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Education for Sustainable Development: Transforming Pedagogies for Teaching Secondary School Chemistry

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Abstract
Teaching and learning of chemistry is critical for equipping learners with knowledge, skills and values to understand and respond to social scientific issues such as pollution, climate change, sustainable consumption and other sustainable development issues facing the world today. This can only be achieved by embracing the dimensions of Education for Sustainable Development (ESD) in the design and implementation of chemistry curriculum. The ESD focuses on content that responds to Sustainable Development (SD) issues and transformative pedagogies that are key in promoting learner's capacity to use their knowledge in real life scenarios as well as to solve problems they encounter in their communities. The study therefore, explored how the Zambian chemistry curriculum and pedagogies used to teach chemistry reflect principles of ESD. It was grounded in the expansive theory of learning, which emphasises the acquisition of knowledge, skills and attitudes relevant to work collaboratively in solving societal problems. The study used lesson observations, document analysis and focus group discussion to collect data. The findings showed that one of the general aims of the chemistry curriculum was anchored within the dimensions of ESD, however there is a mismatch between the aim and specific outcomes. The specific outcomes focus on acquisition of knowledge as opposed to transformational learning outcomes. The curriculum contains various topics that speak to current SD issues. The pedagogies used by teachers were mostly teacher centred characterised by delivery of factual knowledge. The study therefore, recommended for the reorientation of the chemistry curriculum and pedagogies within the framework of ESD principles so as to enhance the relevance of chemistry in learners' lives as well as its critical role in sustainable development.
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1. Introduction

Education for Sustainable Development is regarded as a United Nations initiative aimed at reorienting education (United Nations Educational, Scientific and Cultural Organisation 2005). It is alive to the view that empowering of citizens with appropriate knowledge, skills, values and attitudes is key in supporting sustainable behaviour ultimately Sustainable Development(SD). Education for Sustainable Development (ESD) envisages a life-long approach to learning as such, it is an essential component of quality education (UNESCO, 2017). Further, it can be described as holistic and transformational in nature. This is because it puts a learner at the centre of learning through action-oriented learning. UNESCO (2020) outlines that there are four salient dimensions of ESD and these are; learning content, learning outcomes, pedagogy and learning environment and societal transformation.

In a quest to achieve sustainable development there is need to build a more sustainable world through societal transformation. On the other hand, learning outcomes should emphasise the need to equip learners with necessary knowledge, skills, values and attitudes for them to participate actively in societal transformation for present and future generations (UNESCO, 2015). The ESD also calls for the integration of the sustainability issues in the curriculum as part of learning content. These include but not limited to; climate change, disaster risk reduction, biodiversity and sustainable consumption. Pedagogy is key in enhancing a learning environment that promotes interactive, project based and learner centred approaches. As a result ESD stresses the importance of pedagogies in promoting learner's capacity to use their knowledge to solve problems they encounter in their lives and communities (Armstrong, 2011).

The Zambian Education Curriculum Framework of 2013 is underpinned by ESD principle of lifelong learning. This is also espoused in the curriculum implementation framework that has provided guidance on the use of pedagogies that promote learner's active participation. It is anticipated that "…learner centred approach develops learners' ability, attitudes, skills and values to work independently and help them to take responsibility of their

own learning." (Ministry of Education, 2013: 15).Thus, science learning is said to be relevant whenever learning impacts learner's lives positively. Similarly, science education must prepare learners to lead responsible lives in society by enhancing their understanding of the link between societal participation and skills that are key for society's sustainable development. Hofstein, Eilks and Sjostrom (2017:8) alludes that "chemistry and the industries related to it are at the heart of every developed society". This implies that chemistry fosters the understanding of social scientific issues such as pollution, climate change, sustainable consumption and many more. However, the appreciation of ESD in chemistry education and how it informs pedagogies used to teach chemistry has largely remained inadequate. Thus, the study sought to establish how the chemistry curriculum and pedagogies used to teach the subject reflect the principles of ESD. The study was guided by the following questions:

1. How does the chemistry curriculum integrate sustainability issues?
2. How do the Pedagogies used to teach chemistry reflect the principles of ESD?

