waves**	**Electronics**	**Average value**
1. Design based learning	0	15	0	25	10
2. E-learning (simulations)	20	0	10	0	7.5
3. Experimentation and Practical	5	25	18	18	16.5
4. Exposition and Discovery	0	0	7	12	4.75
5. Group work	10	25	3	15	13.25
6. Homework	18	25	9	12	16
7. Lecture	12	7	3	11	8.25
8. Presentations and discussions	20	3	10	8	10.25
9. Project based learning	0	0	0	5	1.25
10. Resource learning	13	0	0	0	3.25

Table 1: learning methods adopted by the learners

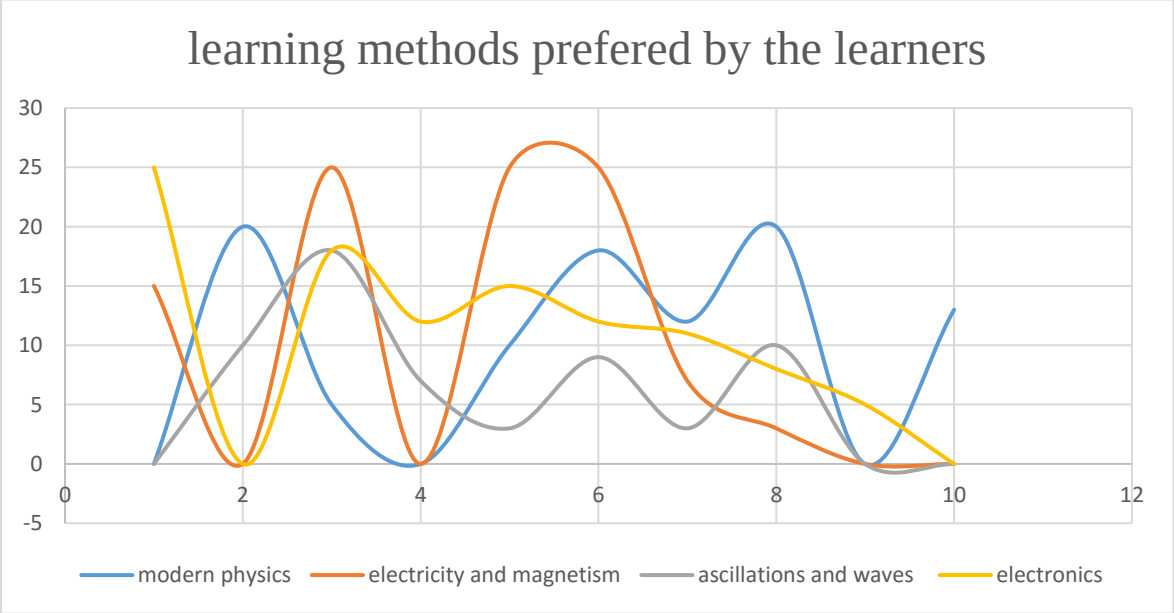

Figure 5: line graph 1

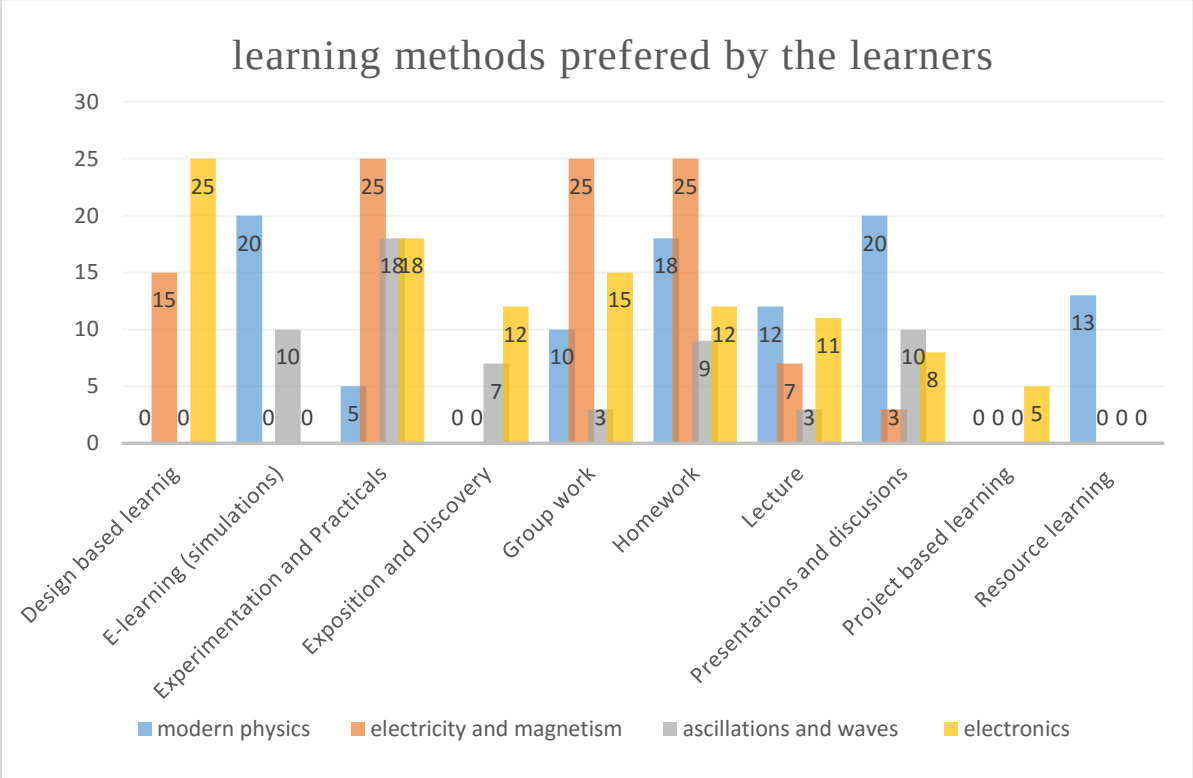

Figure 6: bar-graph 1

TEACHING METHODS ADVOCATED FOR BY THE FACILITATORS	Modern Physics	Electricity And Magnetism	Oscillations and Waves	Electronics
1. Design based learning	0	12	0	12
2. Tours / trips	0	20	0	0
3. E-learning (simulations)	3	7	16	8
4. Experimentation and Practical	20	20	20	20
5. Exposition and Discovery	12	18	15	12
6. Group work	15	10	20	9
7. Homework	5	5	14	11
8. Lecture	20	20	2	16
9. Presentations and discussions	8	5	18	20
10. Project based learning	0	5	0	14
11. Resource learning	0	16	0	8
12. problem solving	20	20	20	20

