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Learners' Active Engagement in Searching and Designing Learning Materials through a Hands-on Instructional Model

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Abstract. When engaging learners in searching and designing, the learning materials are of paramount importance, in order to help the learners in the achievement of academic goals and objectives. However, learners being the primary consumers of chemistry content delivered by the teachers, ought to beware of the learning materials that can facilitate their learning. This can well be done if learners participate fully in searching and designing learning materials that correspond with the lesson content. The purpose of this research was to use a Hands-on Instructional Model (HIM) designed to help secondary school teachers actively to engage learners in searching, designing, and manipulating locally made learning materials, in order to facilitate the face-to-face learning of chemistry concepts. The study employed Design-Based Research (DBR) in designing, refining, and implementing HIM, as well as the learning materials designed by the learners following a pragmatic philosophical world-view. The data were collected and analysed by using qualitative research techniques; and the research instruments included Lesson-Observation Protocol, semi-structured interviews, and Focus-Group Discussions. The study involved three intact senior-science classes deliberately selected from three Dar es Salaam community-secondary schools. The results revealed that learners become actively engaged in the lesson, when the learning materials designed by themselves are used. They used materials, like empty water bottles of different sizes, syringes

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of different sizes, rubber bands, and pegs to prepare locally made apparatus that served as beakers, burettes, droppers, and funnels in titration hands-on activities. In this regard, we recommend teachers involve learners in searching and designing the learning materials to be used in the teaching and learning process, in order to enhance chemistry content mastery and the acquisition of soft learning skills.

Keywords: community secondary schools; hands-on activities; learners' active engagement; learning materials

1. Introduction

Learning materials have been used in the chemistry classrooms since ancient times. Learning materials are the tools that can be used by instructors and teachers within the classroom context, in order to facilitate the learning and understanding of concepts among learners (Arop et al., 2019; Khalil & Elkhider, 2016; Wang, 2021). These materials are mostly used to support teachers in achieving the objectives that are set for a particular lesson (Choppin et al., 2020; Kanellopoulou & Darra, 2018).

According to Hayat et al. (2017), these materials make learning real, enjoyable, practical, and pleasurable for the learners. Also, learning materials facilitate the illustration and reinforce the acquisition of skills, viewpoint, perspective, and ideas (Arop et al., 2019). Furthermore, research has indicated that a large number of learners are not interested in perusing science subjects at the secondary school level (Nbina & Mmaduka, 2014; O-saki, 2007). One of the noted causes is the inappropriate and insufficient learning materials used to facilitate the learning of these concepts.

This may result in the inability to understand these concepts (Ko et al., 2013). Notwithstanding the need for learning materials, Mafumiko (2006), pointed out that the Tanzanian government supplies limited instructional resources to community secondary schools; and as such, there cannot be enough for all the learners in all the schools (Machumu, 2011; Nbina & Mmaduka, 2014). Therefore, there is a need to involve learners in designing locally made learning materials that are appropriate for teaching and learning chemistry. This would go a long way to improve the quality of chemistry teaching, as stipulated in SDG_4 (Jackson et al., 2013).

1.1 The Literature Review

Successful implementation of the chemistry curriculum is dependent on the learning materials available for both teachers and learners in lesson sessions. According to Khalil and Elkhider (2016), the term learning material means all theoretical, practical and skill-oriented resources, which are accessible and available to facilitate the learning acquisition of various learning skills. In addition, learning materials bring the hope of delivering educational facts and experiences vividly and widely with realism that the printed media could hardly achieve (Arop et al., 2019).

For instance, a chemistry teacher can barely explain and describe a pipette, burette or any other learning equipment in chemistry; but it is hard to tell the learners what exactly a pipette or a burette look like, without a picture or physical equipment for clarity (Choppin et al., 2020). The picture of a pipette or burette is considered a learning material that would help the students to comprehend the concepts behind their use. Also, these materials are among the materials needed by teachers and other instructors to assess the knowledge acquired by their learners from the lesson (Ko et al., 2013). Therefore, learning materials have a vital impact on the learning process and the acquisition of various skills.

