The Zimbabwean Advanced Level Physics Teachers' Views on Inquiry-Based Physics Instruction and Level of Actual Classroom Practices

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Abstract: **The study explored how Zimbabwean Advanced Level physics teachers perceive and teach inquiry skills in Advanced Physics classrooms. The study was motivated by misconceptions of physics concepts displayed by learners being enrolled in physics related undergraduate programmes in some of the Zimbabwean universities. The study sought to check on current teachers' views, experiences and practices with respect to current inquiry instructional practices. The mixed method approach was employed for the study. The data was solicited through a questionnaire, an interview guide, lesson observation guide and a document analysis guide. Random sampling was used to select 140 physics teachers from the 10 Educational provinces and purposive sampling was used to select 30 teachers for the interviews. 20 lessons were observed. Descriptive statistics and emerging themes were used to concretise the data for discussion. The main findings suggest that teachers are aware of inquiry-based science teaching approaches yet depict low level inquiry-based physics practices in the classrooms. The low level inquiry-based physics teacher practices could be attributed to limited teacher competencies, public examinations assessment demands, limited human and material resources and limited time for effective teaching and learning. The study recommends teachers need to be capacitated on inquiry-based learning competencies, school authorities invest in both human and material resources and that aligning public examinations assessment demands to inquiry-based competencies will make teachers adapt accordingly.**

Keywords: inquiry; instructional practices; assessment; practical examination; physics curriculum; inquiry-based science

I. INTRODUCTION

Recent curricula reforms in developing countries have called for classroom teachers to embrace more active forms of learning and teaching and shun teacher-dominated forms of lesson delivery, (Bregman, 2008; Kasembe, 2011). This is underpinned by the need to for learners to effective master science concepts and applies them in everyday life. Hence, curriculum innovations are calling upon teachers to facilitate learning, create opportunities for the learner to actively engage in the learning process. Modern economies are guided by Technology development and Physics concepts form part of the grounding. To this end the Ministry of Primary and Secondary Education (2015: 3) projects that the "study of Physics enables learners to be creative and innovative in industry and society that can promote the application of Physics in industrial process for value addition". In view of this thrust the Ministry of Primary and Secondary Education (2015) has embraced inquiry- based learning to orchestrate development of inquiry skills in the learners in Advanced Level Physics.

However, translation of curriculum imperatives into reality is hinged on teachers. If teachers fail to articulate curriculum prescriptions in their daily practice the whole process of curriculum reform is compromised and ultimately flops, (Fullan, 2007; Rammnarian, 2014). Teachers' classroom decisions depend on how individual teachers relate to and interpret the curriculum innovation. Therefore it becomes imperative to understand the teachers' percepertions about a Physics curriculum innovation and maybe enhance the chances of successfully implementing that innovation, (Roehrig & Kruse, 2005). Fullan (2007) underscores the role of the classroom practioner in curriculum implementation by insisting that their classroom practice and what they think about an innovation are critical for translation of any reform into reality. In view of this, the teachers' role becomes essential in the execution of scientific inquiry in the classroom and knowledge of how their perceive the innovation becomes an essential resource for education authorities to map the way forward.

Numerous studies conducted on inquiry-based science learning have underscored the teachers' appreciation of the innovation. However, the actual classroom practices have been different across the educational settings. This has been largely attributed to different classroom environments and diversity in resources availability, educational cultural differences of the learners, teachers, school climate and class sizes, which determine the degree of curriculum implementation (Howitt, 2007 & Zion, Chen & Amir, 2007). In the Zimbabwean educational landscape some of these disparities are quite apparent, specifically with respect to access to material resources, class sizes, school culture and teachers. The prevailing economic meltdown and flight of skilled human capital to greener pastures has adversely affected the Zimbabwean educational terrain. In view of the existence of these disparities in the Zimbabwean Education system and the Advanced Level Physics curriculum specifications with respect to inquiry-based learning it becomes pertinent to study teachers' practices in enacting the innovation in their stations.

Teachers tend to perpetuate archaic practices they are familiar with despite calls for modernised teaching strategies. This points to the idea that lot still need to be done to improve teaching and learning of science subjects in schools. Challenges facing modernisation include teachers' limited ability to teach constructively, limited resources and teachers and learners' concern with timely completion of the syllabus and getting credit for good examination results, (Anderson, 2002).These obstacles need to be ascertained and measures to address them instituted to alleviate the teaching of Physics for the betterment of learner achievement. For instance teachers may be preoccupied with timely completion of syllabi, particularly in environments where teachers may be regarded as authorities of knowledge by learners and society, hence, have an obligation to deliver (Bregman, 2008; Lim & Pyvis, 2012; Ramnarian, 2016; Zhu, 2013). School authorities, teachers and learners mainly draw acclaim from the quality of their public examination results and would do all they can to maintain it. Such practices are antithetical to inquiry-based science teaching and learning.

