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Using Easily Accessible Resources to Teach Acids and Bases: A Namibian Case Study

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ABSTRACT The aim of the study was to explore context based teaching and learning approaches in Namibia using the local improvised instructional materials to teach acid and bases concepts in grade 9. The study is located within an interpretive paradigm as an in-depth study of exploration using easily accessible resources as instructional materials with a grade 9 (27 learners). While the findings revealed that learners did not know that acids and bases exist in their surroundings, it emerged that after the scaffolding by the researcher, learners managed to mention quite a number of local acidic and basic materials. The finding further showed that, conducting practical activities with the improvised instructional materials resulted in the same level of performance as the standardized instructional materials. Therefore, probing of learners' prior everyday knowledge during instruction and usage of improvised instructional materials was a good indicator in promoting conceptual understanding and learner engagement.

INTRODUCTION

Instructional materials used in teaching science help enrich learning, but the lack of these materials in the classroom makes teaching and learning less interactive and more difficult to understand. Of late, the Namibian education system has become examination-oriented, where passing examinations especially in the externally examined grades (grades 10 and 12) is the only benchmark for performance because there is less monitoring of learning achievements at other levels within the education cycle (Simasiku et al. 2015). This has resulted in teaching for examinations and not for conceptual understanding. Many schools in the rural areas lack most of these instructional materials for teaching and learning science. The inadequacy of these materials has been of serious concern to science teachers in rural areas (Aina 2013). In developing countries, there are high expectations from teachers despite the scarcity of resources to achieve these goals (Lingam and Lingam 2013). However, the limited instructional materials they have at their disposal can be improvised and used maximally in absence of the standardized ones in order to bring about the same learning results as the standardized instructional materials.

Purpose of the Study

The main aim of the study was to explore context based teaching and learning approaches in Namibia using the local improvised instructional materials to teach acid and bases concepts in grade 9. This was necessitated by the fact that most schools in rural areas lack the standard (conventional) instructional materials to teach acids and bases concepts. In this study, local improvised instructional materials were produced and designed to teach the acids-bases concepts and these materials may serve as alternative instructional materials to teach science in schools, especially in rural areas where there are limited resources.

Significance of the Study

As a science teacher from a developing country, teaching science in these areas can be very difficult, since it is taught from a more theoretical standpoint and lacks the practicality of concepts. This is attributed to the lack of resources in these areas. This study aimed to explore learners' prior everyday knowledge and the use of appropriate local improvised materials instead of the standardized materials for teaching of acids and bases concepts in science in order to enhance students' interest and conceptual development.

This study answer the following research questions:

- What prior everyday knowledge related to acids and bases do grade 9 learners bring to the science classroom?
- Do improvised instructional materials enable or constrain learner engagement?

Review of Literature

In Namibia, the four goals of education are geared towards the learner-centered approach and thus seek to address the role of culture in education (Ministry of Education 1993). One of the thrusts of learner-centered education (LCE) is that teachers should begin with the known to the unknown. Learner-centered teachers teach students how to think, solve problems, evaluate evidence, analyze arguments and generate hypotheses, and all those learning skills are essential to master material in the discipline (Thompson 2012). LCE sees a learner as an active, inquisitive human being, eager to learn and to investigate in order to make sense of his or her surrounding world. Thus, the knowledge that the learner brings to school from home, the community and the environment should be utilized and drawn into teaching and learning. Research consistently confirms that learning skills develop faster if they are taught explicitly along with the content and contextualized (Thompson 2012).

