Zimbabwe Journal of Educational Research (ZJER), Volume 33, Number 3, November 2021
ISSN: 1013-3445
E-mail: hrrc@education.ac.zw

An Assessment of the Alignment of Curricula Operating in the Same Context: A Case Study of Ordinary and Advanced Biology Practical Work in Zimbabwe

[1]Joe Phaeton Mukaro, [2]R. Chivheya & [3]Fenton Ruparanganda
[1]University of Zimbabwe [2]Bindura University of Science Education [3]University of Zimbabwe

Abstract

The research endeavoured to establish the link between two curricula for biology practical work. This was meant to ascertain the adequacy of the Ordinary Level practical work curriculum as it relates to Advanced Level Biology practical work curriculum. A document analysis of both O and A level biology curricula was done. Content was analyzed for science process skills based on Padilla's 1990 classification of science process skills. The examination papers for both O and A level biology for the year 2019 were analysed for the science process skills examined. Frequencies of the skills were established. Four teachers participated in the research as they provided their views and beliefs about the relationship between the two curricula with regards to science process skills. Findings showed that whilst the curriculum statement for both O and A level biology seem to relate, the examination system and the teacher belief system regarding science process skills development could not consolidate that relationship. The examination system must address what the curriculum statement advocates so as to achieve the intended objectives. Likewise, teachers need to understand and appreciate the curriculum before they can implement it.

Introduction

Zimbabwe has undergone a system wide curriculum reform with regards to both primary and secondary education. This reform has been necessitated by the growing need to transform and grow the economy. In line with Zimbabwe Government Vision 2030, the economy is expected to grow to the middle-income level. This vision therefore, calls for proper human capital base as well as industrial capacity building that would meet the intended endeavours. The previous curricula did not address anticipated skills for this purpose as it had its thrust in theory and less practice. It was therefore paramount for the tasked ministry to initiate this curriculum review process. However, in designing the curriculum it is important to consider how curricula of different levels speak to each other.

Researchers argue that curriculum alignment is a measure of successful implementation (Herman & Webb, 2007; Knapp, 1997; Smith & O'Day, 1991). If gaps exist between curriculum elements results are that there will be a poor instructional policy that makes it difficult for teachers to interpret and implement the curriculum demands (Fuhrman, 1993). Herman and Webb (2007) are of the view that the alignment of the curriculum components helps to produce clear guidance to teachers with regard to the intentions of curriculum planners. Within a curriculum a number of levels may be distinguished. While the alignment of these levels within a curriculum is important, alignment between curricula which operate in the same context is also important. In this research, the focus is on establishing the adequacy of the ordinary level practical work curriculum as it relates to advanced level biology practical work curriculum.

Bennett (2019); Lazonder & Harmsen (2016) as well as Fensham, Gunstone and White (2013) argue that practical work is central to the teaching and learning of science. Similarly, Toplis and Allen (2012) and Kibirige, Osodo, and Mgiba (2014) as well as Lau & Lam (2017) view practical work in science as a key and integral component of the teaching and learning of Science and science related desciplines. Notwithstanding the value given to practical work in science, some researchers in the field are of the view that practical work has to be viewed cautiously as it is a complex process (Abrahams, 2009, Bennett (2019), Donnelly, O'Reily & McGarr, 2013). Other researchers such as Abrahams and Millar (2008) and Millar (2004) regard practical work as one such important tool that can be instrumental in the teaching and learning process. It is therefore regarded as central role in the teaching and learning of Science. However, when used in the teaching and learning within the school system practical work should be viewed as not intended to make new discoveries but rather to enhance the teaching and learning of science concepts (Millar, 2004).

Lau & Lam (2017), Hofstein and Lunetta (2004), purport that practical activities have also been seen to influence the learners' understanding of the nature of Science. It is further argued that through practical work scientific literacy can be developed in learners (Laugksch, 2000). One view of practical work in Science is that it promotes scientific inquiry which is directed at developing the abilities of learners to conduct scientific investigations (The National Research Council of the United States {NRC}, 2000). Practical work should therefore involve teaching and learning strategies that enable learners to master science concepts, hence increasing science literacy and skills development. Kasanda et al (2003) are of the opinion that practical work serves to teach both the content and the method of Science.

Lau & Lam (2017), Haslam and Hamilton (2010) and Abrahams (2010) concur that practical work can develop not only manipulative skills but promotes higher level transferable skills such as observing, measuring, predicting and inference. These transferable skills are valuable for the general utility in life: they are lifelong skills which the learners can use to solve every day problems (Molefe & Stears, 2014). Furthermore, researchers (Abrahams & Reiss, Bennett (2019), 2010; Haslam & Hamilton 2010; Lunetta, Hofstein & Clough, 2007) have shown that the 'hands-on' and 'minds-on' activities in school science are quite effective in making learners acquire both cognitive and manipulative skills inside and outside the laboratory. However, research has acknowledged that although learners can gain experimental skills from laboratory classes they do not always have enjoyable experiences and that laboratory activities do not always contribute to their conceptual understanding of Science.