2. Literature Review

Education for sustainable development is very closely linked to sustainable development (Simasiku, 2020). This is the case because learners learn to build capacity to live more sustainably. The ESD focuses on four dimensions and these are; learning content, learning outcomes, pedagogy and learning environment as well as societal transformation. The aspect of learning content looks at how critical issues of interest such as climate change, disaster and risk reduction, sustainable consumption and production can be integrated in the curriculum. On the other hand, learning outcomes focuses on the promotion of key competencies and skills such as critical thinking, systemic thinking collaboration and taking responsible actions for present and future generations. Pedagogy and the environment constitute a teaching/learning environment which is interactive and promotes active participation of learners in their own learning. In order to promote societal transformation ESD equips learners of all kinds with the ability to transform their societies, develop skills for green jobs, embrace sustainable lifestyles and enable them become responsive to local needs. This helps learners to appreciate their context and make education meaningful (Morgan, 2009; UNESCO, 2012; Mandikonza and Lotz-Sistka, 2016; UNESCO 2020).

The ESD driven pedagogies are said to reorient the teaching/learning practices from teacher centred to learner centred. This is achieved by enhancing participatory learning which is key for conceptual understanding. This negates rote learning and memorisation of concepts hence fostering curiosity, critical thinking and problem solving (UNESCO, 2012). Yamazumi (2006) conducted a study aimed at establishing the relationship between the activity theory and the transformation of pedagogic practice through ESD. The study revealed that through collaboration participants were motivated and actively engaged in various activities that shaped and promoted collaborative learning ultimately fostering their own development. Similarly, Gibbs (2021) allude that when learners are exposed to experiences that accord them an opportunity to develop the link between content and real-world issues they are motivated to make self-directed changes in their lives. This may suggest that through ESD learners are well positioned to use knowledge and skills beyond the classroom. In other words it is apparent to note that contextualising pedagogy to learner's needs and their environment promotes sound learning.

Pedagogical approaches advocated for in ESD are crucial in equipping learners with knowledge, skills and values necessary to contribute to SD through active engagement, social interaction and participatory learning. It also suffices to mention that ESD pedagogies were said to be expansive in nature (Armstrong 2011; O'Flaherty and Liddy, 2018). In the same vein, Ssosse, Wagner and Hopper (2021:4) points out that "ESD calls on the reflection of issues around rather than teaching correct answers". To this end ESD envisages pedagogies that encourage learner's actions in various environments and enable them understand the world through their own observations and presents both opportunities and challenges for learners to engage higher order thinking abilities (UNESCO, 2015; Bourn and Soysal, 2021). It also promotes the multidisciplinary teaching/learning pedagogy that integrates knowledge from different disciplines hence leading to system thinking (Sund and Gericke, 2020).

Additionally, ESD provides social scientific issue based approach to the teaching/learning of science. This is achieved by showing the link between industrial application and science content. For instance, there are opportunities to apply the principles of sustainability to practical activities in a chemistry lesson. This expands the contribution of practical activities to learner's learning by ensuring that they reflect the role of chemistry in sustainable development as well as its real life relevance. Alternatively, ESD fosters the use of low cost experiments, improvised equipment and alternative procedures. In this case, learners tend to appreciate the science behind every day processes and products (Lozano and Watson, 2013; Eilks, 2015). Anastas and Warner

(1998) as cited in Tsakeni (2018:128) highlights the following principles of chemistry: "controlling waste generation; reducing toxic chemical synthesis processes; designing for energy efficiency; designing for degradation; designing safer chemicals; using safer solvents and auxiliaries; using renewable feed stocks; reducing derivatives; using catalysts; doing real time analysis of pollution prevention; and preventing chemical accidents". These principles speak to the kind of chemistry that is grounded and informed by ESD. Therefore, it is imperative to look at how this content is positioned in the secondary school chemistry curriculum as well as how it is repackaged and presented to learners.