Science is a difficult subject to teach, especially in rural areas. Most teachers believe that lack of access to resources and equipment to teach science in these areas is a major obstacle to effective teaching (Laidlaw et al. 2009). The unavailability of resources in rural schools restricts the teachers' ability to be effective in facilitating teaching and learning process. The provision of an enriching educational experience relies on adequate resources in schools, such as science materials and equipment. Making instructional materials accessible is recognized as vital in providing better learning opportunities to learners. The scarcity of resources has a negative influence on the quality of education in remote schools. Inadequate resources for teaching and learning usually result in teachers having a less positive impact on learners' development (Lingam and Lingam 2013). Teachers play a vital role in any education system, and students' learning in the classroom, but the quality of delivery has been adversely affected in rural schools due to challenges they faced such as lack of adequate resources (Shadreck 2012). There is a need for teachers to use indigenous materials in place of the standardized instructional materials to enhance teaching and learning especially in rural areas where resources are scarce.

The traditional methods of science teaching and learning are today widely regarded as rigid, stereotyped and syllabus bound (Mayer 2008: 252). For instance, textbook knowledge has been, and to some extent still is, the focus of knowledge dissemination. This is exacerbated by the fact that rote learning of scientific formulae and definitions, accompanied by lengthy explanations, is still believed to be the acceptable method of science teaching. Instead, one of its limitations is its failure to make connections between classroom instruction and learners' everyday life and experience (Stears et al. 2003; Oloruntegbe and Ikpe 2011; Kuhlane 2011; Rennie 2011). Yet, prior everyday knowledge plays an important role in learning.

Richey and Nokes-Malach (2013: 106) describe prior everyday knowledge as "raw materials to be refined", this raw material being what learners already know about the topic or lesson to be learned. Past work on self-explanation suggests (Richey and Nokes-Malach 2013) that prior everyday knowledge may play a particular important role in learning science from self-explanations, as learners who lack sufficient prior knowledge may not be able to construct meaningful explanations. From the perspective of learners, it could be argued that learners come to class with different understanding and knowledge bases gained from different experiences. Such knowledge and experiences could help them form new ideas during the teaching and learning processes. It is recognized, however, that this prior knowledge could be at odds with meaningful understanding of the subject matter (Simasiku et al. 2015). Hence, teachers need to clear up certain misconceptions pertaining to teaching and learning repertoires. To this end, Kibirige and Van Rooyen (2006) point to problems that can arise when teaching ignores learners' everyday knowledge and value systems, arguing that, for example, learners' enthusiasm and motivation can be diminished. They thus believe that it is important that teachers start from where the learners are in order to facilitate their learning whilst preserving their enthusiasm and motivation. Furthermore, improvised materials have been used across a number of scientific disciplines. For example, Ahmed (2008) presented in his study some biological instructional materials that biology teachers can improvise to replace the standardized ones. Biology teachers may find materials from their local environment that they could improvise without losing the originality of the concept being taught. Examples of these improvised materials include replacing D.N.A. models with stripped cardboard for illustration in teaching genetics, using clothes hangers (pegs) instead of test-tube holders, replacing measuring cylinders with graduated feeding bottles for measuring liquids and so on. Onasanya and Omosewo (2011) discovered in their study that the use of improvised instructional materials have the same importance in the teaching and learning of physics. This study's results showed that both improvised materials and standardized materials were successful in teaching the students. Oloruntegbe and Ikpe (2011: 267) further suggest that building on the relevant experiences of learners from whatever background through a 'place-based' approach to learning within a framework of experiential education could heighten their motivation and enhance their performance in basic science. Stears et al. (2003) also maintain that learners' everyday knowledge should be used as a reference point in thinking about the nature of science, and as a context for applying scientific ideas and skills. Their research revealed that the use of everyday knowledge in the science classroom increases the levels of engagement of learners in the subject. Learners enjoy making links between their everyday experiences and science in the classroom when the curriculum is designed to facilitate such links. Stears et al. (2003) further add that in order to acquire knowledge, learners should be actively involved in a community of practice in the science classroom.

The use of locally produced instructional materials in teaching and learning has many advantages (Ahmed 2008). The use of improvisation in teaching makes the concept more practical and subsequently reduces abstractions. In addition, they are cost effective, because they could be obtained from the local environment. They are generally very safe to use during demonstrations and practical activities, and it might not be capable of inflicting injuries, which means it could be hazard free. In addition, they serve as a motivation to learners in as much as they participate in the activities during the production of the materials and arouse learners' interest. Moreover, the use of these materials minimizes concerns about breakage, repair and loss since they are readily available in the environment. It informs both students and teachers that alternatives for some of the conventional science teaching materials are possible. It also shows that people can do scientific experiments with the materials around them.