Research in chemistry education has indicated that the introduction of modern and innovative methods and teaching-learning have led to developments in the overall system of education (Aydin-Günbatar & Demirdöğen, 2017; Stammes et al., 2020). However, it is assumed that using the hands-on strategy motivates learners' active engagement in the lesson by making learning a more realistic and exciting experience. Working through hands-on in line with a popular proverb, which states 'I hear, I forget'; 'I see, I remember and 'I do, I understand'. Besides, Cirenza et al. (2018) and Holstermann et al. (2010) identified experimentation, the manipulation of symbols and objects, as well as learners' interaction, as being among the learners' hands-on activities that can assist in the learning of chemistry.

According to them, the respective hands-on activities reflect on how they can enhance learning. Schwichow et al. (2016) further highlighted that learning can be accomplished through a careful and thoughtful selection of appropriate teaching strategies that would help in promoting students' ability to create the scientific and mathematical meaning of concepts rather than the passive reception of ideas. Therefore, the learning of the subject matter can be strengthened and emphasized when a learner experiences a learning activity as enjoyable, pleasant, stimulating, and relevant through the design process (Stammes et al., 2020).

Searching and designing learning materials increases learners' knowledge, thereby enabling them to learn how to think scientifically and understand how scientists work in natural life (Alkan, 2019). According to Ibe et al. (2021), deliberate practice and the continuous engagement of chemistry students in the design process are needed, so that learners become familiar with the content. According to Valdez et al. (2015), these practices are more effective when a learner is in an interactive environment and critically analyses the problem. An interactive classroom environment gives room for learners to exercise their ideas, knowledge and competencies (Holstermann et al., 2010; Wood, 2006). Wood (2006) asserts that group discussions create an active learning environment that improves students' ability to work and communicate with others, as well as to develop awareness and control of their thinking. In addition, (Holstermann et al., 2010) highlighted that when learners work in groups, it is possible to predict various solutions for a given task; since they share experiences.

The fact that learners learn through their experiences is not new. John Dewey (1859–1952) in his pragmatic theory of education posited that the experiences brought by learners in a classroom setting, from the outside environment, have a great impact on their learning (Sikandar, 2016). For Dewey, the generation of knowledge takes place in real and meaningful situations, through the spontaneous activities done by learners (Rizk, 2011). Besides, Levy Vygotsky (1920s) in the socio-cultural theory stated that learners' experiences are sharpened in the Zone of Proximal Development (ZPD), in the presence of a mentor (Fani and Ghaemi, 2011; Lui, 2012).

The major idea is that learners learn best when working together with others in collaboration; and it is by such shared endeavours with more experienced persons that learners learn and internalize new concepts, and skills (Fani and Ghaemi, 2011; Glassman, 2001; Lui, 2012).

1.2 The statement of the Problem

Chemistry, as a subject, is a real-life science subject, based on the concepts that comprise it. By its nature, most concepts in chemistry are practically oriented and its teaching and learning really require the use of teaching and learning materials. However, the literature has shown that teachers have been depending on the excessive use of words to express and convey chemical ideas (Stammes et al., 2020; Udogu & Enukora, 2017), theories, principles and fact-related skills and competencies to learners during teaching, which is completely teacher-centred via the lecture method (Sevian & Talanquer, 2014).

Additionally, teachers have played a role in ensuring that learning materials are available in chemistry lessons, although not enough for all the learners, especially in classrooms with a large number of learners. This method of teaching denies learners their active engagement in learning chemistry, which makes some students consider it as a white-man's "magic' (Udogu & Enukora, 2017), yet chemistry is the science that they experience in their everyday life. Also, the majority of individual learners in chemistry lessons only end up observing the learning materials, but not by using them to enhance their learning of various chemistry topics.

Nevertheless, the Tanzanian competence-based curriculum emphasizes the involvement of learners in practical exercises during science teaching and learning, by using various kinds of material resources. But researchers like (Nbina & Mmaduka, 2014), have reported that there are inadequate materials for teaching chemistry in schools. The above assertion prompted us to acknowledge the need to try out the use of locally made learning materials during the teaching of concepts. The problem of this work is to find out whether secondary school learners can search and design learning materials by using the materials available in the environment, in order to enhance their active engagement in hands-on activities during chemistry lessons.

1.3 The Research Questions

This research project answered the following questions:

1. How do learners engage s in searching and designing locally available learning materials through a Hands-on Instructional model?

2. How do learners engage themselves in chemistry hands-on activities by using learning materials designed from locally available learning materials?