Table 2: teaching methods chosen by the teachers

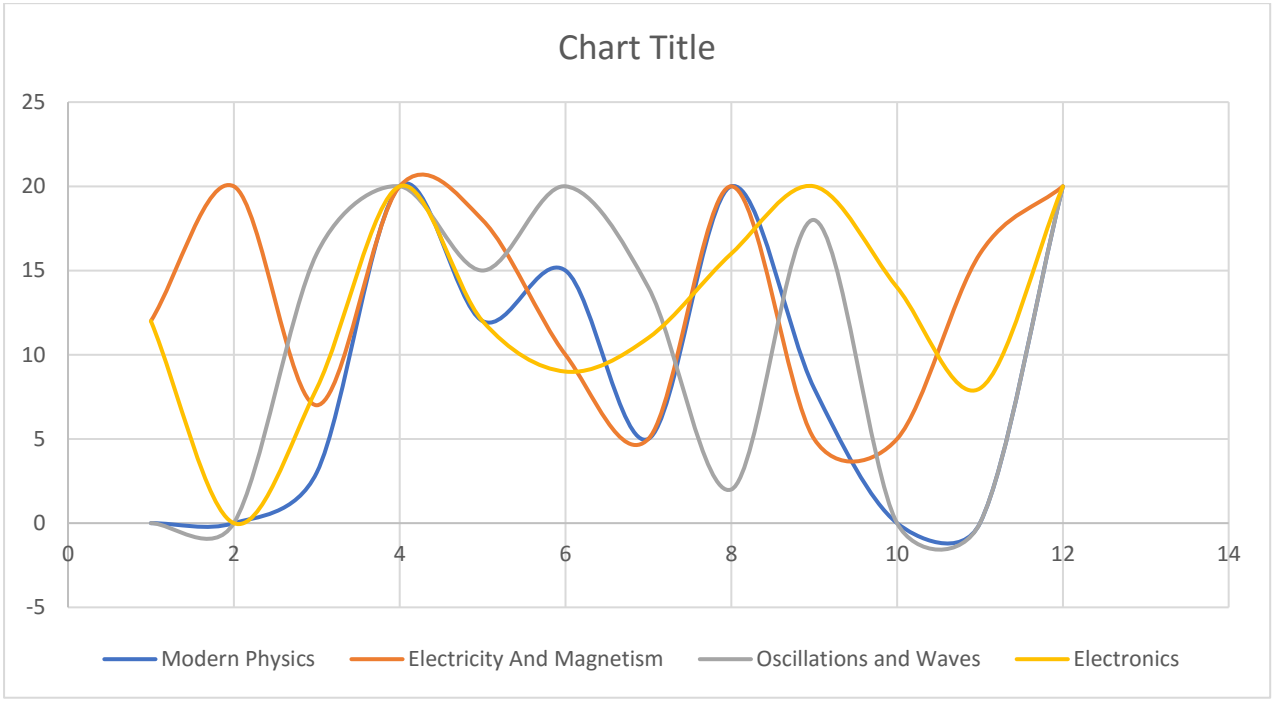

Figure 7: line graph 2

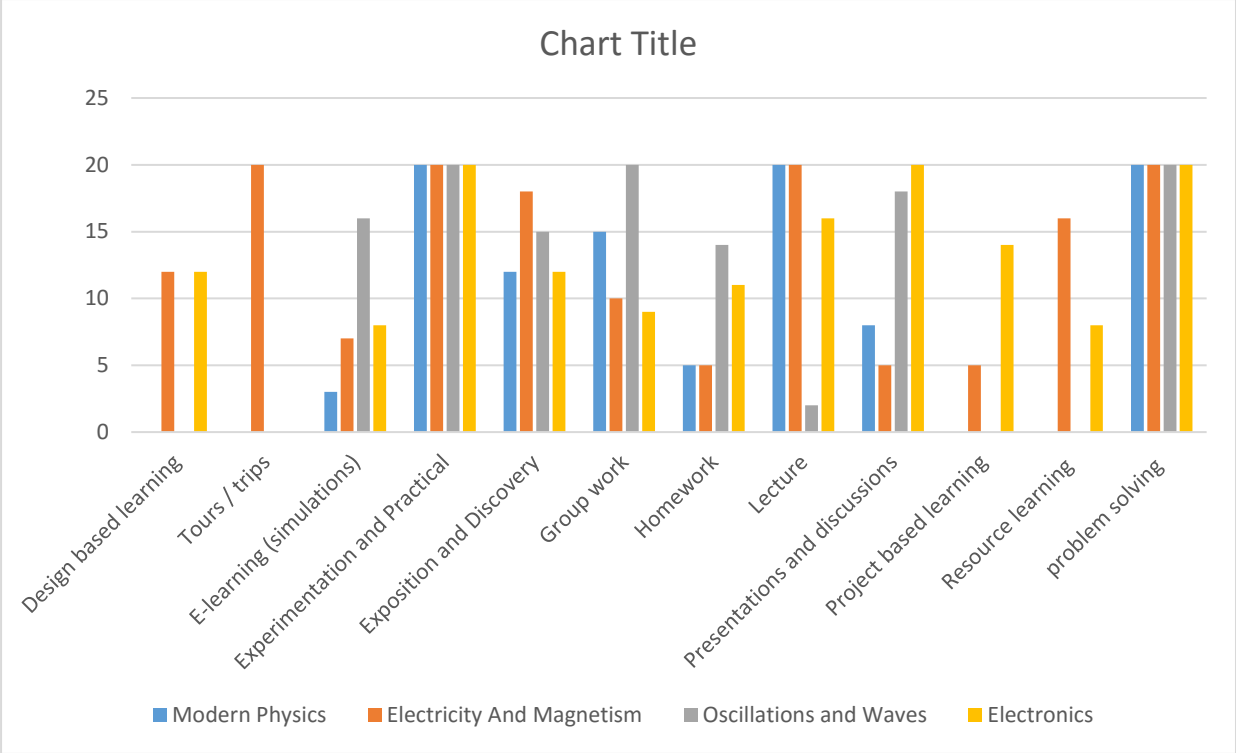

Figure 8: bar graph 2

4.2.1 Discussion and Interpretation

From the data presented above table 1 gives us the learning approaches which had been chosen by the learners, seeming best for them for their understanding to construct useful knowledge. It shows the simple quantitative representation of the number of learners per PA per topic. The data on the table shows that the learners are willing to participate more at the same time they need the facilitator's explanations for elaborations for clarity. When analysing the table, it is realised that the learners are used to some methods which they believe that they are the most appropriate. This is a clear sign showing that some of the pedagogical approaches are not employed by their teachers during the learning processes. From table I then came up with the average which gives us the most prominent method to their learning process.