Effective teachers need to be well-grounded in pedagogical content knowledge (PCK). Shulman (1987) argues that PCK represents the fusing of subject matter and pedagogy creating an awareness of how specific 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 Etkina; (2010) who purports 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. Botha (2012) and Chinyere (2014) 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 practioner who has the skills and capacity to facilitate learning and create an enabling environment. Etkina (2010) advances the notion that teachers tend to teach in the manner in which they were taught. Considering that the majority of Zimbabwean Physics teachers are likely to have been subjected to transmissive pedagogy, it would be interesting to determine the extent to which they have embraced learner-centred teaching approaches in their classrooms and if not, why they have not adopted them. Zimbabwean Physics teachers comprise a mixed bag of subject experts and those who have gone through the rigours of teacher education. Hence, it is pertinent to bring to the fore how the differently positioned teachers value the inquiry-based science demands of the revised Advanced Level Physics syllabus, challenges they encounter and strategies that they employ to mitigate the challenges. One such approach teachers could be struggling with could be inquiry-based science instruction.

Statement of the problem

The continual use of transmissive pedagogy in science classrooms despite overwhelming evidence pointing to their infectiveness in learner concept development is a pertinent subject for further interrogation. Internationally, literature pertaining to science education is awash with evidence pointing to very limited use of inquiry-based science instructional teaching and learning approaches in science classrooms,(Buabeng,2015; Capps & Crawford, 2013; Ramnarian,2016,). Little research into inquiry-based science teacher perceptions and classroom practices in Zimbabwean high schools has been undertaken to date, (Kasembe, 2011; Mtetwa, 2017). This study sought to explore Zimbabwean high school physics teachers' views and practices in implementing inquiry-based science instruction in the Zimbabwean context.

Research questions

The study was executed through the following sub-research questions.

1. How do Zimbabwean high school Physics teachers perceive inquiry-based science learning?
2. What is the extent of Zimbabwean Physics teachers' implementation of inquiry-based science practices in the classrooms?
3. What factors could be contributing towards physics teachers' inquiry based physics instruction classroom practices?

Significance 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.

II. REVIEW OF RELATED LITERATURE

Effective teaching and learning of science is still an area of concern as many science teachers still resort to teacher-centred teaching approaches, (Capps & Crawford, 2013; Mandina, 2012 Tesfaye & White; 2012, Tairabi & Al-Naqbi, 2018). According to DiBiase and McDonald (2015) and The National Research Council, (NRC, 2012) inquiry-based science teaching is concerned with the different ways upon which scientists and learners study natural phenomenon through developing questions and suggesting explanations based on information obtained from their undertakings. In essence, learners learn science effectively by undertaking it in a way reminiscent of how scientists perform it professionally. In support of these ideas Chabalengula and Mumba (2012), Furtak, (2006) and Holloway (2015) project that inquiry is associated with the scientific approach underpinned by learners asking questions, undertaking background research, hypothesizing, testing the hypothesis through experimentation, analysing data and drawing conclusions and communicating results. This indicates that inquiry calls for learners to be actively engrossed in the learning scenario, which culminates in deep-rooted understanding of scientific concepts. Teachers are therefore expected to provide guidance, afford learners opportunities to interact and encourage learners to take responsibility of their learning in appropriate contexts.

BauJaude, (2011), National Research Council (2012) and Tairabi and Al-Naqbi (2018) project that inquiry based teaching employs several teaching approaches among which are hands on and project based activities, guided discovery, experimental investigations, problem solving, designed based approaches and conducting actual research. This indicates the teacher has to be well acquainted with these teaching approaches if she/he has to create relevant and appropriate learning experiences. This calls for a lot of commitment and extensive planning on the part of the teacher for effective inquiry-based instruction to be realised in the science classroom. The proponents on inquiry-based instruction project that teaching guided by inquiry ensures learner engagement in the learning process and facilitates deep science conceptual development, (Capps & Crawford, 2013).From this perspective it may be argued that inquiry-based instruction promotes learning for understanding and growth. To illustrate how inquiry promotes learner engagement and stimulates learning, it is prudent to highlight some of its key attributes. For instance, learners under inquiry based instruction actively take part in learning and as such become engaged in the learning scenario.

The inquiry-based approach calls for the alignment of teaching methods, curricula and assessment practices. The assessment need to reflect the teaching methods employed and curricula should facilitate inquiry. To that effect NRC, (2012:42) call for learners to be guided through learning scenarios that are characterised by the following practices: 1. learner engages in scientifically oriented questions; 2 Learner develops and uses models; 3 Learner plans and conduct investigations; 4.Learner analyses and interprets data; 5. Learner uses mathematics and computational thinking; 6.Learner constructs explanations; 7.learner engages in arguments from evidence and 8. Learner obtains, evaluates and communicates information. It is believed acquiring competencies associated with these scientific practices promotes a better understanding of the manner in which scientific knowledge is generated. However, regardless of curriculum innovation specifying inquiry-based practices in the science classroom, the Zimbabwean education system is examination driven (Ministry of Primary and Secondary Education, 2015). The Ministry of Primary and Secondary Education, (2015) stipulates that The Advanced Level Physics assessment is based on 70% summative assessment and 30% continuous assessment. The continuous assessment is comprised of theory tests, practical tests and a project. Ultimately, the assessment is heavily tilted toward summative assessment. Hence, the concept of assessment playing a significant part in the execution of inquiry-based science teacher classroom practices and thinking warrants an investigation.