2. The Methodology

2.1 The Research Design

In this study, a Hands-on Instructional Model (HIM) was designed through Design-Based Research DBR) when following a pragmatic philosophical view. A HIM prototype designed in this study guided chemistry teachers to lead students in designing locally made instructional materials that were used in the hands-on activities of chemistry lessons. However, the four DBR stages suggested by Reeves (2000), which combine research, design, and practice (Bowler & Large, 2008) were preferred.

Bowler and Large (2008) highlighted that Design-Based Research holds promise, as a research design that can bridge the theory/practice gap in the real educational world. The four steps helped to connect the learners' class activities and the use of the designed materials, in order to meet the chemistry content outcomes.

2.2 The Research Site and Sample

This study was performed in three community secondary schools in Dar es salaam, Tanzania. The sample for this study involved students' purposely selected from three intact science classes from the selected community-secondary, schools. Furthermore, the names of the students were not used in the data analysis, but rather they were identified by using pseudonyms. The implementation of this study was facilitated by three teachers (two females and one male), with an average teaching experience of five years.

2.3 Research Instruments and Data-Collection Procedures

This research was conducted from March to June 2019; and it employed a qualitative research approach. The research instruments for the data-collection process included Lesson-Observation Protocol (LOP), Focus-Group Discussions (FGDs) as guides for students (Appendix A), and semi-structured interviews as a guide for teachers (Appendix B).

A total of 42 face-to-face lessons (14 lessons in each school) were observed in all three schools. The researchers acted as non-participatory observers, in order to avoid influencing the process of data collection in the course of the lesson-observation. Also, during each lesson observed, we identified the resources used by the teachers; and we observed the learners, as they were interacting with the instructional materials locally made by using the materials from the home environment during hands-on activities.

Furthermore, the FGDs in each school were conducted once a week after lesson observation; and a total of 21 FGD interviews were conducted in all three schools, seven per school. Each FGD comprised six students; and it lasted for approximately 30-45 minutes on average; and this time was considered sufficient to reduce any initial anxiety. In addition, a total of 21 interviews with the teacher were guided by the interview guide; and they were conducted, corresponding to seven interviews per school.

All the teacher interviews were conducted after every observation of a lesson, in order to evaluate the lesson and the trend of the designed intervention. All FGDs and the interviews were audio-recorded; and this helped the researchers to elicit both students' and teachers' experiences during the chemistry lessons.

2.5 The Data Analysis

The credibility of all the instruments was checked by two experienced science educators, in order to ascertain their ability to produce credible outcomes and their inter-rater reliability was established. To establish the inter-rater reliability, the external researchers were 'raters' that were familiar with qualitative research. They rated the instruments and recommended some changes. Their recommendations were effected after reaching a consensus before data the collection. Furthermore, the conformability of the information obtained was observed through member checking (Basit, 2003; Yin, 2009), in order to ensure that all the information obtained was based on the participants' responses.

Furthermore, audit trials were done throughout the data-analysis process, in order to ensure that the study's findings portray accurately the respondents' views (Yin, 2009). Also, triangulation of the research information obtained by using different instruments (Cohen et al., 2007; Creswell, 2014; Mertens, 2010; Yin, 2009) was done, to ensure the credibility and the ,accuracy of the research findings.

The analysis of the data collected in this study was done concurrently with the data-collection process (Creswell, 2014) daily. Constant reflection on the information obtained from the interviews, the FGDs, and lesson observations were done to monitor the ongoing process of data collection and to identify those issues that needed clarity and follow-up during the intervention process. Then, the analysis was performed thematically (Braun et al., 2016) in which the whole process began by transcription of the audio data, translation of some transcripts and field notes from Swahili to the English language, as well as organization of all the data, according to their types, thereby forming a database for the inductive-coding process (Yin, 2009).

Generally, the entire coding was done by one of the researchers, and all the codes and the themes were assessed independently by two raters, who were part of the research team. The coded information was sorted and sifted through, in order to identify similar and coherent phrases (Braun et al., 2016), as well as the relationships between variables and patterns, in order to differentiate distinct and common sequences of categories in line with the research question (Basit, 2003; Baxter & Jack, 2008). Also, triangulation of information from lesson observations, teacher interviews, and students' FGDs was done, in order to capture the different dimensions of the same theme (Braun et al., 2016) and to minimize the researchers' biases. Lastly, meaningful information that gave a better interpretation of the data about the research questions was obtained from the developed themes and sub-themes (Baxter & Jack, 2008).

