Southern African Journal of Environmental Education, Vol. 29, 2012/2013

Viewpoint Paper
Exploring Educational Quality and Relevance through Integrating Environmental and Social Issues in Science Education

António Armindo Rúben Monjane, Universidade Pedagógica, Mozambique

Abstract

In this research, the researcher and participating teachers endeavoured to explore ways of contextualising chemistry education in relation to local environmental and social issues in two high schools in Mozambique. The research took place in two secondary schools, one in Beline and the other in Maputo. In this study, only the results of the Maputo school are reported on in detail, although the same process was followed in both schools. After undertaking a literature review, and initiating focus-group discussions on the contextualisation of chemistry teaching, and before dealing with the programme contents, a pretest took place in two Grade 9 classes, one in each school. Subsequently, the programme contents were taught in both classes. However, the new contextualised concept of learning and teaching was applied only to one of them. A post-test was held for both streams following the teaching of the programme. The analysis of the pretest findings showed no significant difference between the two classes, whereas the analysis of the post-test findings indicated a significant difference between the two. In the class where the new concept of contextualising the learning within learners' everyday lives was applied, it was found that learners participated actively in the chemistry lessons. This contrasted strongly with the class where conventional methodology was used.

Background

In the last 20 years, the Southern African Development Community (SADC) region has been characterised by political changes across the region. Most southern African education systems have their roots in a colonial history, but these political changes have resulted in improved access to education. Most southern African governments have extended educational access, with a concomitant increase in the number of learners in schools and formal education programmes. In Mozambique, there are, on average, 50 learners per class. Although Mozambique has made good progress in overcoming the colonial backlog in access to education, the task is formidable and will demand a disproportionate share of the country's resources for decades to come as it struggles to achieve the Millennium Development Goal of universal education.

Since a large proportion of the population in Mozambique lives in situations of poverty, environmental degradation, and increased health risk and food insecurity, these are key issues that need to be addressed through the education system. The localised curriculum (LC) policy initiative which requires teachers to include a component of local education in the curriculum, is one means of addressing this through linking the curriculum to the environmental and social issues experienced by learners on a daily basis.

Currently, the classroom situation in high schools in Mozambique is characterised by transmission modes of teaching and learners play a passive role in the process. Furthermore, learning in many cases is disconnected from the context of everyday life. Science (specifically chemistry) classes in Mozambique are dominated by 'chalk and talk' teaching methodologies, and experiments are very seldom conducted. This is mainly due to lack of material and technical equipment in schools and to inadequate science-teacher training. As a consequence, science is poorly understood by most learners. They only acquire a semblance of theoretical knowledge and have few opportunities for the application and development of practical abilities and skills. The result is a low pass rate, especially in natural-science subjects. There is a need for the introduction of new methods of teaching that relate to the everyday contexts of the learners. The possibility exists that this would better assist learners in their reflection on, and interpretation and understanding of, natural phenomena.

Innovative teaching methods would not only serve the purpose of improving the quality of education, but would also serve to help integrate environment and sustainability education into the mainstream curriculum. As such, this study forms part of a broader SADC Regional Environmental Education Programme (REEP) research programme which is investigating the relationship between education for sustainable development and educational quality and relevance, and is focusing on mainstreaming environmental and sustainability issues.

In this particular study, the project method was used as an innovative way of engaging learners in the learning process. In using this approach, the projects were suggested by the teachers, but they were planned and executed as far as possible by the learners themselves, individually or in groups. Such project work focused on not only imparting specific knowledge or skills, but also on applying these and on improving learner involvement and motivation in order to foster independent thinking, self-confidence and social responsibility. The purpose of the project was for learners to develop innovative approaches using their understanding of scientific (chemistry) concepts to improve their lives in the local context. This required learners to not only bring their understanding of the environmental and social needs in their own community to their learning, but also to apply scientific knowledge in these contexts.

Statement of the Problem, Aim and Objectives of the Study

Statement of the problem

After analysing the national school curriculum in Mozambique and the senior-school science curriculum, it was clear that the curriculum is almost entirely decontextualised from learners' everyday lives. This means that the educational content does not reflect the social, cultural and natural environments of the children or the issues they face daily, indicating a strong need to develop a strategy for teaching and learning processes to make education relevant and to bring science into the social, cultural and environmental contexts of the learners. This is despite the national commitment to a localised curriculum, which it appears is dealt with as 'something separate' to the other subjects, that is, localisation or making links between subject content knowledge and everyday life and experiences of learners is not considered in mainstream subjects such as science.