Burmeister, Rauch and Eilks (2012) states that the learning of chemistry concepts and facts alone is not sufficient to equip learners with the knowledge, skills and attitudes needed to deal with current complex issues. In their comparative study, Sund and Gericke (2020) assert that teachers focus on different aspects in their teaching. They tend to dwell more on classroom based teaching as well as the use of teacher-centred approach. This practice perpetuates the transfer of factual knowledge. This is a clear indication that teachers limit the opportunities accorded to learners to develop action competence through active engagement in the lessons. Therefore, ESD demands for pedagogies that create and promote active participation, collaboration and networks between science and society.

Chemistry as a discipline has a significant role in sustainability to shape the current and future generations to live sustainably (Murti and Hernani, 2023). It is therefore, essential that the chemistry curriculum clearly incorporates ESD in its content. Shumba and Kampamba (2013) conducted a case study on ESD pedagogical content knowledge and learning as connection. The focus of this study was mainstreaming of ESD into science education. The findings of the study revealed that there is some presence of ESD issues in the secondary school chemistry syllabus but no clear guidance has been provided on the teaching/learning approaches. Other scholars argue that, the salient goals of SD are hardly present in the chemistry curriculum because there is no balance between knowledge, skills and attitudes (Jegstad and Sinnes, 2015; Murti and Hernani, 2023).Therefore, educators should consider re-orienting the chemistry curriculum in order to make it more sustainability driven for it is critical to helping societies become more sustainable (Lozano and Watson 2013).

Burmeister, Rauch and Eilks (2012) propose four models of how sustainability issues can be applied in chemistry education. These models include; adopting green chemistry principles and apply them to science education practical work; adding SD issues in chemistry curriculum; using controversial sustainability issues for social scientific issues that drive chemistry education and fourthly, making chemistry education a part of ESD-driven school development. The aspect of adding SD issues to the curriculum shades more light on certain concepts such as fuels, acids, materials and energy for example that are already part of the curriculum though in an implicit manner. However, Shidiq, Permanasari and Hernani (2020) argue that the realisation of ESD in chemistry lessons may not necessarily require specific problems of chemical sustainability. This implies that ESD can be achieved in the curriculum without adding more content but by repackaging what is already there correctly and using appropriate pedagogies during lessons. This can be achieved by using localised and real life examples.

3. Theoretical Framework

This study was by informed expansive learning. The expansive learning theory (concept) is part of the activity theory. It was formulated by Engestrom in 1987. Expansive learning is considered to be the kind of learning in which a learner is involved in constructing and implementing new and more complex object for their activity (Engestrom, 1987; Guberman and Smith, 2021). The theory considers learners as a community in which transformation, creation of culture and agency occurs (Yamazumi, 2009). Further, it guides that learning should not only be limited to the acquisition of knowledge, skills and attitudes classified by learning institutions but it should foster solutions to pressing societal problems. This is a central idea of education for sustainable development, which emphasises the role of education in empowering learners with the knowledge, skills and values to enable them take actions for the good of the environment, economic sustainability and a just society (Armstrong, 2011). In an ESD driven chemistry classroom, emphasis should be placed on the use of pedagogies that promotes learners' ability to use their knowledge to solve real life societal problems.
In expansion therefore, the focus is not only on uplifting people from one level of competence to another but also on horizontal development. This implies that learning should promote the use of knowledge from different disciplines, network and develop a shared meaning. The theory therefore is key in promoting active participation, collaboration, networking, transformation and multidisciplinary approach to learning. This fosters the use of pedagogies such as problem solving which is key in promoting life-long learning, active participation and societal transformation as ultimate goals of ESD (Amineh and Asl, 2015; Shumba and Kampamba, 2013).

4. Methodology

4.1 Study Design

Cohen, Manion and Morrison (2007) allude that the choice of a research design is dependent on the purpose of the study. The purpose of the study was to ascertain how the chemistry curriculum integrates sustainability issues and how the pedagogies used to teach secondary chemistry reflect principles of education for sustainable development. Thus, a descriptive study design grounded in qualitative research was used in this study. This provided an opportunity to use more than a single data source as well as observe participants in a natural setting.