The importance of practical work alluded to in the literature, cannot be underestimated and there is need to pay close attention to the learning of science as a process. Practical work should involve the acquisition of SPS, tools with which Science may be learnt (Molefe & Stears, 2014). Hence learning has ceased to be viewed as a standard process but as a personalised process involving the development of process skills (Chen, Dorn, Krawitz, Lim, & Mourshed (2017), Akinoglu & Tandogan, 2007). One of the domains critical for the development of scientific literacy is SPS (Ongowo & Indoshi, 2013; Mukaro & Stears, 2016). When learners interact with the world in a scientific way, they find themselves using SPS, and this assists in the development of science concepts (AAAS, 2001).
Several researchers have attempted to describe the roles SPS have in the teaching of Science. Padilla views SPS as both the manipulative and critical thinking skills which are used to explain the natural world. Ogunniyi and Mikalsen (2004) and Bilgin (2006) hold the opinion that SPS are the craftsmanship of doing Science which for me implies the competencies required to 'do Science'. This implies that learners will need a wide variety of SPS in order to learn and understand science concepts as confirmed by Chen et al., (2017), Chiappetta and Adams (2004) and Rambuda and Fraser (2004). Researchers such as Akinbobola and Afolabi (2010); Harlen and Gardner (2010) and Rezba et al., (2007) view SPS as central in the teaching and learning of Science. SPS differ in their complexities and it is vital that appropriate SPS be used to enable the learner to achieve the intended objective of the learning process. Akinbobola and Afolabi (2010) posit that SPS are cognitive and psychomotor skills employed in problem solving, problem identification, data gathering,

interpretation and communication of science information. For Ozgelen (2012), SPS are thinking skills that scientists use to construct knowledge in order to solve problems and formulate results. Implicit in these views about SPS is that they are integral and natural to a scientist as they are instruments for the generation of scientific knowledge (Chen et al., 2017, Ongowo & Indoshi, 2013).

There are various views on how SPS may be grouped. For Donmez and Azizoglu (2010) and Farsakoglu, Sahin, Karsli, Akpinar and Ultay (2008) three categories exist for SPS. However, other scholars such as Lumbantobing (2004) are of the opinion that two categories exists, namely, basic SPS and integrated SPS. This grouping coincides with Padilla's (1990) categorisation of SPS. The American Association for the Advancement of Science [AAAS] (1993) has identified SPS as observing, measuring, classifying, communicating, predicting, inferring, using numbers, using space/time relationships, questioning, controlling variables, hypothesising, defining operationally, formulating models, designing experiments and interpreting data. Padilla (1990) has identified similar SPS as described by AAAS (1993) although his differ slightly. Padilla (1990) viewed basic SPS as those simple SPS which form the foundation for studying more complex SPS (integrated). The basic SPS are implied in the integrated (complex) SPS (Mukaro & Stears, 2016). A good foundation in the basic SPS therefore makes the acquisition of integrated SPS easier for learners.

The understanding of the basic SPS helps learners obtain concrete scientific evidence which they can use to resolve more complex problems, hence promoting concrete operational reasoning as advocated by Piaget (1973). The basic SPS include observing, measuring, inferring, classifying, predicting and communicating. Rambuda and Fraser (2004) view the integrated SPS as immediate skills used in doing experiments or problem solving. They combine several basic SPS for the purpose of increasing expertise and greater flexibility in designing experiments and experimental activities. However, Hodson (1991), Jerrim, Oliver, & Sims, (2019) and Osborne and Dillon (2008) view practical work as wrongly conceived and used in the teaching and learning of Science. In our view, if teachers are aware of the role that practical work plays in the teaching and learning of Science they would select appropriate activities that would enable learners to acquire SPS that would enhance their understanding of science concepts.

Purpose of study

Both the new advanced level and ordinary level biology curricula statements place great emphasis on a practical and contextual approach (Ministry of Primary and Secondary Education, MoPSE, 2017-2022). Learning of Science requires the acquisition of skills through the scientific method. Candidates are expected to be familiar with a certain set of science process skills (SPS) for each level. Candidates following the A-level biology curriculum are expected to have completed O-Level Biology and learners are expected to demonstrate a high competence level in both simple and integrated SPS. However, the previous curricula for biology presented discrepancies with regard to skills development and acquisition between the two levels of biology learning arising from the then policy statement by the Education Ministry (Mukaro and Stears, 2016). While the A-level curriculum statement advanced the need for skills development founded on a strong grounding in O-level biology, policy allowed for a weak skills base at O-Level. The policy had provision for alternative to practical work which seriously compromised science process skills development in learners (Mukaro & Stears, 2016; Jerrim, Oliver, & Sims, 2019). It is against this back ground that this research sought to find out if the new curricula statements for both O and A-level biology speak to each other in terms of science process skills development and acquisition.