Aim of the study

To explore ways of contextualising chemistry education in relation to local environmental or social issues in two high schools in Mozambique.

Specific objectives of the study

- To establish how chemistry topics are taught at the schools;
- To explore with teachers and learners how these topics could be better contextualised for the learners through projects that relate to local environmental or social issues;
- To assist teachers in developing and implementing contextualised lessons plans and using a project approach; and
- To evaluate the use of the concept of contextualisation of learning in the curriculum.

Contextual and Theoretical Framework of This Research

Quality education in the Mozambican context

The National System of Education (SNE) in Mozambique was introduced in 1983. It is the first system designed by Mozambicans themselves after independence. Before 1975, Mozambique's education system consisted of missionary schools, public schools and private schools (IESE, 1983). The missionary schools catered for the 'natives', mainly in the rural areas. The public schools catered for the Portuguese and the 'assimilados'.[1] These were located mainly in the urban areas. The private schools (mostly church-owned) were mainly for the well-off Portuguese and 'assimilados'. One of the characteristics of the pre-independence education system was that it was very selective, and this selectivity has been retained by the post-independence education system. The SNE comprises five subsystems, namely: General Education; Adult Education; Technical/Vocational Education; Teacher Training; and Higher Education. The education system is organised into three levels: primary, secondary and higher education.

In 2000, the Ministry of Education initiated the process of decentralising curriculum development and monitoring. This system allows 20% of the national curriculum for basic education to be the 'local curriculum' (referred to as the 'localised curriculum initiative' above), implying that this portion of the curriculum was to be developed locally (INDE, 2003). This is one of the major innovations of the Basic Education Curriculum Transformation in Mozambique Programme. It is expected that the 'local curriculum' will provide for the specific learning needs of the learners.

The UNESCO Institute for Statistics (2009) presented reading and mathematics achievement levels as indicative of educational quality in southern and eastern African countries. Comparing Mozambican education quality with other southern African countries (South Africa, Botswana, Tanzania and Zambia), it was concluded that education quality in Mozambique was very low.

In Mozambique, UNESCO's programme, Families without Illiteracy, trains children to teach their own families to read and write. Partly as a result of this initiative, illiteracy in Mozambique has dropped from 90% to just less than 50% today UNESCO (2009).

While high educational quality is a widely recognised and shared educational objective, there is less agreement about what is meant by the concept and what it entails in practical terms. Gutek (2009) explains that the concept means different things to different people, depending on their perspective. Alexander (2008) blames the lack of clarity of what is meant by quality in education on the fact that the debate is dominated by policymakers instead of practitioners in the field. This results in more attention being given to inputs such as expenditure, teacher-to-learner ratios and textbook supply rather than to the teaching and learning processes.

Approaches to education quality relevant to this research

Tikly and Barrett (2009) differentiated between two major approaches to thinking about quality in education, namely the human-capital approach and the human rights approach. Their reflections on education and the relevance of education are also applicable in Mozambique. We believe that a person who has access to quality education can react against, and respond to, all kinds of injustice. An educated person is also well prepared to contribute to economic growth in his or her community, country and region.

A more recent and very promising approach to analysing education quality is based on Amartya Sen's (1999) notions of 'capabilities' and 'functionings'. Sen uses these concepts as alternative measures of human development, as opposed to increase in personal incomes or in the amount of material goods that people accumulate, measures that are favoured by the human-capital theorists. He defines 'capabilities' as the opportunities that individuals have to realise different 'functionings' that they may have reason to value (Sen, 1999). In this research, and in relation to questions of educational quality, this would mean that learners and teachers need to be involved in ways in which the curriculum gains meaning for them with respect to those aspects of life and being that they have reason to value. Also, it relates to how the curriculum can assist learners to turn their resources (personal, environmental and social) into valued beings and doings or functionings (see Chikunda, this volume). A contextualised curriculum has potential to enable such conversions to occur, as it is likely to assist learners with meaning-making and in developing a better understanding of the relevance of the subject content knowledge that they are acquiring for everyday life and decision-making.