On the other hand, most improvised materials lack precision and accuracy in measurement, which may eventually undermine the exact outcome of the experiment (Aina 2013). Sometimes the cost involved in designing these materials may be more expensive than buying the standardized materials. Additionally, the available materials may not be suitable or appropriate for the lesson and can subsequently yield unexpected results. This can make learning more difficult and frustrating. The improvised materials may not be enough to teach a big class. Furthermore, improvisation demands creativity, adventure, curiosity and perseverance on the part of the teacher, and such skill can only be realized through training programs with the instructional materials. The perception of some teachers towards improvisation could also affect other teachers positively or negatively in the production of instructional materials.

METHODOLOGY

This study is located within an interpretive paradigm as the researchers wished to gain a deeper understanding of teaching and learning using local improvised instructional materials to grade 9 learners in the Namibian context. The approach was mostly qualitative and the research design is that of a case study as one of the researchers was teaching grade 9 physical science at the time of this research, thus, allowing the researchers to obtain a holistic and in-depth understanding of the situation (Punch 2009). The site represents a natural setting as the researchers conducted the research in the participants' school. Twenty-seven learners (9 boys and 18 girls) were by default chosen, as there was only one grade 9 in the school. Therefore, the sample was conveniently selected.

Research Instruments

Videotaped Observation

All lessons were observed by a friend and videotaped. An observation schedule was used to record the teacher and learners' actions during the physical science lessons. Cohen et al. (2010) posit that observational data help the researcher to generate information from a real situation or context, and thus enable the researcher to engage with and comprehend the described situation.

The purpose of these observations was to observe how the learners use their prior everyday knowledge and experiences during practical activities using local improvised instructional materials commonly used at home. Conventional science apparatus and indicators such as litmus paper, phenolphthalein solution, and hydrogen chloride solution were also used, to compare them with the easily accessible resources. With the help of videotaped lessons, the researchers hoped to see how learners interacted and shared their views with others in their various groups. Furthermore, the researchers hoped to see how they interpreted and understood concepts associated with acids and bases.

Focus Group Interviews

Focus group interviews are described as deliberately created, bringing together a specifically chosen sector of the population to discuss a particular given theme or topic, where discussion with the group leads to data and outcomes (Cohen et al. 2010). Based on the above explanation, three focus group interviews comprising of nine learners each, were then conducted after the lessons in order to find out how they had experienced the lessons and what scientific concepts they had learnt concerning acids and bases.

In each focus group, interview questions were asked in English and translated into the learners' vernacular, which is Oshiwambo. In addition, learners were allowed to speak in the language they were comfortable with so that they could express their opinions, ideas and true feelings about how the lessons were, rather than possibly distorting these by having them speak a language in which they are not fluent or proficient.

Procedures

During the brainstorming session, learners were implored to name materials that are acidic or basic. The class was divided into groups, and each group was provided with newsprints on which to write down things they thought contained acids or bases.

Then, practical activities were performed. The practical activities involved the use of standardized instructional materials and improvised materials to teach these concepts (acids and bases). The materials used included standard litmus paper and pH paper. These materials were used to test prepared solutions of household materials, which are considered to have acidic and basic properties. The solutions prepared included orange juice, lemon juice, tomato juice, soapy water, wood ash solution, milk, shampoo, vinegar and baking soda solution. Then, improvised acid-base indicator and pH paper were produced and designed using red cabbage juice and card stock to test the same solutions.

RESULTS

The results of this research are discussed in the context of the two research questions.

Question 1: What prior everyday knowledge related to acids and bases do grade nine learners bring to the science classroom?