Teachers need to guide learners in learning activities that conforms to those of practising scientists. The curriculum and teaching processes should enhance effective learning of science. This is highly demanding on the part of the teacher in planning, creating and facilitating such learning scenarios from which learners derive intellectual growth. The learning context should avail learners with opportunities for posing questions, utilising evidence and explanations. It should also facilitate, linking explanations to existing scientific knowledge and communicating acquired scientific knowledge and evidence to colleagues. The NRC, (2012) projects that for effective inquiry based learning the teacher should be well grounded in mastery of science concepts to be in a position to guide learners towards sound subject comprehension. Lack of subject matter expertise on the part of the teacher may lead to undesirable learning activities of school science being availed to learners, Kim & Tan, (2011). It boils down to the fact that teacher's sound content mastery should be complimented by pedagogical skills for effective implementation of inquiry-based learning.

A major challenge, however, is that the majority of practising science teachers were not exposed to the inquiry approach during their tenure as students, (Capps & Crawford, 2013). Consequently, inquiry-based instruction may be a nightmare for most science teachers. Anderson (2002) argues that teachers' challenges with respect to inquiry based instruction come in three dimensions namely, technical, political and cultural. The technical aspect is concerned with the teacher's limited capability to execute his teaching duties constructively. The political dimension concerns itself with issues like inadequate professional development opportunities, parental resistance and lack of resources among others. The cultural dispensation is concerned with teachers' views of assessment and preparing learners for the next level among others. These ideas are also supported by Buabeng (2015), Chabalengula and Mumba, (2012) and Fernandez, (2017) who project that physics teachers lack competencies to effectively execute inquiry-based instruction. These authorities go further to suggest that the teachers are not availed adequate resources and are under pressure to prepare the learners for national examinations. Hence, the prevailing environment in the science classroom may not be conducive for the effective inquiry-based physics instruction. This is detrimental to science concept development and hinders learners' prospects in the science world and science related vocations. With limited research in Zimbabwe on inquiry-based science teaching one is prompted to undertake research in this area. Against the background of the few research studies conducted in inquiry-based science teaching (Chabengula & Mumba, 2012; Rammnarian, 2016; Mtetwa, 2017) it appears plausible to determine development of inquiry and inquiry skills during Physics lessons in the Zimbabwean context.

The other key concept in inquiry based learning relates to learner autonomy in the classroom. Inquiry-based learning is ceased with the role of the teacher as a facilitator and more pronounced learner autonomy and self directed learning. The Ministry of Primary and Secondary Education (2017:6) reiterates the prominent role that should be accorded the learner-centred teaching approach in the Zimbabwean education system. The approach is to be orchestrated through planned experiments, learning by discovery, problem based learning, individual and group work, educational tours, and project based learning, e-learning such as simulation and resource person. However, it is regrettable that previous studies have indicated that practical work mainly remained teacher-centred, Anderson, (2007) and Munikwa and Mukava, (2011). Rammanarian, (2014) has lamented the low level of learner initiated science practical activities in South Africa Schools. Baubing, (2015) and Chabelangula and Mumba, (2012) suggest that teachers are amenable to inquiry-based teaching but encounter serious impediments in their efforts to implement it. With due respect to these disparities between curriculum specifications for learner freedom underpinning inquiry-based learning and curriculum enactment , the study focuses on teachers' perceptions with regards to affording learners opportunities to undertake inquiry-based activities.

II. RESEARCH METHODOLOGY

Research design

The study adopted the convergent parallel design. According to Creswell and Plano Clark (2011) and Fischler (2014) 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 (Creswell, 2014; Creswell & Plano Clark, 2011). In a way the convergent parallel design ensures corroboration within the conduct of the same study. The study was guided by the pragmatist philosophy perspective that value is determined by realistic consequences. Hence the convergent parallel design was considered the most appropriate approach for the attainment of this task.

Population, sample and sampling procedures

The study participants were drawn from physics teachers from the 10 educational provinces in Zimbabwe namely Harare, Mashonaland Central, Mashonaland East, Manicaland, Masvingo, Midlands, Matebeleland South, Matebeleland North, Bulawayo and Mashonaland West. 140 Advanced level physics teachers were selected using random sampling to complete the questionnaire. From the survey respondents 20 Advanced Level physics teachers were purposively selected to participate in the interviews. The 20 were fairly accessible with respect to school location.