LEARNING METHODS RECORDED BY THE LEARNERS	**Most frequently used**	**Modern Physics**	**Electricity And Magnetism**	**Oscillations and Waves**	**Electronics**	**Average value**
1. Design based learning		0	15	0	25	10
2. E-learning (simulations)		20	0	10	0	7.5
3. Experimentation and Practical	✓	5	25	18	18	16.5
4. Exposition and Discovery		0	0	7	12	4.75
5. Group work	✓	10	25	3	15	13.25
6. Homework	✓	18	25	9	12	16
7. Lecture		12	7	3	11	8.25
8. Presentations and discussions		20	3	10	8	10.25
9. Project based learning		0	0	0	5	1.25
10. Resource learning		13	0	0	0	3.25

Table 3: Frequently used pedagogic approaches

According to this table of averages, I had to add another column which shows a summary of the most frequently used learning methods adopted by the learners at their school. The determination is derived from the fact that the votes were found below average while others are found to be above average. According to these findings the learners at this centre are used to the three PAs; *experimentation and practical*, *group work*, and *homework*. The assumption is that in all schools in the district the pattern is generally the same. I realised that the deviation of the averages in options had been due to the fact that the L 6th class learners have not done some of the topics. The line graphs and the bar graph show the general trend of the PAs per respective topics that had been chosen for this study. The two graphs are meant to enhance the general understanding to the reader or reviewers as they read through this study and they also appeal to the eye hence are subject to scrutiny.

Table 2 shows the PAs preferred by the teachers in the ALPT however the choice of most of the teachers is based on the approaches indicated and recommended by the syllabus.

LEARNING METHODS RECORDED BY THE LEARNERS	Frequently used PA	**Modern Physics**	**Electricity And Magnetism**	**Oscillations and Waves**	**Electronics**	**average**
1. Design based learning		**0**	**12**	**0**	**12**	6
2. Tours / trips		0	20	0	0	5
3. E-learning (simulations)		3	7	16	8	8.5
4. Experimentation and Practical	✓	20	20	20	20	20
5. Exposition and Discovery	✓	12	18	15	12	14.25
6. Group work	✓	15	10	20	9	13.5
7. Homework		5	5	14	11	8.75
8. Lecture	✓	20	20	2	16	14.5
9. Presentations and discussions	✓	8	5	18	20	12.75
10. Project based learning		0	5	0	14	4.75
11. Resource learning		0	16	0	8	6
12. problem solving	✓	20	20	20	20	20

Table 4: Mostly preferred and Frequently used PA by the teachers in Reigate District

According to this table of averages, I had to add another column which shows a summary of the mostly preferred or most frequently used teaching methods adopted by the teachers at their stations where they are deployed in Reigate District. The determination is derived from the fact that some the preferences of the PAs were found below average while others were above the average. According to these findings the teachers in this district genuinely frequently employ six PAs; *experimentation and practical*, *group work*, *homework*, *exposition and discovery*, *lecture*, *presentations and discussions and problem solving* in most of their teaching. The assumption is that in all schools in the district the pattern is generally the same in average. The line graphs and the bar graph show the general trend of the PAs per respective topics that had been chosen for this study. The two graphs are meant to enhance the general understanding to the reader or reviewers as they read through this study and they also appeal to the eye and subject to enquiry.

4.3 Summary

This chapter had been covering the data presentation and analysis as per my findings. It showed it clearly that the learning methods most preferred by the learners are the ones that they are familiar with *meaning that they will always opt for the methods or approaches that are being adopted by their teachers*, psychologically learners learn things by imitation because facilitators / teachers are their role models. There are some differences between the pelagically options for these topics between the teachers and the learners. Most of the teachers' choices of pedagogy are relevant in each case as I took a look at the syllabus 6032.

5 CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter focused on data presentation, analysis and interpretation, where the researcher presented the data from the secondary data sources, briefly explained, analysed the Mzilikazi situation, presented the findings answering the question and qualitatively explained the presented data. This chapter will focus on overall summary, conclusion and recommendations drawn from the whole study.

5.2 Summary of the study

In this study, I focused on the, '*An exploration of the pedagogic approaches in the Advanced Level Physics teaching at Mzilikazi High School* (Reigate District).' I followed my suggested exploratory procedures with the help guidelines from my supervisor Dr Mudzamiri E. The purpose of the study was to; "identify the pedagogic approaches (teaching-learning methods) adopted by the Advanced level Physics teachers in Reigate District in Bulawayo Metropolitan Province. These pedagogical approaches will lead to the effective learning of advanced level physics so that the learners acquire useful and productive education.

I was mainly concerned with the teaching-learning methods which contribute to the attainment useful in modern physics, electricity and magnetism, oscillations and waves and electronics in advanced level physics which will position the learners for their future productive and progressive careers in the world of production. I proposed to carry out a qualitative study of the relevant pedagogic approaches in A Level Physics teaching. Since the target population was the abrupt stakeholders, thus the *Advanced Level Physics Teachers and the A level Physics pupils/learners/students.* For the teachers I had to invite some teachers in the district to consolidate the validity of my findings other than relying on the two Physics teachers at my own station. As I interviewed the teachers some

other issues arose which influence the choice of pedagogy. Here is the summary of the PA choices the twenty Physics teachers in Reigate district.