4.2 Study Sample

The study sample comprised nine chemistry teachers drawn from selected secondary schools teaching pure chemistry and science in Ndola district.

4.3 Sampling and Data Collection

Purposive sampling technique was used to select nine chemistry teachers for lesson observations and focus group discussion. These teachers were considered to be information-rich because they taught both pure chemistry and science syllabi at senior secondary level. Data was collected through lesson observations with the use of an observation schedule as a guide. A total of 12 lessons were observed, the observed lessons were selected based on topics which were being covered. The topics were identified to speak to sustainability issues and these were; Extraction of Metals, Acids, Bases and Salts, Chemical Reactions and Organic Chemistry. The researcher assumed the role of observer-as-participant. This was the case because the identity of the researcher was revealed and the purpose of the study explained (Saunders, Lewis and Thornhill, 2012). On the other hand, two focus group discussions were conducted after lesson observation. Lastly, the pure Chemistry and Science syllabi were analysed to ascertain how the curriculum integrates ESD issues. Patton (2002) posits that documents provide insights about many issues that cannot be observed.

4.5 Data Analysis

The study used a generic qualitative analysis approach to analyse the data. The researcher used both inductive and deductive reasoning in the qualitative data analysis process. The initial stage was reading the data repeatedly to get an overall impression from lesson observation, focus group discussions and document analysis. This process was followed by categorisation, the research questions were used as a guide in coming up with categories. These categories were then labelled based on terms and phrases that emerged from the data. Secondly, text of data was attached to these categories in order to get units of data as described by Saunders, Lewis and Thornhill,2012:558) that " a unit of data may be a number of words, a line of a transcript, a sentence, a number of sentences, a complete paragraph or some chunk of textual data that fits the category". Thirdly, the categories were explored to establish connections, patterns and relationships which resulted into major themes.

4.6 Limitations of the Study

The study involved nine teachers due to the labour intensive nature of lesson observation. There was some aspect of self-selection of teachers who took part in the study due to the fact that only those who were willing to be observed as well as taught both pure and science were included in the sample. Thus, this may have introduced observation bias because the teachers might have behaved in an unnatural way during lesson observation. However, the data from lesson observation was triangulated with data from focus group discussions and document analysis to strengthen and provide a deeper understanding of the problem.

4.6 Ethical Considerations

Ethical consideration is a key aspect of the research process. This is because the data collection process is dependent on gaining access to appropriate data sources (Saunders, Lewis and Thornhill, 2012). In order to gain access to the district, the researcher sought permission from the district education authority. The authority introduced the researcher to the school Head teachers before gaining access to the participants. Secondly, consent was obtained from participants before participating in the study by way of completing consent forms. Their identity was kept confidential and anonymous through the study.

5. Results and Discussion

The results are presented and discussed in line with two main themes: (a) Chemistry curriculum and sustainability issues, (b) Pedagogies used to teach Chemistry and how they link to ESD.

5.1Chemistry Curriculum and Sustainability issues

5.1.1Outcomes of the syllabi

The analysis of the two syllabi indicated that only one of the six general aims highlight sustainability issues. The general aim number 6 is highlighted in Table1.

Table 1: General aim 6 and its Sub-aims

Pure Chemistry Syllabus (5070)	Science Syllabus (5124)
Aim: To promote awareness that:	*Aim: To promote awareness that:*
i. Chemistry is subject to social, economic, technological, ethical, cultural influences and limitations *ii. The applications of Chemistry maybe both beneficial and detrimental to the individual, the community and environment.* *iii. Stimulate interest in and care for the local and global environment.*	*i. Chemistry is subject to social, economic, technological, ethical, cultural influences and limitations* *ii. The applications of Chemistry maybe both beneficial and detrimental to the individual, the community and environment.* *iii. Stimulate interest in and care for the local and global environment.*
-	*iv. Develop knowledge and understanding of the scientific and technological applications with their social, economic and environmental implications.*