The purpose of the brainstorming session was to find out if learners were already familiar with acidic or basic substances. From their responses, it emerged that most learners were not familiar with what acids or bases were. However, after some hints were provided, such as anything that has a sour taste or anything that can be used as a cleaning material, then the responses reported in Table 1 emerged.

All the materials listed in Table 1 are found in their local vicinity and wild fruits found in the forest surrounding their homesteads. All fruits mentioned are edible by humans and they do have a sour taste even when they are ripe. With regard to most of the fruits mentioned, learners stated that they were also used to make *ombike* (a traditional Oshiwambo alcoholic drink that is very strong). With regard to bases, learners were able to come up with locally available materials

Table 1: Learners' prior everyday knowledge on acids and bases

Local materials known to be acidic	*Translated names in English*	*Frequency*	*Local materials known to basic*	*Translation in English*	*Frequency*
Ombeke	Sour plum	11	*Omutoko*	Wood ash	7
Onkenkete	Buffalo thorn fruit	5	*Mbundjambundje*	A smelly and sticky plant that grow in the mahangu field	5
Oombu	A sour-sweet fruit	3	*Elyata*	A thorny plant that grows in the forest	4
Ooshe	A local sour-sweet fruit (known to be a delicacy of San people)	3	*Kanangalambundje*	A small wild plant	5
Oonkwiyu	Cluster figs fruit	6	*Katangakamuthithi*	A small wild plant that grows in the mahangu field	7

that they thought contained bases, after a little bit of scaffolding. This proved that it was learners' first time to have had encountered. As one can see from Table 1, none of the conventional laboratory acids or bases was mentioned.

Question 2: Do improvised instructional materials enable or constrain learner engagement?

Two guided practical activities were used to answer this research question. Both the practical activities were performed using standardized and improvised instructional materials in teaching of acids and bases concepts. Firstly, learners used the conventional materials to test if a solution was an acid or a base and subsequently tested the pH scale for each solution as well using the standard pH paper. Different groups of learners were taught the same concepts with improvised instructional materials. Learners designed and brought the improvised materials to replace the standardized ones in order to determine if the solution was a base or an acid and tested the pH of each solution as well using improvised pH paper designed. Table 2 shows the results from the first experiment. In the second practical activity, learners carried out a titration experiment using standardized and improvised materials as well. Table 3 presents the results from the experiment.

Table 2: Results from both experiments

Substance	*Litmus paper (color)*	*Acid/ bases*	*Red cabbage juice (color)*	*Acid/ base*	*pH paper*	*Improvised pH paper*	*Error of analysis: accepted value-experimental value/ accepted value* 100%*
Baking soda	Blue	Base	Green-blue	base	9	8.5	5
Vinegar	Orange-red	Acid	Red	Acid	2	1.5	5
Orange juice	Yellow-orange	Acid	Yellow	Acid	4	3.5	5
Lemon juice	Red	Acid	Red	Acid	2	2.5	5
Tomato juice	Greeny-yellow	Acid	Greeny-yellow	Acid	6	5.5	5
Milk	Green-yellow	Acid	Green-yellow	Acid	6	6	0
Shampoo	Dark-blue	Base	Purple-blue	Base	11	10.5	5
Wood-ash solution	Dark-green	Base	Dark-green	Base	10	10	0
Soapy water	Purple-green	Base	Dark-blue	Base	12	11.5	5