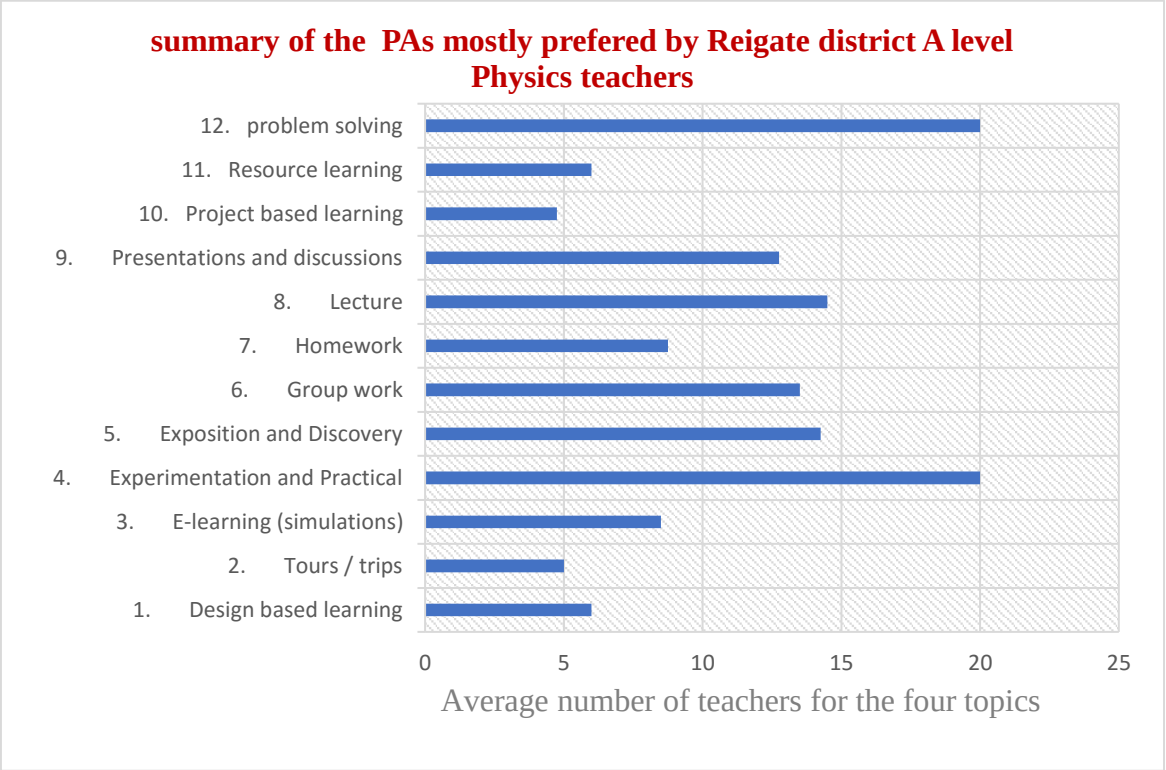

Figure 9: summary of the PAs mostly preferred by Reigate district A level Physics teachers.