Data collection 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.

Data analysis techniques

Descriptive statistics was employed to elaborate quantitative data and qualitative data was collated into emerging themes for purposes of analysis and discussion. This enhanced data presentation clarity and facilitated for easy analysis and interpretation. The teachers' responses to the closed statements in the questionnaire were categorised and ranked as 1(not important) to 4 (very important).

III. RESULTS AND DISCUSSION

Table 1 shows the frequencies and descriptive statistics of the self-reported items on the teachers' perceived inquiry-based physics teaching and learning practices. The responses are configured as Not Important (NI), Somewhat Important (SI), Important (I) and Very Important (VI).

	Frequencies, percentages and means (N = 140)						
Statement	**NI**	**SI**	**I**	**VI**	**Mode**	**Mean**	**Std Dev.**
I afford learners the opportunities to construct meaning from inquiry experiences such as engaging in open-ended questions and group discussions	5 (3.6)	8 (5.7)	60 (42.9)	67 (47.9)	4	3.36	0.75
I involve learners with Physics experiments with known outcomes.	2 (1.4)	17 (12.1)	55 (39.3)	66 (47.1)	4	3.18	0.69
I prepare daily lesson plans guided by textbooks.	8 (5.7)	35 (25)	60 (42.9)	37 (26.4)	3	2.91	0.86
I encourage learners to design their own investigations to solve a scientific question	8 (5.7)	10 (7.1)	35 (25.0)	87 (62.0)	4	3.45	0.85
I teach learners guided by national examinations	3 (2.1)	30 (21.4)	37 (26.4)	70 (50.0)	4	3.25	0.86
I use inquiry method in Physics instruction	3 (2.1)	12 (8.6)	85 (60.7)	40 (28.6)	3	3.16	0.65
I teach facts as the primary goal of Physics instruction.	0	30 (21.4)	75 (53.6)	35 (25.0)	3	3.04	0.69
I teach the processes of Physics as the primary goal of physics instruction	5 (3.6)	23 (16.4)	87 (62.1)	25 (17.9)	3	2.95	0.70
I use of open-ended (essay, problems) questions as the main strategy to evaluate learner learning.	13 (9.3)	27 (19.3)	73 (52.1)	27 (19.3)	3	2.82	0.86
I encourage learners to work in collaborative groups on investigations	0	5 (3.6)	53 (37.9)	82 (58.6)	4	3.57	0.60
Average mean scores						3.05	0.77

Table 1 shows that the teachers attached great importance to methods for employing inquiry-based science teaching in the classrooms as indicated by the overall mean score (M=3.05;SD=.77. The items:" I encourage learners to work in collaborative groups on investigation", (M=3.57; SD= 0.60) and "I encourage learners to design their own investigations to solve a scientific question", (M=3.45; SD=0.85) were rated highly. This may indicate that the teachers value learners collaborating in groups and designing their own experiments to solve scientific problems as critical aspects of inquiry-based physics teaching. This finding is consistent with National Research Council (2000) who project that open inquiry activities avail learners with credible opportunities for deeper understanding of scientific concepts. The item: "I use multiple–choice questions as the main strategy to evaluate learning" (M=2.07; SD=0.91) was the least rated. This shows that teachers lowly rate use of multiple choice questions as a strategy of imparting inquiry skills on learners. Consequently multiple choice questions should not be utilised frequently for assessing inquiry skills.

About 87% of the respondents rated the item: "I involve learners with physics experiments with known outcomes" as important and very important. This may portray the physics teachers' narrow conception of inquiry-based skills classroom activities. This finding is consistent with Chabalengula and Mumba (2012), who suggest that teachers focusing more on learners undertaking confirmatory experiments are operating on low levels of inquiry. Teachers need to engage learners more in high order inquiry skills to enhance effective learning of physics and enhance better understanding of Physics concepts by the learners.

The data from the interviews corroborated the findings from the survey by entrenching the perception that very little was being done in the schools with respect to inquiry physics teaching. The qualitative data was collated into emerging themes for analysis and discussion purposes. The dominant emerging themes were the limited time, assessment demands, lack of adequate infrastructure material resources and lack of teacher competencies in some inquiry-based teaching approaches. The limited time allotted to teaching and learning of physics is the first theme to be explored.

Limited time

Inquiry-based activities need both teachers and learners to invest time. This could be attained through availing learners opportunities to undertake the science inquiry related activities at their own pace and understanding. Content coverage is a peripheral issue. What is critical and relevant is effective conceptual and competencies development in the learners. The following sentiments from some of the respondents may give the impression of the prevailing scenario in the Zimbabwean high schools with regards to time management and utilisation.

"Time is limited for learners to understand all concepts they need to go through. Ours is a day school, there are many activities and the time for teaching and learning is limited. We have a double session schooling system. So we have to rush through the syllabus", (Teacher, 8).