The purpose of this research therefore was to establish the nature of the relationship between the O and A-Level curriculum regarding practical work by interrogating the way SPS are covered in both curricula. We wished to understand what the expectations of both curricula are with regard to the acquisition of SPS. The study of the expectations of both curricula with regard to SPS provided some understanding of how the two curricula speak to each other in terms of SPS, and hence enabled us to assess the relationship between the two curricula with regards to SPS. The research therefore sought to address the following questions:

- What science process skills does the new O-level biology curriculum consider as important in the teaching and learning of biology practical work?
- What science process skills does the new A-level biology curriculum consider as important in the teaching and learning of biology practical work?
- Does the O-level biology curriculum provide a good foundation for studying practical work in A-level biology?

Framework

The research is informed by the categories of science process skills as defined by Padilla (1990). These categories are supported by Coil et al.'s (2010) and NRC (2004) understanding of SPS. Padilla (1990) defines SPS as tools scientists use to study Science. Padilla categorizes SPS into basic and integrated SPS. The integrated SPS are complex skills which embed the basic SPS. Practical work in Science requires a clear understanding of the SPS. Therefore, in order to learn the integrated SPS there is need for the learner to have a strong foundation of the basic SPS. Figure 1 shows the classification of SPS based on Padilla (1990), Coil et al.'s (2010) and NRC (2004).

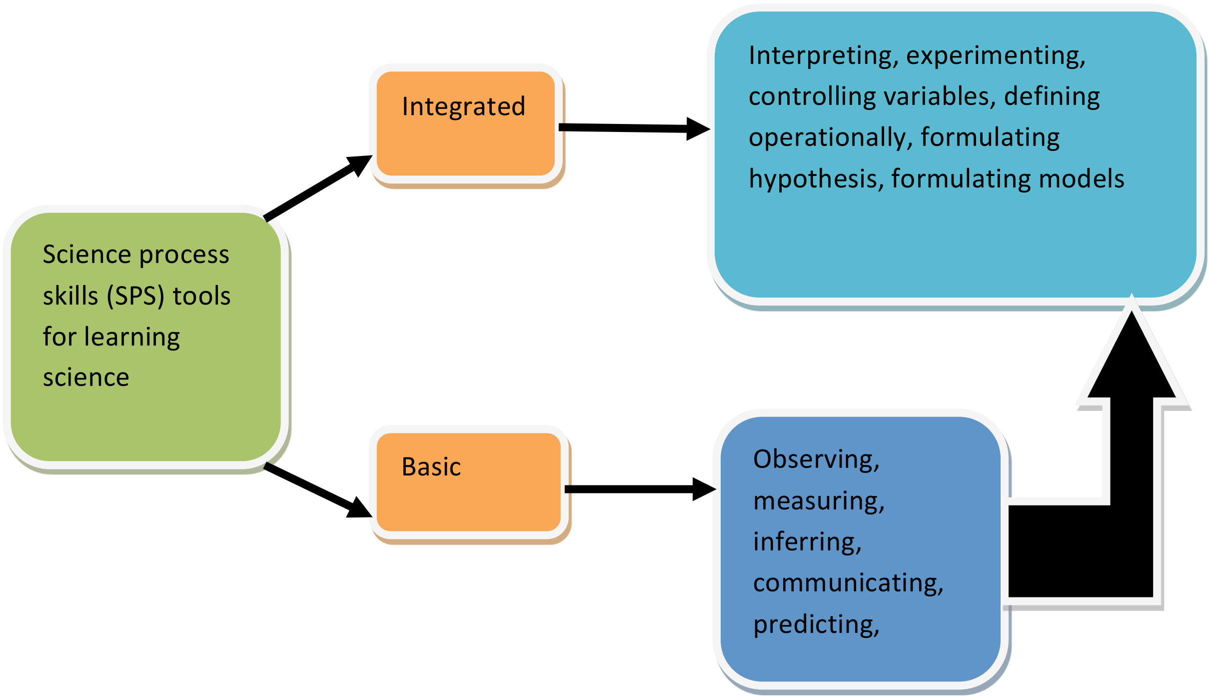

Figure 1: Adapted from Molefe and Stears(2014)

Methodology

This qualitative study is located within an interpretive paradigm as the purpose was to understand the nature of the relationship between the O and A-Level Biology curriculum with respect SPS in practical work.

Our method of data collection was document analysis and interview of the biology teachers for both O and A levels. Both the O and A-Level Biology syllabi as well as examination papers for practical work were analysed in order to understand the kind of SPS learners were expected to acquire at both levels of learning. Four Biology teachers for both O and A level Biology were interviewed in order to gain an understanding of how the two intended curricula linked with each other with regard to SPS for practical work.

The conceptual framework guided the development of a document analysis instrument and interview questions. The different SPS and their categories as classified by Padilla (1990) were used to determine the degree to which SPS development is advocated by the O and A-level curricula respectively. It also served to assist in the analysis of the examination papers.

We analysed the relevant documents to determine which SPS were found at each level of the learning as dictated by the syllabus topic content as well as the examination questions for practical work for both O and A-Level Biology. We found document analysis appropriate in this context in that data needed to be examined and interpreted in order to gain meaning, understanding and develop empirical knowledge as viewed by Bowen(2009) and Corbin and Strauss (2008; 2014). We required a systematic procedure for reviewing and evaluating the two curricula in order to gain insight into the nature of SPS expected to be learnt at each level. By examining information collected through different curricula we were able to compare the findings across data sets. A content analysis approach of the both the A-level and O-Level Biology Curriculum was employed for a better understanding of the link between the two phases of education with regards to the expected practical work to be implemented.