Four perspectives (*society*, the *child*, the *teacher* and the *learning context*) on pedagogical quality focusing on children's opportunities for learning and development in preschool are suggested by Gutek (2009). This study explored how these four related aspects of pedagogical quality can be used for evaluation, to discern pedagogical quality as a whole and to understand how quality is experienced and valued from different perspectives; in this case, the science education chemistry curriculum. It is said by Burbules and Berk (1999) that developing critical thinking, reflexivity, and decision-making skills in learners, and involving them in democratic processes in their learning, better equips them to not only understand their work better, but also be become lifelong learners. These abilities are considered essential outcomes of transformative learning, which Merriam and Caffarella (1999) codify into three distinct phases: critical reflection; reflective discourse; and action.

Methodology

Overall study design

The study used a *participant–researcher case study approach*. It is a case study of two high schools, one in Bilene (located in a rural area) and the other in Maputo (located in an urban context) so that comparisons could potentially be made between the schools. This is not the focus of this article, as only one case is reported on in detail; the Maputo case. Initially, a number of teachers were interviewed, but, ultimately, the researcher worked closely with a single Grade 9 teacher and a group of Grade 9 learners in each school. A pretest was conducted in two Grade 9 classes in each school, but the new contextualised concept of learning and teaching was only applied to one in each case.

In this research, the learners also carried out practical activities (water analysis and treatment) following the principles of the project method proposed by Knoll (1995). Learners were divided into groups, and each group had to develop specific activities.

The selected project method has several steps: the teacher and the learners examine a particular environmental topic, they choose a problem that is important to them, and then they develop and carry out an action plan (Kilpatrick, 1929). With each step, the learners become increasingly independent in engaging with the environmental topic. Responsibility is passed on gradually from the teacher to the learners.

Overall, the study was structured into a baseline phase, a development and implementation phase, and an evaluation phase. Each is discussed briefly below.

Baseline phase

The baseline phase involved conducting semi-strutured interviews with teachers involved in this study. This was to establish how they teach chemistry topics and whether these topics are contextualised in everyday life for the learners. Seven teachers were interviewed at each school, but only two continued with the implementation phase of the study. Documents were also analysed. These included analysis of the lesson plans for particular chemsitry topics. This was done to futher understand what and how teaching takes place in the classroom.

Pretest and post-test

Before dealing with the programmed contents in one of the two classes in each school, a pretest took place in two classes in each school (Groups A and B), and, after that, the programmed contents were taught in both classes, with the new contextualised concept of learning and teaching being applied to only one of them (Group A). Subsequent to the running of the programme, a post-test was held for both streams (A and B).

Development and implementation phase

Since it would have been difficult to work with a large group of learners, a small number (20) of Grade 9 science learners in each school was randomly selected to participate in *focus-group discussions* and *workshops* on a particular science topic (water). The purpose of each workshop was to select a particular chemistry concept, and then identify ways that would help them relate to it better, based on their own backgrounds. The learners needed guidance in this regard, as it was difficult for them

to identify social and/or environmental issues associated with a particlar concept. Following this, the researcher worked closely with the teachers to help develop materials and prepare lesson plans covering particular chemistry topics, and for Group A lessons that could contextualise the topic to the problem scenario (using water). When these topics were taught in the classroom, the researcher was present in the classroom to observe how learners engaged with the topic.

Evaluation phase

The efficacy of the approach used was evaluated both through a small focus-group session with a number of learners, and by analysing their answers in an assessment that had been designed to test their understanding of the contextualised chemistry topic (i.e. the post-test).

Validity and ethical considerations

Since the researcher worked as a participant observer, he used member-checking of interviews and group discussions to ensure the validity of the collected data. He also obtained all the necessary consent from relevant stakeholders, such as heads of schools, teachers and learners.

Findings

The findings of the study reported below are related only to the one case study, the Maputo school. I report first on the pretest and post-test results, and then provide a more detailed description of the contextualised lesson in order to shed light on what occurred in the Class A group context. In the Class B context, 'normal' decontextualised science was taught to the learners, where they were told about pH, acids/bases, and chemical reactions in water. There were no experiments to demonstrate, and there was no contextualisation of the learning to wider issues of water pollution, water quality, and so forth, as in the contextualised lesson.