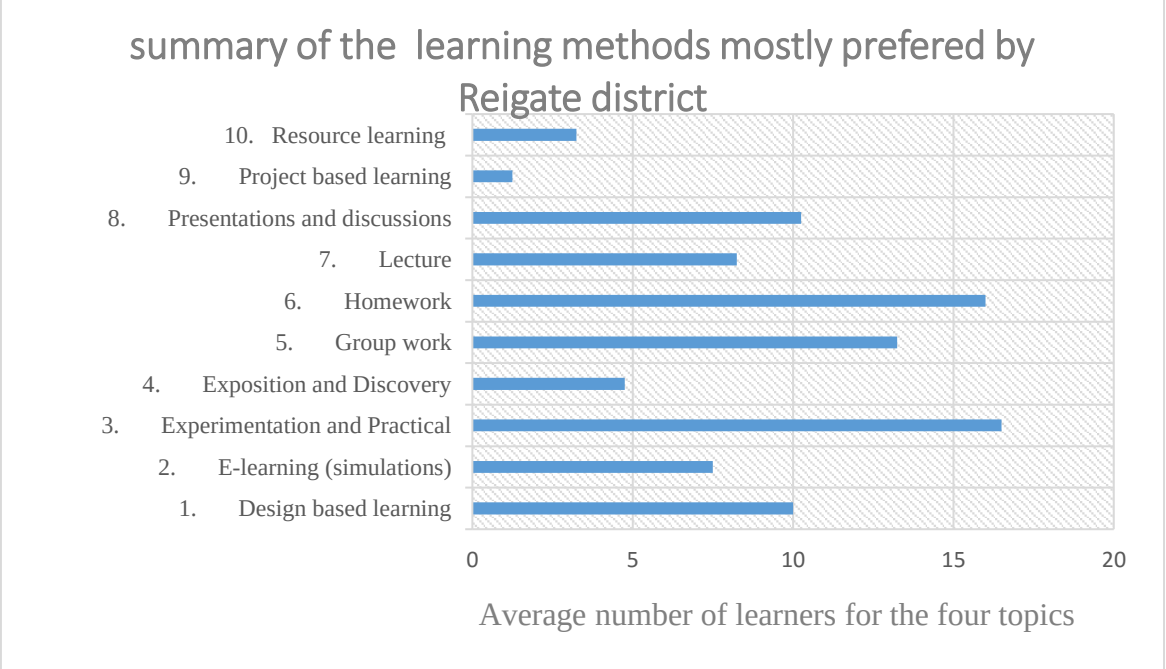

Figure 10: summary of the PAs mostly preferred by Reigate district A level Physics teachers.

5.3 Conclusions

This research has examined the key pedagogical approaches to the teaching of advanced level physics in the Reigate district. The study was set out to find out the relevant teaching methods that would lead to accomplishment of the educational goals in A level Physics.

Some other issues arose during study, I could consider them because the have influence on the pedagogy employed by the Advanced level Physics teachers in their stations. The issue which arose on my way is that there are no standard laboratories in most of our schools and most of the administration members who run the have blind eye and a blunt attitude towards science, hence all the requisitions made by the science department are overlooked and not attended to most of the time.

The present study makes several contributions to the secondary teacher training institution, schools and to the whole Zimbabwean educational fraternity. Awareness of some issues raised in this study is brought across so as to mobilise the Teacher Training Institution to adequately equip the new teachers with diverse tactics to overcome the problems at schools. Although the current study is based on the factors contributing to the low pass-rate at ordinary level science subjects, the findings suggest that the factors do contribute to the overall pass-rate at all levels with premium quality outcomes of secondary education at large. However not all the pupils do the same science subjects, some pupils have been screened to some classes and pupils were afraid to raise some of the issues affecting them, and this stood as a limiting factor to the researcher.

5.4 Recommendations

The researcher suggests that science teachers should use child centred methodologies in teaching science. He also recommends that teachers should not depend upon one teaching method, instead they should vary. For example, use group work method, homework, discovery, field-trip, panel discussion, resource person and experimental method in teaching most of the science

topics. Pupils are motivated when they do experiments themselves being supervised by a teacher, they learn to share ideas. The other advantage of using experiments is that it is pupil centred and pupils are able to make their own observations and conclusions, thus enabling both guided and self-discovery. Teachers are also obliged to teach their pupils how to use their mobile devices as a gain to their learning progress, so that they are taken away from the issue of focusing on the social network and unselective media which pollutes the brain.

The teacher recommends that science teachers should vary their media and pupils should be given a chance to explore the learning aids on their own so that they have concrete evidence to cater for pupils' individual differences and enhance the grasping of concept. The use of a models, charts, realia and ICT will validate the learning to pupils / learners sufficiently and makes it easy for pupils to recall some concepts.

The researcher also recommends that science teachers should give tests and exercises frequently so as to find out strengths and weaknesses of pupils and weigh the effectiveness of their methods. The teachers are advised to give adequate remedial and extension work to slow learners and high-flier so as to cater for individual weaknesses and strengths that all pupils are accommodated.

The researcher also suggests that there should high degree of improvisation towards bridging the gap between the inadequacy of resources. All who are to do this are the teachers of the subjects periodically to make sure attainment of learning objectives.

I recommend that the Zimbabwean government through the appropriate arm of the state and ministry help to put more emphasis on the parents to pay fees at the school so that the school may help to source resources for teachers to teach the Advanced level Physics learners adequately as required by their level so as to enable them to advance in their studies with ease. The resource is key to effective and efficient action in the educational fraternity.

Teachers should give constructive comments even when pupils' performance is not good. This is done to "transmit" to students the idea that mistakes are an essential part of the learning process and definitely something not be feared. This aids interactive process when pupils correct themselves in groups and are also corrected by the teacher, inculcating the inquiry mindset to the learners.

Finally, the I recommend that the schools should work together with parents to mould the academic life of the pupils which shall in turn determine their future and career. Teachers should work together with parents or guardians or parents and learners as well, hence the communication links should be created and consolidated. This will help in monitoring the pupils' activities both at school as well as at home so as to confine their focus to school work. In this way the parents will be able to share views and ideas with the teachers so as to be able to encourage pupils to work hard towards a successful academic life. This should change the trend of result and quality in Zimbabwean High Schools.