In this research the official curriculum documents from the Ministry of Primary and Secondary Education were analysed with the view to understand what the teachers needed to consider in implementing the curriculum. The documents included the new curriculum statement in the form of the national syllabus for A-level biology and the national examination papers for A-level practical work in Biology for the past four years. The national syllabus for O-Level Biology served to depict the intended curriculum for O-Level Biology which served as the foundation for A-level studies in Biology. SPS were used as a measure for content analysis of all the documents pertaining to practical work in both O and A-level Biology practical work. These documents provided an insight into what the intended curriculum expected for practical work in Biology. The data gathered contributed to answering the first and second research questions. Critical review of the data gathered for both O and A-level curricula helped to answer the third research question.

Findings

Objectives for O-level biology practical work

The objectives for practical work examinations consider both the minds-on and hands-on activities. This is a practical work paper where learners are expected to select and purposefully manipulate apparatus and equipment in order to achieve the set objective. The objectives for this paper define the specific SPS that the learner needs to acquaint him/ her with in order to achieve the demands of the curriculum. The objectives for practical work in Table 1 show that emphasis is placed on such SPS as observing, measuring, communicating, predicting, inferring, classifying (basic SPS) and some integrated SPS such as experimenting and defining operationally.

Table 1: Objectives and SPS for O-Level Biology practical examinations (MoPSE 2015-22)

Objectives for Practical Work	Science process skills(SPS)
Performing simple calculations	Measuring, defining operationally
Making clear, labeled, line drawings	Communicating, observing, measuring
Describing tests for foods, water, carbon dioxide and oxygen, pH and/or draw conclusions from tests	Communicating, predicting, measuring, controlling variables, experimenting, defining operationally, inferring
Using familiar and unfamiliar techniques to record their observations and make deductions from them	Communicating, observing, predicting, interpreting data, inferring
Recognising and observing features of familiar and unfamiliar biological specimens recording the observations and making deductions about functions of whole specimens or their parts	Observing, communicating, interpreting data
Interpreting unfamiliar data and drawing conclusions	Observing, interpreting, communicating, Predicting, inferring

Recording readings from diagrams and drawing conclusions	Communicating, predicting, inferring
Describing, explaining, analysing or suggesting experimental arrangements, techniques and procedures	Communicating, interpreting, experimenting, controlling variables, inferring, formulating hypothesis
Interpreting, drawing conclusions from and evaluating experimental data, including graphical data	data, inferring, formulating hypothesis

Considering the objectives shown in Table 1 it is necessary that learners have basic knowledge of Biochemistry and basic Mathematics. Recognition of decimals, simple measurements, calculations of ratios and percentages, representation of information through graphs and their interpretations, marking approximations and estimates are some of the important SPS required.

In A-level biology examinations learners are expected to show evidence of knowledge of broad practical skills of planning, implementing, interpreting and concluding observations (MOPSE, 2015-22). These are broad practical skills which encompass both integrated and basic SPS. The broad skills require that learners to be conversant with the use of laboratory equipment and apparatus such as the hand lens and the use of the microscope to make important observations. Table 2 shows the objectives for the three broad skills

Table 2: Broad Practical Skills examined in A-Level Biology

Planning	Implementing	Interpreting and Concluding
Designing practical activities, assembling respective apparatus and materials.	(a) Carrying out experimental work in a methodical and organised way with due regard for safety and living organisms. (b) Using apparatus and materials in an appropriate way. (c) Making and recording: (i) Accurate and detailed observations including low power and high power drawings of a specimen. (ii) Measurements to the appropriate degree of precision allowed by the apparatus.	(a) Assessing the reliability and accuracy of experimental data and techniques by identifying and assessing errors. (b) Applying knowledge to explain and interpret experimental results to reach valid conclusions. (c) Communicating information, results and ideas in clear and appropriate ways, including tabulation, line graphs and continuous prose.

Table 2 shows that A-level learners are expected to develop a systematic way of doing practical work in Biology. This systematic way involves the skills of planning practical work in such a way that the planned practical work is implementable using the various SPS (basic and integrated). Learners are expected to interpret the findings they obtain from the experimental procedures they perform. These broad skills fundamentally require that learners develop competence in the use of SPS in trying to meet the demands of the curriculum. The underlined phrases or words in Table 2 have SPS implied in them. Both basic and integrated SPS are implied in the scheme (i.e. Observing, measuring, predicting, inferring and communicating (basic) as well as experimenting, defining operationally, interpreting and formulating models (integrated).