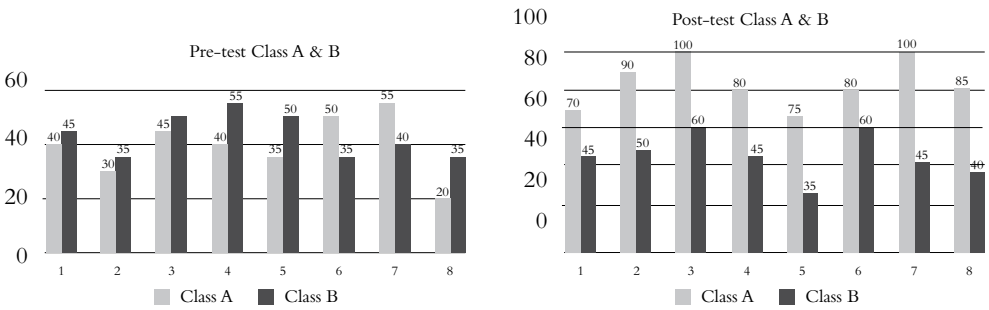
The pretest and post-test results

The analysis of the pretest findings showed no significant difference between the two classes, whereas the analysis of the post-test findings indicated a significant difference between them (see Figure 1).

Class A is the class that was offered the contextualised lesson. The pretest and post-test had 8 test items. For Question 1 in Class A, there was an improvement from 40% to 70%; for Question 2, an improvement from 30% to 90%; for Question 3, an improvement from 45% to 100%; for Question 4, an improvement from 40% to 80%; for Question 5, an improvement from 35% to 75%; for Question 6, an improvement from 50% to 80%; for Question 7, an improvement from 55% to 100%; and for Question 8, an improvement from 20% to 85%.

Class B is the class that was offered an ordinary lesson on the topic, not the contextualised lesson. The same pretest and post-test used for Class A was administered, with the same 8 test items. For Question 1 in Class B, the results stayed the same at 45%; for Question 2, the results rose from 35% to 50%; for Question 3, the results increased from 50% to 60%; for Question 4, the results dropped from 55% to 45%; for Question 5, the results dropped from 55% to 35%; for Question 6, the results rose from 35% to 60%; for Question 7, the results increased from 40% to 45%; and for Question 8, the results rose from 35% to 40%.

Figure 1. Pre-test and post-test comparative results (%)



The content and process of the contextualised lessons

Both groups, Classes A and B in each school, were taught science lessons focusing on chemical reactions in water. However, the contextualised lessons (taught to Class A) engaged more with chemical reactions in water in the context of water analysis and treatment. The lesson started by introducing the vocabulary associated with chemical substances in water as per the science curriculum, and concepts associated with water analysis and treatment (as per the contextualisation lesson's objectives). The lesson also sought to develop information collection and processing skills, as well as to teach learners about water as a chemical substance, and about chemical reactions in water. For the contextualisation group (Class A), the learners were also introduced to issues of pollution, focusing on understandings of pollution and sources of pollution.

Methods and procedures

The methods and procedures followed during the lesson included discussion, observation, experimentation, discovery, raising of problems, analysis, and individual and group work. The main task was to complete a project in groups so as to identify the sources of pollution in the Infulene River. The river is located around Maputo, where people have developed agricultural activities using pesticides and other chemicals. Also along the river are industries, some of them discharging their effluents directly into the river without adequate treatment and contaminating the water body with harmful compounds.

Introductory lesson process – vocabulary and understanding development

In the preparatory phase, learners worked with literature and interviewed some stakeholders in order to explore concepts related to water and water quality, such as water and pollution, and water and climate change. This literature review and consultation process was followed by discussions in class about these concepts.