(MOE, 2013)

It is clear from the findings that the syllabi have made an attempt to position chemistry knowledge in a manner that it contributes to education for sustainable development. This is also echoed by Shumba and Kampamba (2013) who pointed out that there is some presence of ESD issues in the secondary school chemistry syllabus. However, this is an indication that there is less focus and emphasis on sustainable development issues. On the other hand it suffices to mention that the remaining five general aims focuses more on the knowledge to be acquired without clearly showing the contribution of Chemistry to the social, economic and environmental issues. Lozano and Watson (2013) states that there is need to re-orient the Chemistry curriculum so as to make it more sustainability driven for it is critical to helping communities become more sustainable. This is important because Chemistry education is regarded as one of the appropriate disciplines to be used for the incorporation of education for sustainable development (Tsakeni, 2018). As such it provides context to the teaching/learning of sustainability issues.

The findings further indicated in Table 2 that most of the specific outcomes that speak to sustainability knowledge at grades 10 to 12 fell in the cognitive domain of learning as opposed to the main aim that speaks to learning outcomes that is associated with emotions, attitudes and values.

Table 2: Specific Outcomes linked to SD in the syllabi

Specific Outcome	Grade/level
i. Explain the importance of Chemistry	10
ii. Demonstrate an understanding of the importance, production, use and effect on the environment of common elements and simple compounds. *iii. Demonstrate an understanding of the importance, production, use and effect on the environment of acids, bases and salts.*	
iv. Demonstrate an understanding of chemical reactions and energy changes *v. Explain the advantages and disadvantages of energy sources*	11
vi. Describe the effects and use of fuels on the environment *vii. Describe extraction of metals (Copper, Iron and Zinc)* *viii. Explain the use and harmful effects of some metals*	
ix. Describe the fractional distillation of crude oil *v. Describe the formation of alcohols*	12

(*MOE, 2013:1; 17; 44)*

Therefore, it seems that there is a discrepancy between the general aim and specific outcomes to be achieved in relation to sustainability issues. The general aim points out the importance of raising awareness which is nested in the affective domain while the specific outcomes largely dwell on the cognitive domain.

5.1.2 Topics Related to Sustainable Development in the Curriculum

The Pure chemistry and science syllabi are structured in such a manner that topics run from grades 10 to 12. There are 10 main topics in both the pure chemistry and science syllabi. Of the 10 no single main topic is directly linked to education for sustainable development, however some content and sub-topics indirectly speak to sustainable development. There are various topics that were identified to contain some content that speak to SD. These include: *Introduction to Chemistry; Aids, Bases and Salts; Chemical reactions; Metal; Non-Metals and Organic Chemistry*. The findings revealed that certain concepts with real life relevance to learners were either not emphasised or completely left out. For instance, Energetics of Reactions a subtopic under chemical reactions is absent in the science syllabus. However, this component is key because it covers content to do with energy sources (fuels); effects of fuels on the environment such as pollution and greenhouse effect. This was echoed by Teacher 5 during a focus group discussion who narrated that:

> *…sometimes the curriculum is a challenge to itself, why do I say so…the things that should be there must be relevant to the learners within their community. That is why leaners do not show interest because how do you force me to learn something that I will not use.*

In a similar manner the topic Metals covers the extraction of metals and uses. But the curriculum is silent on the environmental friendliness of these extraction methods. Jegstad and Sinnes (2015), shares that the chemistry curricula have placed more emphasis on the content but neglected its real life application. Chemistry is key in highlighting sustainability issues because a number of products in our daily lives are based on chemistry. Therefore, the curriculum ought to be intentional and clear about content linked to SD. This is important because it may help teachers to emphasise and enhance learners' appreciation of chemistry's role in their lives and society.

5.2 Pedagogies used to teach Chemistry and how they link to ESD

It was important to look at the approaches and methods used and how they reflected the ESD dimensions to teach the identified topics that are related to SD issues. In order to ascertain this, the study focused on the following aspects: Facilitation of learning and activities and the Engagement of learners with the environment.