Time is the main constraint I would like to involve learners in conducting projects to promote better understanding of concepts, however this is not feasible in the given time frame. ", (Teacher, 15).

"Time is not on my side to use inquiry based teaching methods, the syllabus is too long. I need to adequately prepare learners for the public examinations so; I mainly

resort to the lecture method. My headmaster and parents are interested in good grades learners obtain in the final examinations, which is what critical to me and the community", (Teacher, 10).

From the teachers' responses it would appear that the teachers dedicate a large chunk of their time to preparing learners for public examinations. This distracts their focus from being creative, innovative and planning interesting and enriching learning experiences for the learners. This finding is consistent with Buabeng (2015) and the Ministry of Primary and Secondary Education, (2015) who project that in examination driven education system teachers spend a large chunk of their time preparing learners for public examinations. This is detrimental to planning and facilitation of relevant and credible learning activities that promote understanding of concepts by learners. There is need for reality definers to demystify the essence of public examinations and focus more on continuous assessment to promote interactive learning.

The school master-timetable in most school centres visited indicated that physics was allocated 10 lessons per week each lasting a maximum for 35 minutes. Of these seven lessons were for theory and three for practical work activities. The syllabus document stipulates that physics should be allocated a minimum of 12 lessons per week each lasting 35 minutes, eight for theory and four for practical work activities. From this it can be argued that the majority of the schools are operating below the minimum expected standards time allocation specified for the Advanced Level Physics teaching and learning activities. This is mainly attributed to timetabling issues and manpower shortage in the school systems.

Assessment

The manner in which learners are evaluated at the end of the course and their performance in public examinations is paramount. Teachers are judged by the performance of their learners and their credibility is at stake. Consequently, teachers may be forced to work to meet their clients' and key stakeholders' expectations. Some of the interview respondents had the following to say:

"The assessment of the practical paper has a predictable pattern. Question 1 is always on oscillations; Question 2 on electricity and question 3 the design question is basically a theoretical question since it does not demand the carrying out of the design experiment", (Teacher, 4).

"We teach to complete the syllabus in time, so that the learners are prepared for the public examinations. The syllabus specifies continuous assessment, yet we are still to be advised on how this is going to be rolled out, (Teacher, 2).

"I heavily depend on my experience as an examiner. I assist in setting up questions for Advanced level physics main theory paper, which helps me in teaching theory to public examinations expectations and learners under my guidance pass very well in the public examinations,"(Teacher 10).

The above sentiments may indicate the teaching and learning is guided by public examinations rather that learner needs. Teachers are subjected to extreme pressure to cover the physics syllabus and produce good grades, so that learners can find their way into institutions of higher learning. The excessive pressure to cover the syllabus hampers the adoption of inquiry-based approaches in the physics classroom. This finding is consistent with findings by Buabeng (2015) and Ramnarian (2016) who suggest that teachers give precedence to covering content for assessment purposes at the expense of developing inquiry competencies in the learners. The practice promotes surface learning to the detriment of conceptual development processes, which is a drawback to efforts to enhance effective teaching and learning of physics using science inquiry-based approaches. This may be an indication that inquiry-based teaching propagated by the Physics syllabus is not consistent with the assessment criteria. Therefore, there may be need for curriculum designers to revisit the assessment criteria and align it with the anticipated inquiry- based teaching practices and competencies.

Synthesis of the above arguments may lead to the idea that some teachers are doing what works for them and for the education system. If the education system focuses on effective assessment of inquiry-based learning skills, the teachers would adapt accordingly. The prevailing environment may not be supporting the effective imparting of inquiry skills in the physics learners. The physics teachers may neglect planning for inquiry-based practical work activities in other areas of the physics syllabus that they consider not to be the focus of public examinations. This practice is a hindrance to the effective development and acquisition of physics concepts in the neglected areas. Such practices result in physics learners getting into tertiary institutions with serious misconceptions about the some aspects of the discipline.

Limited teacher competencies in some inquiry-based teaching approaches

Teacher competencies play a pivotal role in the planning and execution of their classroom responsibilities. Some of the respondents' sentiments below indicate teacher impediments with respect to some of the suggested teaching approaches that would support the development and acquisition of learner inquiry competencies.

"I am not well versed with the project based learning method. It was never exposed to it as I went through my academic and professional journey. I wish they could make project based learning part of teacher education teaching methods in the faculties of education," (Teacher 15)

"I have limited knowledge on Project based learning and design based learning. Hence, I am not comfortable to use them regularly with my physics classes," (Teacher 17).

A closer look at the above responses show that some of the teachers are not quite conversant with the project based learning and design based learning. Some of the physics teachers may not have encountered these teaching methods during the learning, hence they may find it problematic to employ them in their classroom engagement with the learners. This finding is consistent with, Anderson, (2002), Capps and Crawford, (2013) and Fernandez, (2017) who suggested that some of the science teachers lack the competencies to implement inquiry based learning approaches. Such teachers need to be capacitated through staff development workshops so that learners are not short-changed in the science classrooms as far as development of inquiry competencies are concerned.