National examinations and practical work in 'O' and 'A' level biology

The practical examinations are regarded as part of the intended curriculum as the examiner follows the curriculum requirements closely when setting practical examinations. Practical work is examined both as a component of the final examination as well as continuous assessment (formative evaluation). The continuous practical assessment has a weighted average of 10% whilst the final practical examination has a weighted average of 20% for O level biology. In the A level assessment scheme, continuous practical work assessment constitutes 10% by weight whereas practical examination has a weighted average of 14%. In the final examination candidates for both O and A level are expected to answer three compulsory questions which involve knowledge of Biochemistry, Physiology and biological processes. The distribution of marks throughout the respective papers varies from year to year. The allocation of time per question also varies from year to year following the expected demands of the questions.

Examiners set questions in form of instructional procedures and candidates are expected to interpret, implement and draw conclusions from the results obtained. Implied in the procedures are various SPS which candidates are expected to perceive as they undertake the examination tasks and these skills range from basic SPS to integrated SPS. The questions have blank spaces in which the candidate is expected to fill in answers based on the results of the experimental procedure. The mark next to the question informs the candidate of the value given to the question (MOPSE, 2015-2022).

Practical examination question one

The first question is usually a biochemistry question involving either a food test or enzyme activity. The questions are based mostly on investigative processes (MOPSE, 2015). The procedures in the questions require the candidates to apply manipulative skills as well as investigative skills. The major SPS identified in Question One for the year 2019 for both levels are shown in the Table 3. Frequency referred to the number of times a specific SPS was considered within the practical work question, i.e how many times a particular SPS is implied in the question.

Table 3: SPS in practical examination question one

Science Process Skills in the 2019 in both O and A level examinations	Frequency in O level examination	Frequency in A level examination
Observing	17	46
Communicating	18	35
Measuring	8	23
Predicting	0	10
Inferring	1	27
Experimenting	2	10
Controlling variables	2	16
Defining operationally	0	9
Formulating hypothesis	0	9

The same SPS were examined in Question One of the O and A-level biology practical examinations for the year 2019. The most prevalent SPS in the examinations for practical work in 2019 were observing, measuring, and communicating. Integrated SPS such as experimenting which encompass more SPS has low prevalence in O level biology practical examination paper. The presence of these SPS in the examinations is an indication of the importance of the skill to the examiners and by implication, curriculum designers (who provide instructions to supervisors on practical examinations), ascribe to these skills.

Practical examination question two

Question Two requires that learners carry investigative work either be based on Physiology, Genetics or Biochemistry (MOPSE, 2015-2022). Learners are required to carry out investigative processes or in some cases they are expected to do some formulation of models (Genetics). The number of times the SPS is implied in the question constitutes the frequencies entered in Table 4. The SPS identified in this question for both O and A-Level Biology practical examinations of 2019 are shown in the Table 4 below.

Table 4: SPS in practical examination question two

Science Process Skills in 2019 examination	Frequency in O level examination	Frequency in A level examination.
Communicating	31	63
Inferring	5	41
Measuring	11	26
Predicting	6	22
Observing	9	18
Experimenting	2	10
Controlling variables	0	9
Defining operationally	0	10
Formulating hypothesis	0	5

Similar SPS were examined in both O and A-level biology practical examination for 2019. Learners were required to apply process skills of inferring predicting, measuring and communicating information. Generally the basic process skills of observing, measuring, and communicating remain prevalent in the examination papers for practical work in both O and A-level Biology practical examination. Knowledge of basic mathematics and interpreting of the graphical information and good skills in handling laboratory equipment and materials are quite pronounced in all the examination papers (MOPSE, 2015-2022).

Practical examination question three

Both examination papers for practical work in O and A-level biology were analysed (2019) **Question Three** was on microscopy. The question involved tasks that required learners to have competence in making observations and communicating this observation in a pictorial form. Therefore, a variety of skills were required. Where the learner was required to make measurements the learner had to be conversant with the calibration technique which is one task directly linked to the learner's capacity to use a microscope. Understanding of the rules for producing a biological drawing was an important aspect of this question. The number of times the SPS is implied in the question constituted the frequencies entered in Table 5. Table 5, therefore, shows the different SPS that were identified in Question Three of the 2019 practical examinations.

Table 5: SPS in practical examination question three

SPS in 2019 examination	Frequency in O level examination	Frequency in A level examination
Observing	9	14
Classification	0	0
Communicating	7	18
Measuring	5	17

Observation, measurement and communicating were the required SPS in both O and A-level biology examinations for the years 2019. In this question a number of manipulative skills were required in order to achieve the intended objectives. Knowledge of and use of the microscope enabled the candidates to tackle the questions. The SPS of observing, measuring and communicating were quite prominent. The SPS communicating was demonstrated by recording what was observed through a drawing and labeling the important features as per demands of the question. Basic mathematics was shown through the calculations candidates were required to do in showing magnification of the drawings (MOPSE, 2019).

The handling of equipment and use of the microscope was important as well. Communication of the observations was done by use of labeled high power magnification drawings. Candidates were expected to have knowledge of the physiology and anatomy of the nervous system in animals so as to be able to answer the question. The SPS classification features in this question as well (MOPSE, 2019).