Table 3: Results obtained from the titration practical activities

Standardized materials			*Improvised materials*			
Vol of wood-ash (carbonate ion) solution to titrate in a beaker	*Vol of 1 mole hydrogen chloride solution used (in a burette)*	*No. of moles of carbonate ion=vol of HCL* conc of HCL * (1 mol carbonate/2 mol of hydrogen ions*	*Vol of wood-ash solution in a cup*	*Vol of 1 mole hydrogen chloride solution used to titrate (1teaspoon= 4.93 ml)*	*Convert Vol of hydrogen chloride solution from ml to Liters*	*No. of moles of carbonate ion=vol of HCL* conc of HCL * (1 mol carbonate/2 mol of hydrogen ions*
20 ml	20 ml = 0.02l	0.01	20 ml	4.05 tsp =19.97 ml	0.019L	0.01
30 ml	30 ml = 0.03l	0.015	30 ml	6.08 tsp = 29.97 ml	0.029L	0.015
40 ml	40 ml = 0.04l	0.02	40 ml	8.11 tsp = 39.98 ml	0.039L	0.019
55 ml	55 ml=0.055l	0.028	55 ml	11.16 tsp = 55.02 ml	0.055L	0.028
65 ml	65 ml = 0.065l	0.033	65 ml	13.19 tsp = 65.03 ml	0.065L	0.033

Vol= volume; HCL= hydrogen chloride; mol= mole; No= number; ml= milliliters.

DISCUSSION

From the brainstorming sessions, for the first research question, the finding revealed that learners were not familiar with what acids or bases. After giving learners some hints, in an endeavor to scaffold their learning that anything that has a sour taste or anything that can be used for cleaning qualified as one or the other, learners were able to provide examples with which they were familiar. This result echoed what Rennie (2011) found that students arrive at school each day with their experiences from their communities but generally they are expected to ignore the knowledge from those experiences. Furthermore, while at school, they have to work with school-based disciplinary science knowledge and understandings that often seem quite narrow and very different from their own experiences (Rennie 2011). Herein lies the importance of mediation of learning by science teachers and as a result learners gave the following examples:

- *Ombeke (a very sour wild berry which is red-yellowish in color when ripens)* (sour plum)
- *Onkenkete (a local fruit known to be eaten by San people. It is also sour whether ripen or not)* (buffalo thorn fruits)
- *Oombu (a local fruit brownish in color, a very delicious fruit for cattle herders, especially young boys)*
- *Ontantahe (wild berries also known to the food of san people)*
- *Ooshe (wild berries also delicacies of young boys when herding the cattle)*
- *Oonkwiyu (fruits from Fig tree)* (cluster figs)

From this list, it is clear that learners were not familiar with the conventional or canonical (Aikenhead 2006; Rennie 2011) examples of acids. It was then up to the teachers to help them connect what they knew to the textbook knowledge. In their study conducted in Nigerian schools, Oloruntegbe and Ikpe (2011) found that some teachers do not encourage learners to connect their daily activities with classroom science and that it was difficult for learners to develop scientific concepts without the help of their everyday life experiences. Similarly, in her research conducted in South Africa, Kuhlane (2011) found out that learners' prior everyday knowledge and experiences were hardly taken into consideration by some teachers during teaching and learning. In terms of meaning making and collaboration, learners greatly appreciated that they were able to share knowledge and ideas when they worked in groups. During the focus group interview, learners testified that they were able to point out each other's errors such as (mixing of *ombeke* (sourplum) and wood ash, instead of a reaction between *ombeke* (sourplum) and wood ash, is called a neutralization reaction) and thus learned from one another. The findings also revealed that learners who normally feared to ask assistance from the teacher had an opportunity to ask for help from other learners and thus received assistance. A finding running through the responses of a critical friend after observation of the brainstorming sessions revealed that there was active participation and excellent engagement in the lessons. The critical friend indicated that learners' concentration was also good, and exceeding her expectations given the type of learners the researchers had at the school during the time of this research. It seemed clear that using the learners' prior everyday knowledge as a starting point for the exploration of scientific concepts and inquiry procedures served to enhance learner engagement and hence meaningful learning.