Material resources

The issue of both human and material resources was among the topical concern raised as an enabler in the effective execution of inquiry- based learning . Some of the sentiments put forward by the teachers painted a gloomy picture of the situation that is currently prevailing in the Zimbabwean high schools with respect to human and material resources. The following responses from some of the respondents serve to illustrate their concerns.

"Planning for learners to do own experiments is very difficult due to limited material resources. The school only buys new equipment for public examinations. Hence, most of the experiments learners undertake during class activities are based on past examined concepts since equipment are available," (Teacher, 10).

"I Have an upper six class of 40 learners. The laboratory space has 20 work stations, so I have to organise two sessions for practical work for the class every week. Worse still I am the only physics teacher at our school., I also have a lower sixth class and two ordinary level physics classes. Hence, there is very limited room for learners to plan and conduct own experiments, since I can hardly avail myself to supervise and guide them,"(Teacher,12).

From the above sentiments one can deduce that the schools are not investing adequate financial resources to source for infrastructure and equipment for the conduct of effective and relevant practical activities. Without the requisite equipment in the science laboratories then very limited inquiry-based science learning can be anticipated. It is also disgusting to note that some of the teachers had excessive workloads to such an extent that effective and relevant science teaching for learner concept and scientific skills development is not sustainable. This situation does not augur well for effective scientific concepts development in the learners.

Lesson delivery

Of the twenty lessons observed a dominant practice emerged that was characterised by the following steps:

- Review of previous lesson through teacher asking questions
- Teacher explains new concept
- Teacher demonstrates application of a new concept
- Teacher uses demonstration experiment to illustrate new concept (used in very limited cases; 5%)
- Learners given problems to solve in pairs
- Class discussion
- Individual work
- Teacher wraps up the lesson through asking learners questions on concepts covered
- Follow up task given to the learners
- For the practical activities lessons observed learners conducted guided experiments individually

The classroom practices are repetitive and lack creativity. The teaching and learning scenarios are rooted in teacher-centred, transmissive pedagogy, devoid of experimentation and tended not to promote inquiry-based science teaching. The practical activities were employed to confirm to theoretical concepts that had been covered that week. This reelects little focus on scientific practices that produce reliable and credible scientific knowledge. This practice is inconsistent with the Ministry of Primary and Secondary Education, (2015) and NRC (2012) who propose that science classroom practices should be pragmatic and learner-centred. Learner autonomy, interaction and engagement are seriously compromised. This situation undermines effective learner development and understanding of physics concepts. The teachers need to be assisted to migrate to the learner-centred approaches through continuous professional development and reflective practice.

Analysis of physics practical questions

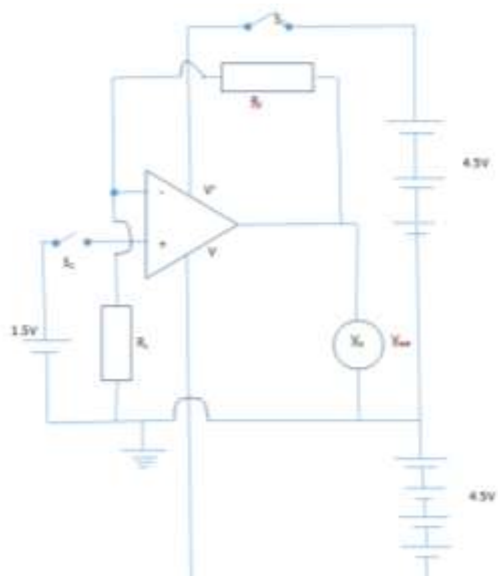
Based on the November 2010 to November 2018 Paper 4 examinations questions that were analysed, it was established that question 1 and question 2 were guided experimental questions mainly on electricity and oscillations and question 3 a design question from any section of the syllabus. Question 1 and 2 each carry 18 marks and are to be done in an hour each. While question 3, should be completed in half an hour accounting for 14 marks. The design question is weighted less than the other two questions and the learner can pass the practical examination without having attempted the design question. This scenario may cause teachers and learners to undermine the design practical work activities. This may have serious repercussions on teachers affording learners opportunities to undertake open inquiry activities. Such practice curtail learners opportunities to design own experiments and to construct own knowledge based on their undertakings.