The SPS communicating was assessed through the production of plan drawings in practical examination. The skill of observation manifested throughout the question. Identification of important features of the structures and labeling was based on correct observation. The skill of measuring featured in the form of calculations that the candidates were required to make after calibration using a microscope. Conversion of measurements from one form to another was examined in this question, especially the calibration of the eyepiece graticule unit using the stage micrometer (MOPSE, 2019).

The SPS observing and communicating using annotations in plan drawings were important in this question in the practical examination for A level biology for the year 2019. Knowledge of the principles of producing a plan drawing and anatomy of the plant was vital. A good use of the microscope was a requirement for the candidates to achieve the expected objectives in this question (MOPSE, 2015-2022).

Teacher interviews on the new curricula for biology practical work

Four biology teachers teaching both O and A level biology (two females and two males) were purposefully selected for this study. The researchers wanted to gain a deep understanding of how the curriculum implementers viewed the curriculum in light of the science process skills. Teachers showed some reservation on the impact of the curriculum with regards to the attainment of the objectives of the curriculum. One teacher had this to say:

….there no difference between the old and new curricula statements and we are using the same styles of teaching as before……..except that there is too much work to do…. too much practical work, but we never do it as we do not have the resources and skills… no training on the new curriculum was done…we are not sure on what to cover and how…it seems we are tied up..alternative to practical in the old syllabus was better.

The above intercept reflects some worries teachers have regarding the interpretation and implementation of the new curriculum. Teachers expressed serious handicaps they have in linking the O and A-level practical work versus the teaching load. They too had practical skills deficit.

Discussion and conclusion

The findings pertaining to the new curriculum as revealed by the three sources discussed, gave both an insight into the strength and weaknesses of the curriculum components with regard to practical work, as well as their implications for curriculum implementation and achievement of the intended objectives of the curriculum.

The general aims of the new A-level biology curriculum have their foundation in the previous levels of education in Biology. The O-level biology curriculum stands as a foundation for progression to the A-level curriculum and the relationship between the two curricula depict a spiral character of the curriculum in a similar manner as presented by Ornstein and Hunkins (1993). The general aims and practical work objectives of both the new A and O-level curriculum statement exhibit commonalities in their design but differ in their depth to cater for the cognitive development of the learners, a notion shared by Ornstein and Hunkins (1993). This relationship between the two curricula has implications for curriculum implementation.

In the introductions of the curriculum documents the O-Level biology curriculum statement assumes that learning of O-level biology is based on the knowledge and skills gained at the junior certificate level. It is further assumed that the knowledge gained through the study of this course should enable learners to engage in further studies in Biology and other professions (MOPSE, 2015-2022). A similar notion is depicted in the A-level biology curriculum statement which views the foundation of the study of Biology at A-level as the knowledge and skills gained in O-level biology (MOPSE, 2015-2022). Abrahams and Reiss (2010; 2012), Millar (2004) as well as Mostafa, Echazarra, & Guillou, (2019) are of the strong view of linking theory with practice. The underlying intention here is that the learning of Biology should be viewed as taking place through transitional stages based on the cognitive development of the learner. Recognition of the transitional stages of the Biology curriculum has an important bearing on the nurturing of the learners' practical skills development in A-level biology.

Both curriculum documents place emphasis on application of scientific concepts, principles and skills. The designers of the curriculum advocate a practical and investigative approach in the teaching and learning of the subject in order to achieve the intended objectives (MoPSE, 2015; 2016). Abrahams and Miller (2008) and Goodrum and Rennie (2007) Mostafa et al., (2019) advocate for a simultaneous operation of the domain of observable and of ideas so as to ensure learning is achieved. Great emphasis is therefore, placed on practical work in order to achieve the intended objectives of the curriculum.

The O-Level curriculum is good in that is specifies exactly what the activities are and that it provides guidelines for the teachers. Both types of SPS are included, although not as complex as A-Level Biology. This corresponds with the views of Chen et al., (2017), Abrahams and Reiss (2010), Haslam and Hamilton (2010), Lunetta, Hofstein and Clough (2007) whose views are that 'hands-on' and 'minds-on' activities in school science effectively provide opportunities for learners to acquire both cognitive and manipulative skills. This implies that if the learner passes through O-Level Biology having acquired the necessary practical skills as dictated by the O-level curriculum statement, he/she will have a greater chance of mastering the challenges that come with the A-Level curriculum with respect to practical work. The opposite can also be true. Donmez and Azizoglu (2010) are of the view that teaching SPS especially is strongly linked to the transition from one level of cognitive development to the next.

In many of the A-level biology content topics the curriculum has practical skills implied in the general content outlines (MOPSE, 2015-2022). The ideal scenario is that the implied skills, if identified by the teacher maybe achieved through a variety of activities ranging from those that target the development of manipulative skills, improving understanding of a scientific phenomenon, development of scientific inquiry and those that target the development of transferable skills. This is in line with Godding, Smith, Patterson and Perry's (2013) views of the categories of practical work activities. Implicit in these practical activities are a whole range of SPS (basic and integrated) which learners are expected to use when carrying out practical work in the light of Padilla's (1990) categories of SPS. The intention is that the teacher should interpret the practical activities embedded in the curriculum statement in order to guarantee that learners acquire the expected practical skills initially intended by the curriculum designers.