3. The Results

The analysis of the data from students' FGDs, observation protocol, and teachers' interview transcripts resulted in the generation of three themes for better presentation and interpretation of the gathered information. These themes included the lesson plan and presentation, the search and the design. As mentioned earlier, the questions were asked of both the teachers and the students; these focused on the active engagement strategies and resources, rather than on the chemistry content.

Theme 1: The *Lesson plan and the Presentation thereof*
All the lessons were planned and presented, according to a competency-based framework from the Ministry of Education and Vocational Training (MoEVT). The teachers prepared a written lesson plan for each lesson that was to be observed. Additionally, the learning objectives (success criteria and the learning intentions) for each lesson were well stated in the lesson plan; and these were shared with students before and after every lesson. The sharing of the success criteria and the learning intentions was seldom done by the teachers before the beginning of the study.

The observations done at the beginning of the teaching and learning process using the designed intervention revealed that the teachers mostly preferred the lecture method. For example, it was observed that teacher A was largely using a textbook to teach; while teachers B and C used notes, which are not currently available. When they come to chemistry lessons they mostly talk, write on the board, and rarely involve any of the students.
"……Surely with this number of students, I just use my Oxford textbook to prepare notes to at least cover the content in the allocated time. The preparation of the materials is a challenge for some reasons. …..Firstly, it consumes a lot of time, which could have been that of used to teach ….therefore, with this number of students in the class, the preparation of the learning materials is another disturbance. …."again we have too much to cover" **(Interview, Teacher C).**

"….Frankly, I cannot pretend that it is not hard for us to prepare the lesson notes with their corresponding learning materials; since we have too much to cover. To do all those activities requires one to search from various sources, in order to understand those materials that correspond with the lesson content" **(Interview, Teacher B).**

The students were only involved when they were supposed to answer questions, such as "Are we together? Understood? Is it clear? Can I carry on? However, the answers given by the students were also general, which could not be enough to verify whether the concept was clear. However, the teacher could carry on with the lesson. The students in FGDs expressed a similar view, as the statements below demonstrate.
Carol: "*Our teacher normally teaches and gives us notes to write*".
Jeff: *"The learning style you introduced is new; I can say we are not familiar with it"*.
Halima: "We *are many in the class, so we cannot be involved in classroom activities"*.
Khauthal: *"Our teacher normally talks and writes notes on the blackboard for us to copy…..It is very rare to be asked questions, or for us to get involved in discussions among ourselves."*

However, with time, interactive teaching methods like group discussions, paired with some hands-on activities, were adopted. Teachers allocated students in respective groups before the lessons based on students' needs, and abilities, as well as ensured gender balance. During the group discussions, students were observed to be able to design various learning materials and solve some problems in the given activities of the lessons within their groups; and they were sometimes told to answer directly, or to make attempts on the blackboard.
"….first allocating students in groups makes them come together, and to combine their ideas to work for the materials and attempt various working activities that are given to them. These days, I don't use much energy to engage the students in the lesson. Together in their groups, they prepare and present some concepts related to these topics that you have put more emphasis on in your work. In their groups, they co-operated and used the learning materials they design to ensure the questions given to them are well prepared and ready for presentation to the whole class." **(Interview, Teacher C)**

Also, students were able to freely move around to check on the materials prepared by other peers and how they were able to implement the prepared equipment. Besides, individual students could collaborate with other group members to ensure that the equipment is designed, based on the learning intentions and the objectives of a particular lesson.

Theme 2: *Search*

The learning intentions and the objectives for a lesson were always shared by the teachers before and after the lessons, in order to give students the prerequisite knowledge of content to be learnt in the coming lesson; and to be able to associate the content with the materials in their environment that could enhance their learning. The students prepared themselves for the next lesson by going through what was to be taught and searching for the instructional materials that corresponded with the specific chemistry content. However, as time went by during the intervention, both the teachers and the students seemed to enjoy the use of hands-on activities; because they both realized that the teaching strategy was possible to implement; and it was fruitful. This means that there was a gradual paradigm shift; from being more teacher-centred to becoming learner-centred; and the students had great joy while searching for their instructional learning materials.