Analysis of the Physics Paper 4 (6032/4) design question

One design question was scrutinised to give an idea of its skills demands and expectations. The November 2018 paper 4 design question guides the learner that: Damping is a major factor that is considered when designing shock absorbers. It is suggested that the degree of damping depends on, among other factors. (a) viscosity of the hydraulic fluid (b) temperature of fluid and (c) cross sectional area of the vibrating fluid. The learner is tasked to design a laboratory experiment that can be used to investigate how damping depends on the above factors. In the design, the learner is advised to pay particular attention to: (a) arrangement of apparatus (b) the control variables and (c) the procedure to be followed. One can deduce that the candidate is expected to define the problem, know how instruments are appropriately used, have an idea of the procedure, apply concepts in a new environment and provide a solution. So in some way the design question is basically rooted in theoretical knowledge since the learner does not execute the plan. This finding is inconsistent with the Ministry of Primary and Secondary Education; (2015:53) who project that learners "will be assessed on their practical skills rather than their knowledge of theory". Overall the question is limited in terms of testing for high order inquiry skills, which may restrict physics teachers to focus their thrust and energies on low order inquiry skills at the expense of higher order inquiry skills. Hence, the demands of the design practical questions in the public examinations could be contributing to the way teachers plan and execute design practical activities in the Physics classrooms. This could be compounded by the realization that the physics syllabus does not prescribe the scope and depth of the design based learning experiences. The physics syllabus also lacks scope and depth of anticipated inquiry activities and how to enact design based inquiry teaching and learning.

Analysis of the Physics Paper 4 (6032/4) guided experiment question

A guided experiment from the November 2018 paper 4, question 2 was analysed for its demands and expectations. The question based on electronics required the learners to investigate the voltage output (V_{out}) with feedback resistor, (R_f) of a non-inverting amplifier with negative feedback. A circuit diagram was given to the learners to set up. The circuit diagram is shown in Figure 1.



The learners were instructed to set up the circuit and follow the instructions below:

(a) (i) With R_f = 150 Ω, close S_1 and S_2, measure and record the output voltage, V_{out}.
(b) (ii) Determine uncertainty in measurement of V_o.
(iii) Repeat **b (i)** with R_f in the range $150 \leq R_f \leq 900\ \Omega$ for seven further sets of measurements of R_f and V_{out}.
(c) (i) Plot a graph of V_{out} (y-axis) against R_f (x-axis).
(ii) Determine the gradient at R_f = 600 Ω.
It is suspected that the gradient G is related to V_{in}, R_f and R_x by the equation,

$$G = V_{in}\left(\frac{1}{R_f} + \frac{1}{R_X}\right),$$

(iii) Use the graph to determine the value of R_x.
(iv) Justify the number of significant figures quoted for R_x.
(v) State the significance of the gradient.
(vi) Calculate the absolute error in the gradient.

The question expects the learner to follow instructions, use apparatus effectively, take measurements, record measurements, manipulate, interpret and analyse data and draw inferences. On the whole one can conclude that some of the demands of the practical assessment paper are consistent with the demands and expectations of the Advanced Level physics syllabus (Ministry of Primary and Secondary Education. 2015) with respect to carrying out the experiment, making measurements, interpreting data and making inferences.. However, these demands fall short of the high order inquiry skills as stipulated by the Ministry of Primary and Secondary Education,(2017) and NRC, (2012).Theses authorities suggest that activities like evaluating the method and quality of data, good design features, constructing explanations and suggesting improvements may foster higher order inquiry skills. Such activities have been proven to enhance science concepts development in learners. The Zimbabwe Examinations Council need to revisit the assessment criteria and address this gap to make the Physics practical public examination more responsive to higher order inquiry skills. Failure which teachers may continue to focus on the low order inquiry-based practical competencies undermining effective concept development and intellectual growth of the learners.

Analysis of the practical assessment question papers

An analysis of the 18 questions from the practical paper (6032/4) from 2010 to 2018, revealed that 12 questions were found to be structured inquiry and verification inquiry. The other six questions were focused on guided inquiry. The Table 3 shows the distribution of examination practical questions focus areas from November 2010 to November 2018.

Table 2. The practical paper question focus topics analysis from 2010 to 2018

Year	Question 1	Question 2	Question 3
Nov 2010	Modern Physics	Electricity	Electricity
Nov 2011	Oscillations	Electricity	Newtonian

			Mechanics
Nov 2012	Oscillations	Electricity	Electricity
Nov 2013	Oscillations	Electricity	Modern Physics
Nov 2014	Oscillations	Electricity	Oscillations
Nov 2015	Oscillations	Electricity	Modern Physics
Nov 2016	Matter	Electronics	Electricity
Nov 2017	Oscillations	Electricity	Electricity
Nov 2018	Oscillations	Electronics	Oscillations

From Table 2 it can be concluded that question 1 is mainly based on oscillations (77.8%) question 2 on electricity (77.8%) and question 3 has 44.4% of the questions based on electricity with very limited diversity. This scenario creates room for teachers to easily predict and focus on the type of practical work concepts that are likely to be in the practical examinations and the requisite skills for learners to do well in the examinations. The predicament to this scenario is that the teachers may decide to focus on specific inquiry skills that are pertinent to the public examinations demands and ignore others, particularly higher order inquiry skills likely not to be examined. Alternatively the teachers may just concentrate on practical work activities on those topical areas on which are most likely to be targeting in the public examinations at the expense of other topics. Such situations hinder the effective teaching of scientific competencies development which would make learners more competitive in the knowledge economy.