The findings from the second research question revealed that, practical activities using improvised instructional materials resulted in the same level of performance as the standardized instructional materials, thus enabled learner engagement. From Table 2, nine different solutions were prepared and tested. All the nine solutions in the Table were first tested by a group of learners with standard materials. Standard litmus paper was dipped into each of the solutions, and the color change was recorded as shown in the second column on the Table 2. The results from the test on whether the solution is an acid or a base was recorded based on the color change of the litmus paper as shown in the third column of Table 2. Drops of the improvised (red cabbage juice) acid-base indicator were added to each of the solutions and the color change was recorded in the fourth column of the above table. From the color change, students were able to determine if the solution was an acid or a base. This is recorded in the fifth column. The pH of each solution was determined using the standard pH paper and the results can be seen in column sixth of Table 2. Again, a different group of students tested the pH of the same solutions with the improvised pH paper and the results are indicated in the seventh column of Table 2.

From the titration practical activities, different volumes of one mole of hydrogen chloride (HCl) were used to determine the concentration of potash in wood-ash solutions, as shown in the Table 3. A standard burette and beaker were used in the first practical activity as a control group experiment, to determine the concentration of the volumes of the wood-ash solutions. The number of moles for each of the wood-ash solution was calculated using the formula:

Number of moles = $C^{*}V$

Where, C = concentration and V = volume

An indicator was added to each of the wood ash solutions in the beaker and the color changed to red, then drops of the HCl were added to the wood-ash solution until the solution became clear, and it reached neutral pH. Since the concentration of the HCl solution was known, the concentration of the wood-ash solution was then calculated and this is recorded in Table 3. Then the other part of the practical activity of the titration used the improvised materials to determine the concentration of the same volume of wood ash solutions by using a tablespoon to add drops of 1 mole HCl to the wood-ash solutions in a cup, the number of teaspoons used was counted until the solution reached neutral pH. The concentration of the wood ash solutions were calculated again using the same formula, but the researchers converted the volume of HCL solution that was used with the teaspoon to measure into milliliters, that is 1 teaspoon = 4.93 ml and multiplied 4.93 to the number of teaspoons that was used to titrate to obtain the volume of HCl. The results from both experiments were analyzed and compared. As it can be seen from the findings in the Table 3, that the concentration for the wood-ash solutions for both improvised and standard materials were the same.

Qualitatively, findings from the analyses of the practical activities showed that using the improvised instructional materials resulted in the same level of performance as the standardized instructional materials. This can be inferred from the low error percentage in Table 2. These findings conform to what the research community found. For example, Beard and Wilson (2006: 21) emphasize this by saying that "experience is meaningful engagement with the environment in which we use our previous knowledge to bring new meanings to interactions." Therefore, if learners are not given opportunities to explore their own knowledge and depend only on textbook knowledge, then their cognitive development and conceptual understanding might be superficial. Vygotsky (1978) concurred positing that what facilitates the learning is that moves a child's understanding from individually held "spontaneous concepts" to culturally shared scientific concepts. Learners were impressed by witnessing the reaction between acids, improvised materials, phenolphthalein-changing colors in bases, and when the red color of *ombeke* (sourplum) disappeared when added to the phenolphthalein indicator. Thus, the integration of learners' prior everyday knowledge and experiences with practical activities enabled meaning making and an understanding of acids and bases.

CONCLUSION

It has emerged that probing of learners' prior everyday knowledge during teaching and learning was a good indicator in promoting group discussion and active participation by groups of learners. In addition, learners were able to identify some concepts and thus, to a certain extent, conceptual development on acids and bases was promoted. Overall, there is strong evidence to suggest that eliciting and mobilizing the learners' prior everyday knowledge and experiences and incorporating it into practical activities enables learner engagement and meaningful learning.

In the light of the findings of this research, it was discovered that the improvised instructional materials produced the same performance as standard instructional materials. From the results of the study, it can be deduced that improvised instructional materials were very useful in teaching and learning of the concepts acids and bases.

RECOMMENDATIONS

The improvised materials, which were designed for the study, can be very useful for the rural schools that have limited or lack resources in teaching the concept acids and bases. This study recommends that programs that deal with teachers' professional development should recognize the importance of prior everyday knowledge and its incorporation in teaching and learning. Areas for future research could be to investigate the teachers' attitudes towards practical activities using local materials that learners are familiar with, and learners' perceptions of local materials usage in science lessons.

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