The discussions developed the following insights among the learners: that water scarcity may be a result of climate change; and that countries (such as Mozambique) will have to take greater care of their water bodies, which includes reducing pollution and pollution flows into the rivers. Learners also discussed the concepts of water pollution, learning that water pollution

involves the contamination of water bodies (e.g. lakes, rivers, oceans and groundwater). They discussed how water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. They learnt further that water pollution affects plants and organisms living in these bodies of water; and, in almost all cases, the effect is damaging not only to individual species and populations, but also to the natural biological communities. They also discussed the concept of water quality. 'Water quality' refers to the physical, chemical and biological characteristics of water, as stated by Snyder, Handrick and Brooks (1943). It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose. Water quality is most often defined by referring to a set of standards against which 'good' or 'acceptable' water-quality levels can be assessed. These are often informed by World Health Organization (WHO) standards for human health. Environmental or ecosystem standards are also set to ensure the health of the ecosystems, and high quality standards are most often set for drinking water or for human consumption.

Experimental phase of the lesson

In the second phase of the project work, some scientific parameters of water, such as pH, chemical oxygen demand (COD), and nitrate and phosphate concentrations, were defined. The experimental work started with the sampling and analysis of water. Water samples were examined using the Aquatest system. The Aquatest is a small, single-use device for testing water quality. It is a very simple and quick method of water analysis. The purpose of the sampling and analysis of the water was:

- To determine the background, natural concentrations of chemical constituents in the water;
- To determine the concentration of harmful pollutants in the water; and
- To compare the findings with internationally acceptable standards.

The analysed parameters included pH[2], COD, and nitrate and phosphate levels.

At the end of the experimental work, learners presented their results and compared the concentration of analysed parameters with the recommended standard parameters of the WHO. Learners discovered that the concentrations of nitrates, phosphates and dissolved organic compounds in the water in the Infulene River water were much higher than recommended by the WHO standards. They discussed the possible sources of the pollution and identified the industry along the river and the agricultural activities as the main reasons for the water pollution.

Evaluation and testing

After the lesson, the performance of learners was evaluated and they were asked questions about the topic using the post-test. The text below gives a summary of the 'model' answers for the post-test. There were variations on the answers given by the learners in the post-test.

1. What is the importance of water to human life? *Water is the basis of life; all living things – plants, humans and animals – use water for drinking and for many everyday activities.*
2. What is water pollution? *Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans and groundwater).*
3. When does water pollution occur? *Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.*
4. What should be done about water pollution? *We must take care of water; we ought not to pollute and waste it, and we should keep our waterways clean so that future generations* [will] *have clean water.*
5. Is there a relation between water pollution and climate change? *There is a relation between water pollution and climate change, as climate change will cause water scarcity.* Here it was particularly interesting that a number of learners showed a misunderstanding of the relationship between water pollution and climate change, as they said, for example: *then chemical substances that contaminate water can contribute* [to] *global warming and climate change.*
6. How should water sampling take place? *This must be rigorous, ensuring that a representative sample is collected and at no time should the sample or sample bottle be contaminated by the collector.*
7. How should the sample be transported to the laboratory for the analysis? *Transport to the laboratory for analysis needs to be done under appropriate conditions, often in a dark cooler with ice packs.*
8. How should the water sample be processed? *Many samples need to be filtered before testing. In some cases, the filtering step must be done in the field as soon as the sample has been collected. The sample analysis needs to be carried out according to a protocol that doesn't introduce contaminants or otherwise compromise the sample.*

Discussion and Conclusion

In the classes where the new concept of contextualised pedagogy was applied, it was found that learners participated actively in chemistry lessons. Figure 1 shows that the majority of the learners in the experimental class (A) could give correct answers in the post-test. It would appear that, while learners in this class (A), where the concept of contextualising science was used, had gained sufficient background to give correct answers in the post-test, the learners in the control class (B), where conventional methodology was used, were not able to achieve good results in the post-test.

The main significance of the study was its attempt to show the increasing quality and relevance of educational processes through the inclusion of contextualised environmental issues in a science curriculum. It was also hoped that, through a better understanding of the sciences, in particular chemistry, the pass rate of learners might also improve, although this was not a focus of this study. However, the study could be used to inform the development or design of a larger, carefully designed study that can probe the manner in which contextualisation can enhance learner performance in subjects. Currently, there is little evidence of this in a Mozambican context, and even less research on the topic.