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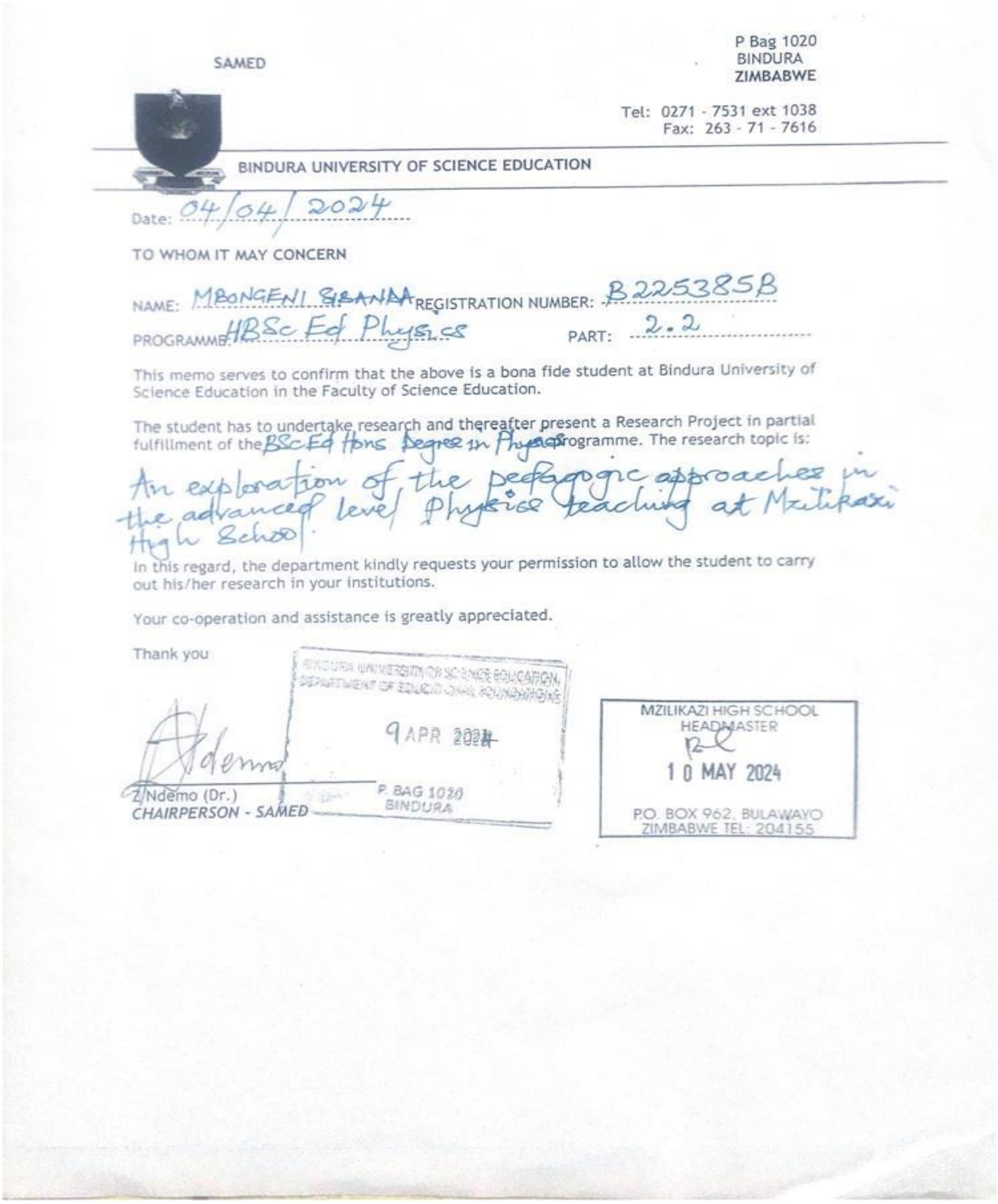
APPENDICES

APPENDIX A: PERMISSION SEEKING LETTER FROM BUSE



SAMED

P Bag 1020
BINDURA
ZIMBABWE

Tel: 0271 - 7531 ext 1038
Fax: 263 - 71 - 7616

BINDURA UNIVERSITY OF SCIENCE EDUCATION

Date: 04/04/2024

TO WHOM IT MAY CONCERN

NAME: MBONGENI SIBANDA REGISTRATION NUMBER: B225385B

PROGRAMME: HBSc Ed Physics PART: 2.2

This memo serves to confirm that the above is a bona fide student at Bindura University of Science Education in the Faculty of Science Education.

The student has to undertake research and thereafter present a Research Project in partial fulfillment of the BSc Ed Hons Degree in Physics programme. The research topic is:

An exploration of the pedagogic approaches in the advanced level Physics teaching at Mzilikazi High School.