This matter is amplified in the teachers' and students' statements below.
*"After the guidance given to my class during the orientation, searching for materials related to what is supposed to be learned has been engaging, especially when students are aware of what is going to be learned in the next lesson"***(Interview, Teacher C).**

"I have learnt that it is important for the materials used in teaching and learning to be interesting and to motivates learning in classroom sessions; and that it can continuously be used by students outside the classroom" **(Interview, Teacher B).**

"…if the objectives of the lessons are shared with the students, they normally take their time to search for appropriate learning materials….You see these days, the syllabus is

available to the students; and they always know what is going to be taught in advance. Therefore, being familiar with the content, designing of materials does not become an issue to the students." **(interview, Teacher A)**

To complement the two statements given by the teachers, Jeff and Vanesa (not real names) in different FGDs sessions said:
Jeff: *"….Normally at the end of each lesson, our teacher informs us about what is going to be learned in the coming chemistry lesson…. By doing that, we can easily look for materials that would facilitate active participation in the lesson and co-operation in our specific groups."*

Vanesa: *"…..Interestingly, these days you can pace on your own and interact with the content, while thinking of the materials that correspond with it….. Frankly, these days it is not a hustle to understand what the teacher teaches…..because when the teacher comes to the class, it becomes like repetition…… this kind of repetition strengthens our understanding."*

Theme 3: *The design*

The lesson observations revealed that different materials obtained from the learners' environment were partly used to engage learners in mole-concept lessons and to design/prepare various volumetric analytical apparatus. It was also realized that when students get the proper teacher guidance, they fully engage themselves in hands-on activities, as well as searching for quality learning materials.

The teachers said in the interview:
"…..imagine what happens when students, who are the major concern of the learning processs, are positioned in a role of a manufacturer…..this time manufacturing equipment that is going to be used for their learning. You would find them concentrating and they would dedicate much of their efforts to designing neat equipment. ….for instance, when you assign them to make a pipette from fabricated materials, students would do their best effort to make a well-calibrated apparatus." **(Interview, Teacher A)**

"…when students are given a task to design learning materials, they take time to think, read, explore and come out with materials appropriate for their learning. Sometimes, the task of designing the materials is taken as competition between themselves, whereby each group desires to design better and more durable materials than any other group." **(Interview, Teacher B)**

"……Well, if students are engaged in various activities in the lesson, they feel belongingness; and they tend to own the learning process, so, yeah, they seem to enjoy the making of learning materials; and they can show that they've participated in the process by looking at how they practically use those materials in hands-on activities." **(Interview, Teacher C)**

The students managed to make some apparatus on their own by using home-based materials. They used materials like empty waterbottles of different sizes, syringes of different sizes, rubber bands, and pegs to prepare the locally made apparatus used during volumetric analytical lessons. Some of the apparatus served as beakers, burettes, droppers, and funnels. Some of these materials are published in (https://doi.org/10.29333/ejmste/10856 and https://doi.org/10.36681/tused.2021.93).

With the appropriate apparatus made by the students, teachers prepared solutions for simple titration experiments, which students used to perform the experiments in their respective groups. This was directly expressed in the FGDs excerpts as follows:
Katoto: *"….I enjoy using materials, which I had used my own ideas to make."*

Marina: *"…if the system like this continues, I think we will be able to design even complex equipment that could not be imagined, simply by using the materials we see around us."*

Niki: *"….these days I ask my father a lot of questions, if I fail in some steps or I don't get an idea that could guide me throughout the process. This is because I want to design good materials. Sometimes I ask my eldest sister; or I search through the internet until I succeed in designing the materials I want."*

Lincoln: *I managed to make a burette, simply by using a transparent pipe, rubber, the tube of a pen and a clothes' peg. I only faced some challenges in labelling the exact volume. But when I came to school I used the pipette in the laboratory to calibrate the volume."*

Considering the responses from both teachers and students, as well as the observations made in different lessons, it is clear that when students are well guided to engage in hands-on activities, they can own the learning process and help each other throughout the lesson. Not only so, but they have also participated in lesson preparation by searching and designing learning materials.

4. Discussion

This paper gives evidence that it is possible to successfully engage students in the chemistry-lesson process by involving them in searching and designing the appropriate learning materials, in order to render the learning process active and engaging. Engaging students in searching for appropriate materials relevant to a particular subject matter makes the process of learning continuous. Teaching chemistry content should not only be the priority of learning; but chemistry teachers can value the design of learning materials as a way to present chemistry content knowledge to their students (Stammes et al., 2020).