Coherence between the O and A level biology curricula is vital as it guarantees continuity and development of skills in learners. The examination system is such that particular portions are always examined to the exclusion of the other parts of the curriculum. It was established that in every A-level biology examination **Question One** deals with Biochemistry, **Question Two** is on Physiology and **on** is Microscopy. This influences the teacher's and learners' views about how practical work should be organised and taught to learners.

Biology learning at advanced level has both basic and integrated SPS embedded in the content. The SPS assessed in the practical examinations were far less than those demanded by the curriculum. Findings from this research indicate that less SPS are examined in O-level biology, yet this constitute the foundation for A-level studies. This discrepancy between the demands of the curriculum and what was examined brought may influence the teachers' beliefs on the acquisition of SPS as they may tend to rely on those which appear in the examination papers.

An analysis of the Biology curricula for both O and A level revealed that while there is a direct link between the two curricula, they seem not to speak to each other with regards to the science process skills development. The designed curricula statements are very clear about the purported link between the two as they both advocate for skills development at each level. However, the examination system seems place emphasis on certain skills at the expense of others. This has implications for curriculum implementation by teachers. Teachers view the curriculum as extended and demanding. Teachers seem to reside in their old traditional instructional designs as they lack the skills in linking the curricula with regards to SPS. That teachers have to interpret the SPS embedded in the O level curriculum in preparation for A-level is eroded by the deficiency of practical skills as well as the belief system teachers have developed over time regarding interpretation and implementation. Statement of skills does not necessarily translate into correct interpretation and implementation. The two curricula give an outline of the skills but lack fine details of how these skills need to be implemented at each level.

References

Abrahams, I. (2009). Does practical work really motivate? A study of the affective value of practical work in secondary school science. *International Journal of Science Education*, *31*(17), 2335-2353.

Abrahams, I., & Reiss, M. J. (2012). Practical work: Its effectiveness in primary and secondary schools in England. *Journal of Research in Science Teaching*, *49*(8), 1035-1055.

Abrahams, I. & Reiss, M. J. (2010). Effective practical work in primary science: the role of empathy. *Primary Science*, 113, 26-27.

Akinbobola, A. O., & Afolabi, F. (2010). Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria‖. *American-Eurasian Journal of Scientific Research*, *5*(4), 234-240.

Akinoglu, O., & Tandogan, O. R. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education, 3,* 71-81.

American Association for the Advancement of Science [AAAS] (2001). Project 2061. *Atlas of Science Literacy*. Washington, DC: American Association for the Advancement of Science.

American Association for the Advancement of Science [AAAS] (1993). *Benchmarks for scientific literacy: A Project 2061 report*. New York: Oxford University Press.

Bennett, T. (2019). The skepticism threshold: Is there any evidence for inquiry learning? *Education Review.* Retrieved from http://educationreview.co.nz/the-skepticism-threshold-is-there-any-evidence-for-inquiry-learning/

Bilgin, İ. (2006). The effects of hands-on activities incorporating a cooperative learning approach on eight grade students' science process skills and attitudes towards science. *Journal of Baltic Science Education, 1*(9), 27-37.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27-40.

Chen, L.-K., Dorn, E., Krawitz, M., Lim, C. S. H. & Mourshed, M. (2017). *Drivers of student performance: Insights from Asia*. Washington DC: McKinsey & Company.

Chiappetta, E. L., & Adams, A. D. (2004). Inquiry-based instruction: Understanding how content and process go hand-in-hand with school science. *Science Teacher, 71*(2), 46-50.

Coil, D., Wenderoth, M. P., Cunningham, M., & Dirks, C. (2010). Teaching the Process of Science: Faculty Perceptions and an Effective Methodology.*CBE—Life Sciences Education, 9*, 524-535.

Corbin, J. & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks: Sage publications.

De Boer, G. (2000). Scientific Literacy: Another look at Its Historical and Contemporary Meanings and its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, *37*(6), 582-601.

Dönmez, F., & Azizoglu, N. (2010). Investigation of the students' science process skill levels in vocational schools: a case of Balıkesir. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 4*(2), 79-109.

Donnelly, D., O'Reily, J., & McGarr, O. (2013). Enhancing the student experiment experience: Visible scientific inquiry through a virtual chemistry laboratory. *Research in Science Education, 43*, 1571-1592.

Farsakoglu, O. F., Sahin, C., Karsli, F., Akpinar, M., & Ultay, N. (2008). A study on awareness levels of prospective science teachers on science process skills in science education. *World Applied Sciences Journal, 4*(2) 174-182.

Fensham, P., Gunstone, R., & White, R. (2013). *The content of science: A constructivist approach to its teaching and learning*. London: The Falmer Press.