The use of the contextualised approach in the teaching of chemistry pH–acid/base and chemical reactions in the context of a broader lesson on water analysis and the treatment of local river water turned out to be a positive condition for learning as far as the learners were concerned. The use of the pretest and post-test approach showed improved results for Class A, which was also taught the contextualised approach. The questions of the post-test were, however, framed in this discourse, which favoured the Class A learners. In future, other questions that are more neutral and that might be oriented towards a 'middle ground' related more to the key concepts of the science (pH, acid/base and specific chemical reactions in water) should have a greater weighting in the test. This would probably enhance the validity of the test, and not bias the test too much in favour of the Class A learners. The study with the learners could also be expanded to further strengthen critical reflection, bring about more reflective discourse and also involve the learners in actions to address water pollution issues such as regular water quality testing of the river, and reporting the results to the municipality. These abilities, as reported on above, are considered essential outcomes of transformative learning (Merriam & Caffarella, 1999). The problem-based lesson approach initiated here in this small-scale research could be further developed along these lines in future. From a capabilities perspective, this research showed that a contextualised curriculum approach could help learners turn their resources (e.g. abilities to conduct scientific tests – in this case water quality tests) into functionings (testing water against standards of the WHO) in order to achieve capabilities of healthy and safe living.

However, this research was experimental in the sense that it was the first time that the researcher had engaged in contextualised curriculum development research. The outcomes of this small-scale study show much promise and can be used to plan more substantive research on this theme. It is my view that more research on the topic of a contextualised curriculum is needed in Mozambique and that we, as a research community, need to continue to develop research approaches and instruments to understand the relationship between curriculum contextualisation and learner performance. This was just one small-scale study oriented in that direction.

Notes on the Contributor

António Armindo Rúben Monjane is an Associate Professor and Head of the Chemistry Department at the Pedagogical University in Maputo. His research interests include pedagogy (natural science teaching) and environmental education. Email: monjanea@gmail.com.

Endnotes

1. 'Assimilado' is the term given to African subjects of the colonising Portuguese Empire from the 1910s to the 1960s who had reached a level of 'civilization', according to Portuguese legal standards, that theoretically qualified them for full rights as Portuguese citizens (Wikipedia, 2014).
2. In chemistry, pH is a measure of the acidity or basicity of an aqueous solution. Pure water is considered to be neutral, with a pH close to 7.0 at 25 °C.

References

Alexander, R. (2008). Education for all: The quality imperative and the problem of pedagogy. *Create Pathways to Access Research Monograph No.20,* University of London Institute of Education. At: http://www.create-rpc.org visited 17 March 2010.

Burbules, N.E. & Berk, R. (1999). Critical thinking and critical pedagogy: Relations, differences, and limits. In Popkewitz, T.S. & Fendler, L. (Eds), *Critical theories in education*. New York: Routledge.

Gutek, D.L. (2009). New perspectives on philosophy and education. Pearson Education. At:
http://faculty.ed.uiuc.edu/burbules/ncb/papers/critical.html.

IESE (Instituto de ERstudos Sociais e Económicos). (1983). Lei do Sistema Nacional de Educação 4/83.

INDE. (2003). Plano Curricular do Ensino Básico.

Kilpatrick, W.H. (1929). *The project method: The use of the purposeful act in the educative process.* Teachers College, Columbia University.

Knoll, M. (1995). The project method: Its origin and international influence. In Volker, L. & Rohrs, H. (Eds), *Progressive education across the continents. A handbook.* New York: Lang.

Merriam, S. & Caffarella, R. (1999). *Learning in adulthood.* San Francisco: Jossey-Bass.

Sen, A.K. (1999). *Development as freedom*. Oxford: Oxford University Press.

Snyder, H.R.; Handrick, R.G. & Brooks, L.A. (1943). Imidazole. *Org. Synth,* 3, 471. At: http://www.orgsyn.org/orgsyn/orgsyn/prepContent.asp?prep=cv3p0471.

Tikly, L. & Barrett, A.M. (2009). Social justice, capabilities and the quality of education in low income countries. *EdQual Working Paper No.18*. Bristol. EdQual.

UNESCO (United Nations Educational, Scientific and Cultural Organization). (2009). World Conference on Education for Sustainable Development. Bonn.