In this regard, the department kindly requests your permission to allow the student to carry out his/her research in your institutions.

Your co-operation and assistance is greatly appreciated.

Thank you

Z. Ndemo (Dr.)
CHAIRPERSON - SAMED

BINDURA UNIVERSITY OF SCIENCE EDUCATION
DEPARTMENT OF EDUCATIONAL FOUNDATIONS
9 APR 2024
P. BAG 1020
BINDURA

MZILIKAZI HIGH SCHOOL
HEADMASTER
10 MAY 2024
P.O. BOX 962, BULAWAYO
ZIMBABWE TEL: 204155

APPENDIX B: MANDATORY LETTER FROM MZILIKAZI HIGH

MZILIKAZI HIGH SCHOOL

Telephone: 204155
Fax: 200142
Email: matshobana@mweb.co.zw
mzilikazihighschool@gmail.com

P.O. Box 962
Bulawayo
Zimbabwe

Re: Confirmation of research permission granted to Mbongeni Sibanda to do Research at Mzilikazi High School

This note serves to confirm that Mbongeni Sibanda had been granted permission to do his research at Mzilikazi towards completion of his Bachelor of Science Education Honors Degree in Physics at Bindura University of Science Education. We are in a position to help him attain data that his research needs, he can also execute his research activities.

Yours Faithfully

Mr Dube B. (Head)

MZILIKAZI HIGH SCHOOL
HEADMASTER
22 MAY 2024
P.O. BOX 962, BULAWAYO
ZIMBABWE TEL: 204155

FOCUS-GROUP GUIDE for Physics Learners

Discuss and write down best way you expect learn the following topics in a way that will enhance better understanding, state the learning-teaching methods:

1. Modern Physics:

_____

_____

_____

_____

2. Electricity and magnetism:

_____

_____

_____

_____

3. Oscillations and waves:

_____

_____

_____

_____

4. Electronics:

_____

_____

_____

_____

APPENDIX D: INTERVIEW QUESTIONS TO THE PHYSICS A LEVEL LEARNERS

TOPIC:

AN EXPLORATION OF THE PEDAGOGIC APPROACHES IN THE ADVANCED LEVEL PHYSICS TEACHING AT MZILIKAZI HIGH SCHOOL

INTERVIEW QUESTIONS FOR PUPILS

1) List the methods of teaching and learning methods that are suitable for your learning in Physics, take a look at your syllabus:

   i. _____
   ii. _____
   iii. _____
   iv. _____
   v. _____
   vi. _____
   vii. _____

2) What is your perception about the nature of Physics learning at your level?

   _____
   _____
   _____

Kindly complete the following table by ticking the appropriate option/choice of the teaching teaching-learning process for the following A level Physics topics as shown in the example on the table below:

LEARNING METHODS RECORDED BY THE LEARNERS	**Modern Physics**	**Electricity And Magnetism**	**Oscillations and Waves**	**Electronics**	**Average value**

Example Learning method	✓	✓	✓	✓	✓
1. *Design based learning*					
2. *E-learning (simulations)*					
3. *Experimentation and Practical*					
4. *Exposition and Discovery*					
5. *Group work*					
6. *Homework*					
7. *Lecture*					
8. *Presentations and discussions*					
9. *Project based learning*					
10. *Resource learning*					

APPENDIX E: INTERVIEW QUESTIONS TO THE A LEVEL PHYSICS TEACHERS

TOPIC:

AN EXPLORATION OF THE PEDAGOGIC APPROACHES IN THE ADVANCED LEVEL PHYSICS TEACHING AT MZILIKAZI HIGH SCHOOL

INTERVIEW QUESTIONS FOR PUPILS

1) List the methods of teaching and learning methods that are suitable for your learning in A level Physics 6032:

viii. _____

ix. _____

x. _____

xi. _____

xii. _____

xiii. _____

xiv. _____

2) What is your perception about the nature of Physics learning at your level?

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Kindly complete the following table by ticking the appropriate option/choice of the teaching teaching-learning process for the following A level Physics topics as shown in the example on the table below:

LEARNING METHODS RECORDED BY THE LEARNERS	**Modern Physics**	**Electricity And Magnetism**	**Oscillations and Waves**	**Electronics**	**Average value**
Example Learning method	✓	✓	✓	✓	✓
1. Design based learning					
2. E-learning (simulations)					
3. Experimentation and Practical					
4. Exposition and Discovery					
5. Group work					
6. Homework					
7. Lecture					
8. Presentations and discussions					
9. Project based learning					
10. Resource learning					
11. Other					
12. Other					
13. Other					
14. Other					

NB: *Indicate for the other Pedagogical Approaches on number 11 – 14. Thank you, Physicists.*