Students can continue being in a learning mood outside the classroom environment, especially when they associate different materials in their immediate environment with the subject of interest. Searching and designing learning materials is a very useful and important aspect of the learning process, despite this not being included in the learning standards (Vos et al., 2010). For instance, thinking of what materials can be used to make apparatus like conical flasks, pipettes, burettes, and measuring cylinders remains a challenge in students' minds all the time, until they successfully make such apparatus. In the context of this study, therefore, designing learning materials was considered to be a part of the learning process. (Stammes et al., 2020)

Students who participated in the study had no previous experience in searching and designing instructional materials. Teachers used to design only a few learning materials that were only used for demonstration of the lesson content. The few learning materials designed by teachers could not be enough for all the students in one classroom session. This was evident at the beginning of the intervention. In the interviews and FGD conducted in the first week of the intervention, both the students and the teachers reported how, initially, they saw the intervention as an inconvenience, interference, and time-consuming exercise. As the intervention progressed, both the teachers and the students became accustomed to the intervention; and eventually, they enjoyed the lessons.

However, researchers recommend the use of design to help students develop an understanding of any new concepts (Alkan, 2019). This has led to some countries dedicating effort to the design of learning materials, in order to stimulate context-based chemistry education (Prins et al., 2018). During the intervention, students managed to prepare the apparatus used for titration procedures by using materials from their immediate environment. The locally made apparatus was a solution to the scarcity of laboratory equipment, which hindered students' frequent experimentation (Galabawa, 2008; Machumu, 2011).

Previously, the available equipment was reserved for examination classes (Mafumiko, 2006). Therefore, with the locally made apparatus, titration activities were conducted practically, thereby making the process of learning a reality.

The findings from the lesson observation and FGDs indicated some improvement in the learners' active engagement in the lesson, whereby learners seemed to be more active a few weeks after the intervention than at the onset of the intervention. Teachers should persist in traditional views of chemistry education concerning students' chemistry-content knowledge (Stammes et al., 2020), rather however. they should take a more contemporary perspective by valuing design as an approach to address soft skills like curiosity, creativity, meta-cognition and problem-solving skills (Ibe et al., 2021).

This is also consistent with previous research reports (by (Freeman et al., 2014; Jensen & Lawson, 2011; Prince, 2004). The research report by Freeman et al. (2014), indicates that the instructional method had a minute effect on the learners' achievement when measured by using Bloom's taxonomy. Some effects were detected on learners' active learning, for instance, students gained the ability to learn independently, which was minimal before the intervention. Besides, it is clearly stated in 'pragmatism' by Dewey that the ability of the individual student is strengthened through shared experiences (Sikandar, 2016).

Engaging students in hands-on activities enhances students' active involvement in chemistry lessons at the individual level.

Also, with time, students gained the ability to search for learning materials, and to actively use them for learning the respective content during chemistry lessons. In addition to acquiring skills to search for materials and active engagement in the lesson, the intervention enabled students to improve their reasoning and ability to respond to given activities with confidence, as proposed by Khoiriyah et al., 2015; Pirttimaa et al., 2017. Thus, it can be noted from the findings that the intervention contributed to students' reasoning, exploratory ability and active engagement in-class activities.

Although all the teachers went through a similar orientation and the students from the participated classes went through training before the commencement of the intervention, the students from school C seemed to grasp the instructions given by the teacher more quickly than the students from the other two schools. As Prins et al. (2018) found, we saw some variation in the learning materials designed by the students. Perhaps, teacher guidance (Cirenza et al., 2018) might have been the cause of the difference in the quality of learning materials made by students from school C. Also, students' active participation in school C was possibly due to close mentorship and scaffolding of the teacher, as suggested in Vygotsky's ZPD concept of socio-cultural theory (Fani & Ghaemi, 2011).

Proper guidance of the teacher enhances students' collaboration with other peers and better interaction with learning materials (Fani & Ghaemi, 2011; Glassman, 2001; Lui, 2012). To the teachers, design and the searching of learning materials seemed to mean having the opportunity to address mentorship and scaffolding in chemistry education which highly motivated them to include design practices in their teaching (Stammes et al., 2020). Additionally, students can perform above their current level of knowledge, while collaborating with other peers of higher ability, rather than when they work independently (Fani & Ghaemi, 2011). Indeed, active learning takes place and less memorization is expected, when students collaboratively learn together with others (Jensen & Lawson, 2011). According to these authors, active learning is due to the helping behaviour to effect that which occurs within the groups. This finding is in line with the findings of this study, where the peers in the groups helped each other with the tasks done within the groups and showed less memorization.