Table 3: Key elements of methods for teaching ESD related Chemistry topics

Teacher Code	Topic Observed	Presentations &Analogies	Activities learners engaged in	Linking Content to real life
TE1	*Extraction of metals*	*-Questions (write the two chemical reactions involved in the extraction of Zinc; Teacher Exposition; An example of the mining pollution in Mufulira (SO_2)*	*Group work - learners worked in groups to come up the 2 chemical reactions and reported their answers to the whole class*	*An example of the mining pollution in Mufulira to explain the effect of SO_2*
MS3	*Extraction of metals*	*-Teacher Exposition; Questions (What are effects of mining on the environment? What are the advantages of recycling?)*	*Whole class discussion- the questions were posed to the whole class, learners responded and discussed their responses*	*-Land pollution- gave an example of mine dumps such as the "black mountain" ;Air pollution- Due to emissions such as CO_2 and SO_2 ; Waste management, the metals are recycled to other usable products*
NC1	*Acids, Bases & Salts*	*-Demonstration (the teacher demonstrated the preparation of Barium Sulphate); Discussion; An example of football spectators to explain spectator ions*	*-Practical activity (preparation of Barium Sulphate);Group work- Learners worked in manageable groups*	–
CH2	*Chemical Reactions*	*-Discussion(What factors affect rate of reactions; Teacher Exposition*	*Group work- Learners discussed in small groups and reported to the class*	–
KN1	*Organic Chemistry (Alcohols)*	*-Questions (Asked learners to write structural formula of alcohols; Reactions between alcohols and carboxylic acids to form Esters -Teacher exposition -An example on use of alcohol to produce perfume*	*Whole class discussion- learners volunteered to try out the questions on the board*	–

5.2.1 Facilitation of Classroom learning and Activities

The findings in Table 3 showed that teachers mostly used questions to promote participation and interactions in their lessons, a total of 12 lessons were observed. For example, TE1 used a question to encourage learner participation in the lesson on Extraction of Metals specifically Zinc. The teacher asked learners to write the reaction between Zinc Blende and Oxygen, learners came up with reactions *i* and *ii*

i. $2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2\,(g)}$

ii. $ZnO_{(s)} + CO_{(g)} \rightarrow Zn_{(s)} + CO_{2(g)}$

Learners worked and discussed in small groups to answer the question, while the teacher monitored the groups closely. Thereafter, one member from each group was appointed to present their answers. This was an indication that the teacher made an effort to promote and encourage learner participation in the lesson. However, there were no deliberate opportunities for exploration because the question was low level. A higher level question would have enabled the teacher to probe further, by focusing on the effects of Sulphur Dioxide (SO_2) and Carbon Dioxide (CO_2) on the environment. This is important in promoting critical thinking and problem solving skills among learners when they are able to create a link between content and society. This is supported by Gibbs (2021) that when learners are exposed to experiences and content that gives them an opportunity to develop a link between content and real-world issues they become motivated. Further, this may imply that through ESD informed pedagogies learners are likely to be well positioned to use their knowledge and skills beyond the classroom.

It was also observed as shown in Table 3 that Teacher Exposition was frequently utilised through Question and Answer as well as Discussion. This observation was an indication that mostly teachers used teacher centred

methods in their lessons because they took an active role in the lessons. This was reaffirmed during focused group discussion when teachers were asked to highlight the methods that they usually use. They were quick to mention Question and Answer; Demonstration; Class Discussion and Teacher Exposition. Nonetheless, when asked what methods enhances learners knowledge, skills and attitudes to enable them address environmental challenges in their communities, the participants indicated that experimental and discovery methods were ideal. For instance Teacher 1 said;

> *…experimental method is ideal though I did not use it in my lessons. The problem with the methods we frequently use is that…sometimes it makes chemistry seem as a subject you should just learn in school. Learners will not appreciate most daily processes and actions such as dropping a plastic bottle on the road is actually not good because of what it may do to the environment. So experimental method may help them appreciate environmental concerns.*