Goodrum, D., & Rennie, L. (2007). *Australian school science education national action plan 2008 – 2012*. Canberra: Department of Education, Science and Training

Haslam, C.Y., & Hamilton, J. (2010). Investigating the use of integrated instructions to reduce the cognitive load associated with doing practical work in secondary school science. *International Journal of Science Education, 32*(13), 1715-1737.

Hodson, D. (1990). A critical look at practical work in school science. *School ScienceReview*, *71*(256), 33–40.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, *88*, 28-54.

Kasanda, C., Lubben, F., Campbell, B., Kapenda, H., Kandjeo-Marenga, H., & Gaoseb, N. (2003). Learner-centred teaching–The rhetoric and practice. The case of Namibia. In B. Putsoa, M. Dlamini, B. Dlamini, & V. Kelly (Eds.), *Proceedings, Southern African Association for Research in Mathematics, Science and Technology Education Conference,* 11th annual meeting (pp.132-137). Mbabane: SAARMSTE.

Jerrim, J., Oliver, M., & Sims, S. G. (2019). The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. *Learning and Instruction, 61*, 35-44. https://doi.org/10.1016/j.learninstruc.2019.12.004.

Kibirige, I., Osodo, J., & Mgiba, A. N. (2014). Exploring Grade 7 Science Teachers' Perceptions Regarding Practical Work in Limpopo, South Africa. *Mediterranean Journal of Social Sciences, 5*(4), 399-405.

Lau, K.-C., & Lam, T. Y.-P. (2017). Instructional practices and science performance of 10 top-performing regions in PISA 2015. *International Journal of Science Education, 39*(15), 2128–2149. https://doi.org/10.1080/09500693.2017.1387947.

Laugksch, R. (2000). Scientific Literacy: A Conceptual Overview. *Science Education*, *84*(1), 71- 94.

Lumbantobing, R. (2004). "Comparative Study on Process Skills in the Elementary Science Curriculum and Textbooks between Indonesia and Japan" in: *Bulletin of the Graduate School of Education, Hiroshima University. Part II*, *53*, 31-38.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Learning and teaching in the school science laboratory: An analysis of research, theory, and practice. *Handbook of research on science education*, 393-441.

Millar, R. (2004). *The Role of Practical Work in the Teaching and Learning of Science.* Paper prepared for the Committee: High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington DC: University of York.

Ministry of Primary and Secondary Education. (2016). *Biology syllabus Form 5-6, (2017-22)*: Curriculum Development and Technical Services, Harare: Zimbabwe.

Ministry of Primary and Secondary Education. (2015). *Biology syllabus Form 3-4, (2015-22)*: Curriculum Development and Technical Services, Harare: Zimbabwe.

Molefe, L and Stears, M. (2014). Rhetoric and Reality: Science Teacher Educators' Views and Practice Regarding Science Process Skills. *African Journal of Research in Mathematics, Science and Technology Education, 18*, (3) 219–230.

Mostafa, T., Echazarra, A. & Guillou, H. (2019). *The science of teaching science: An exploration of science teaching practices in PISA 2015* (OECD Education Working Paper No. 188). Paris: OECD Publishing.

Mukaro J.P & Stears M. (2016). Exploring the alignment of the intended and implemented curriculum through teachers' interpretation: a case study of A-Level Biology practical work; *EURASIA Journal of Mathematics Science and Technology Education 13*(3), 723-740.

National Research Council. (2004). *On evaluating curricular effectiveness: Judging the quality of K-12 mathematics evaluations*. Washington, DC: National Academy Press.

Ogunniyi, M., & Mikalsen, O. (2004). Ideas and process skills used by South African and Norwegian students to perform cognitive tasks on acids, bases and magnetism. *African Journal of Research in Science, Mathematics and Technology Education*, *8*, 151-164.

Ongowo, R. O., & Indoshi, F. C. (2013). Science Process Skills in the Kenya Certificate of Secondary Education Biology Practical Examinations. *Creative Education, 4* (11), 713-717.

Ozgelen, S. (2012). Scientists' science process skills within a cognitive domain framework. *Eurasia Journal of Mathematics, Science & Technology Education, 8,* 283-292.

Ornstein, A. C., & Hunkins, F. P. (1993). *Curriculum: Foundations, principles, and issues*. Boston: Allyn and Bacon.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: The Nuffield Foundation.

Piaget, J. (1973). *To understand is to invent: The future of education.* New York: Grossman.

Rambuda, A.M., & Fraser, W.J. (2004). Perceptions of teachers of the application of science process skills in the teaching of Geography in secondary schools in the Free State province. *South African Journal of Education*, *24*, 10-17.

Rezba, R.J., Sprague, C., Fiel, R.L. (2007). *Learning and Assessing Science Process Skills.* (5th ed.). Dubuque, IA: Kendall/Hunt Publishing Company.

Zimbabwe School Examinations Council. (2019). *General Certificate of Education, Advanced Level. Biology Paper 4 (6030/4). Practical Test. November 2019*. Harare. Zimbabwe.

Zimbabwe School Examinations Council. (2019). *General Certificate of Education, Ordinary Level. Biology Paper 3 (4025/3). Practical Test. November 2019*. Harare. Zimbabwe.