Given the above differing empirical results and the theoretical perspectives employed in this work, we evaluated the success of the intervention in the use of home-based learning materials designed by students to be used in hands-on activities during chemistry lessons, to have an impact on the development of learners' active learning and their acquisition of soft skills. Furthermore, the findings of this study contribute to the improvement of educational practices, instructional designs, and other related literature in chemistry education.

Little work is evident on active engagement in searching and designing chemistry learning materials in the context of community schools. Therefore, this work adds to the literature to improve educational practice, as well as the need to engage students in activities, consequently putting them at the centre of the learning process.

Regarding the limitations of this research, the learning materials developed for this study and the content thereby facilitated, were based on two topics in the

Chemistry senior three content syllabus. This is because an in-depth understanding of the association between the learning materials and the content was required. The iterative nature of the DBR design used in the study also required developing prototypes of the same materials. Furthermore, since the study allowed successive reviews of the materials, it was possible to identify and overcome weaknesses in the design of the materials.

If the procedures to make these materials are clearly outlined, it would be easy to design more materials from other topics in the Chemistry syllabus and other science subjects. Additionally,, the study covered only hands-on activities in Chemistry, particularly the learners' ability to search and design learning materials. This is because many Chemistry concepts can be demonstrated through hands-on activities, as well as both practical and theoretical concepts. Additionally, the study was limited to only three community secondary schools, in order to establish a deep understanding of the identified problem and to ensure that the research participants became accustomed to the designed intervention.

In this regard, future researchers should increase the population of the sample to improve the reliability and the generalizability of the research results. Thus, triangulation of multiple methods were utilised, in order to minimize the mentioned limitations.

5. Conclusion

With this study, a body of knowledge on searching and designing learning materials in chemistry has been built; because the learning materials designed were useful for chemistry learning in community schools. This study was carried out to enhance senior three chemistry students' ability to search for and design chemistry learning materials that could be used in hands-on activities, to stimulate students' active engagement in the learning process.

What differentiates the present study from others in the same field is the fact that the study focuses on students' ability to work independently to make learning materials from home-based materials. Other studies mostly engage teachers to enhance the learning process; and they rarely emphasize the need for the learners to work on their learning materials, especially in the context of community secondary schools.

From the results, we can conclude that engaging students in the process of searching and designing the learning materials to be used in chemistry lessons enhances learning to become a continuous process from the classroom to the outside environment; and it prepares the students for lifelong learning. Based on the key findings obtained from this research, it is recommended that more emphasis should be placed on learners' abilities to search and design the learning materials – not only in chemistry – but also in other science subjects of a similar educational context to the research participants, as those of this study.

The study brought about a paradigm shift from teachers being the centre of all aspects of the learning process, by empowering learners to take control of their learning and to reduce the workload of the teachers. Consequently, making learners the centre of the learning process can create a meaningful learning environment which in turn would enhance the nurturing of a generation of independent learners, equipped with skills essential for the fast-growing 21st-century world economy.

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APPENDIX A
Focus group discussion (FGDs) guide

The focus-group discussion was mainly for students; and the following questions guided them throughout the discussion.

a. Introduction of the researcher and the students, who were involved
b. Researcher gives guidelines of the discussion
c. Are you taking chemistry and what do you think is the importance of studying chemistry?
d. What should teachers do to improve the way you are learning chemistry?
e. What can you say about this way of teaching, in which the teacher involves you in hands-on activities? (Probe, depending on the answer)
f. Do you think it is good to search and for your own learning materials? (Why do you say that?)
g. In what ways can this strategy be used to help you acquire desired competences and learning skills?
h. What suggestions do you have for improving the next lessons?
i. What else would you wish to add?

APPENDIX B
Semi-structured interview guide for teachers

Interviews for all teachers started with the introduction of each other, in order to establish rapport with teachers and to make them free to talk. Thereafter, the following questions guided the interview:

a. What can you say about this learner-centred teaching approach, which involves learners in different activities during the lesson?
b. Has this strategy been helpful to you (probe; how)?
c. How do students perceive the issue of involving them in hands-on activities?
d. What about being involved in searching and the designing of learning materials?
e. How are students interacting with learning materials?
f. What could be done to improve this instructional strategy and to make it more useful to your teaching practice?
g. What challenges have you encountered in using this instructional strategy?
h. Are there any other things related to chemistry, instructional strategy and instructional materials that you think are important to consider? (What are they?)