Out of the 12 observed lessons only two engaged learners in hands-on activities on the topic Acids, Bases and salts. The findings seem to suggest that teachers were more inclined to use methods which do not encourage active participation and experiential learning. As a result, they lacked a theoretical underpinned understanding of pedagogies that can be used to implement ESD in chemistry teaching (Burmeister, Schmidt-Jacob and Eilks, 2013). Armstrong (2011) also underscores the expansive nature of ESD pedagogies. The expansive learning theory emphasises the importance of using practical activities and projects to teach Chemistry content. This is because practical activities can be designed in such a manner that promotes active learning and critical thinking while fostering a sense of responsibility towards sustainability. Teachers should strive to foster collaboration among learners from different disciplines and encourage projects that integrate knowledge from multiple fields.

5.2.3 Engaging Learners with the Environment

It was observed that teachers did not engage learners with the environment despite the opportunities presented by the topics to do so. In most cases teachers opted to highlight concepts using teacher exposition. For example, they presented lessons on the topic extraction of metals and how SO_2 affect the environment. The teachers explained how the gas results in acid rain hence affecting soil fertility. Teacher 2 further added that:

> *…on the same topic metals we do emphasise recycling, because I feel it does add to sustainable development…when you talk about proper use of resources and recycling it is like you are limiting the excessive usage of resources. So during the lesson on recycling we should just use our environment to effectively teach the concept instead of just talking from our classrooms.*

The environment is an important teaching/learning resource that must be utilised to enhance learners understanding of chemistry concepts and to instil sense of appreciation of SD issues. The lessons presented opportunities that would have been used to explore and probe further beyond the classroom. Burmeister, Rauch and Eilks (2012) adds that learners should be able to relate Chemistry content learnt in class to their real life issues such as environmental pollution. This is because learning facts alone is not enough to equip learners with knowledge, skills and attitudes needed to deal with current complex issues. In the same vain expansive learning advocates that Chemistry teachers should connect classroom learning to issues in their community. These experiences may provide learners with real-world examples of phenomena and enable them to take an active role in promoting sustainability. Equally ESD emphasises the need to promote a clear connection between science and society. Therefore it suffices to mention that Chemistry education can help address challenges such waste management and pollution. Learners can learn about the chemical composition of various types of waste, explore recycling techniques and understand the environmental concerns of incorrect waste disposal for example (Tsakeni, 2018).

It can be deduced from the findings that the observed teachers were aware of the important role Chemistry of content in various daily activities. However, they did not provide more opportunities through hands-on activities or use of other appropriate methods so that learners experienced phenomena first hand. ESD pedagogy envisages the need for the teacher to understand their context and environment so as to choose the best methods to use during their lessons (Burmeister, Schmidt-Jacob and Eilks, 2013; Gibbs, 2021).

Conclusion

The study shows that one general aim of the curriculum has pointed to ESD. However, there is a mismatch between the aim and the specific outcomes seemingly derived from it. This is because the aim is nested in the affective domain while the specific outcomes are in the cognitive domain. It is an indication that the curriculum

has focused more on the acquisition of chemistry knowledge rather than its application. Further, that there are 10 main topics in the syllabi of which none is directly linked to education for sustainable development, those topics regarded to speak to ESD are mostly through sub-topics. Teachers made an effort to promote learner participation in their lessons through questions. But there were no opportunities for exploration because the questions were low level. This was coupled with the use of pedagogies that did not provide opportunities to engage learners hands-on, promote participatory learning and use the environment as part of the teaching resource. Largely, the pedagogies used did not empower learners with knowledge, skills and values to solve complex issues facing society today. In light of the findings, the study recommends that curriculum developers should align the major aim that speaks to ESD with specific outcomes in order to clearly guide the teachers as they implement the curriculum. Build capacity of chemistry teachers through continuous professional development (CPDs) so as to enable them use pedagogies that promote active participation, use of the environment, so as to promote collaboration, forge networks to spur conceptual understanding and societal transformation.

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