However, the harmonisation in inquiry skills emphasised in the physics syllabus, the examinations and the teachers' schemes of work may well be a fascinating attribute as it guarantees syllabus validity. At least the basic inquiry instruction practices are being observed though a lot more is expected from the teachers to engage learners in a wide range of practical work activities taking on board higher order inquiry skills. It is anticipated that the teachers would challenge the learners to design and undertake their own practical work activities, reflect on the quality of the design and method , gather data, interrogate it and make adjustments to the design. Such a development would enhance learner conceptualisation of physics concepts and form an excellent grounding for the pursuit of physics-dependent disciplines in higher education institutions.

Analysis of schemes of work

The 30 teachers' schemes of work were analysed to determine the teaching approaches they employ to enhance inquiry skills in the learners. The schemes of work had been stamped by school authorities for authenticity and were for the third term of 2018. In the majority of cases the learning and teaching approaches were repetitive, an indication of lack of seriousness on the part of the practitioners. Prominent among which were, lecturing, Problem based learning and Individual and group work. Creativity and innovation was glaring lacking. The seven teaching instructional methods that fixture prominently from the activities section are shown in Table 3.

Table 3: Distribution of the physics teachers' methods and frequencies

lecture method	frequency	Percentage (%)
Transmission method	170	38.6
Problem based learning	104	23.6
Individual & group work	90	20.5
Planned experiments	50	11.4
Design based learning	20	4.5
Project based learning	6	1.4

The lecture method (38.6%) is the teaching method that is used most by the physics teachers. This is despite overwhelming evidence pointing to the fact that the lecture method is the least effective on imparting inquiry-based learning competencies (Tesfaye & White 2012). The least employed instructional strategy is project based learning with a paltry, (1.4%).This could be an indication that the teachers are not conversant with the teaching strategy. Design based learning is also seldom employed by the physics teachers accounting for only (4.5%). The teaching approaches regularly used by the teachers indicate dominance of the teachers in the learning activities in the classroom serious undermining learner autonomy. This finding is consistent with Buabeng (2015), who established that learners were subjected to very few opportunities to plan and conduct their own classroom activities. The teaching model employed by the majority of the teachers is inconsistent with the Ministry of Primary and Secondary Education, (2015) who advocated for learner-centred teaching approach. This scenario does not augur well for pragmatic teaching and learning of physics inquiry skills and the development of the competitive scientific process skills in learners.

The survey findings suggest teachers are aware of inquiry-based science teaching approaches yet findings from the interviews, lesson observations and document analysis depict low inquiry-based physics public examination assessment demands and classroom practices. The low inquiry-based physics teacher practices could be attributed to limited teacher competencies, public examinations practical examinations assessment demands, lack of material resources and limited time to cover the syllabus. If school authorities invest in material resources and public practical examinations assessment demands could focus more on higher order inquiry-based skills, the teachers would react accordingly.

IV. CONCLUSIONS

The physics teachers value inquiry-based instruction but are utilising it in their classroom to a very limited extent. Mere appreciation without value addition to learning and teaching practices does not benefit the learner. The physics teachers are still stuck with the teacher-centre teaching and learning paradigm. This is tantamount to promoting low learners outcomes. The school authorities are not allocating the appropriate stipulated time for the effective teaching of the physics content due to timetabling and human capital issues compromising teaching and learning. School authorities are not respecting the physics syllabus specification with respect to time allocation which is detrimental to the effective teaching of the subject. The predominantly summative evaluation system currently employed by the reality definers does not support inquiry-based learning. The engagement of teachers as item writers for public examinations compromises the effective teaching of scientific concepts and competencies to the learners in the schools. Continuous assessment has not been taken on board by the Zimbabwe Secondary Education system despite the fact that it is well specified in the current syllabi. Last, but not least the physics teacher's maybe lacking key competencies that are essential for the effective implementation of inquiry-based learning for credible and appropriate scientific processes and competencies development.

Recommendations

In view of the study findings the following recommendations are proffered:

- The physics teachers may need to be capacitated with respect to higher order inquiry-based science learning demands and competencies and learner-centred teaching approaches.
- The curriculum designers may need to align the Advanced Level physics syllabus content, instructional methods and assessment criteria to revitalize inquiry-based science instruction quality and relevance.
- The Ministry of Primary and Secondary Education should enact a specific continuous assessment policy.
- The Zimbabwe Schools Examination Council should engage full time item writers so that it does not compromise quality of teaching and learning in the schools through hiring teachers for this exercise
- School authorities need to create conducive environments for the effective teaching of physics through conforming to the stipulated appropriate time allocations for content coverage and investing in material resources to enhance tangible and sustainable development of inquiry competencies in the learners.

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