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Exploring teaching practices of science and technology in Malawi primary schools

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Research about primary school teachers' understanding of the meaning and implications of science and technology as a learning area has revealed considerable confusion about these terms, both in their professional sense and concerning their roles in education and economic development. Many countries established science and technology in their school curriculum to help pupils develop scientific and technological literacy but programme structures and emphasis have tended to differ. Malawi also attempted to achieve the goals for a scientifically and technologically literate citizenry through the introduction of an integrated science and technology as a single learning area in schools. While the need for scientifically and technologically literate citizens is governments' strategic goal, teachers' understanding of science and technology has implications on their teaching practices and ultimately on student learning. This paper reports on a study that aimed at identifying the teachers' conceptualisation of science and technology and their teaching practices. The study was implemented using a qualitative paradigm in order to develop a holistic understanding of the situation in the schools and it was undertaken in two primary schools in Blantyre. Schools participating in the study were identified through convenient sampling and involved 8 science and technology teachers for standards 5-8 from each of the two schools. Data generation for the study involved classroom observations, group discussions and teachers completing an open ended questionnaire. The data generated were analysed using thematic analysis. Findings revealed the teachers' gaps in content knowledge about scientific and technological concepts arising from their lack of understanding of the differences between science and technology. The teachers' perceptions and practices were also compounded by the nature of the science and technology curriculum and the teachers' lack of induction when the subject was being introduced. The study recommends redefining the assumptions of the science and technology curriculum. It also suggests providing interventions to help teachers' develop appropriate conceptualisation of science and technology as this has implications on their choices of what to teach and how to teach it.

Key words: Science and technology, scientific literacy, technological literacy, teaching practices, curriculum change.

INTRODUCTION

Governments worldwide have developed policy guidelines to incorporate learning for scientific and technological literacy (Bencze, 2010; Nampota et al., 2009). Consequently, developing countries have joined the bandwagon

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to incorporate science and technology in their school curriculum because of its likely influence on economic growth and development leading to poverty alleviation. In Malawi, the promotion for learning that epitomizes science and technology is espoused in Vision 2020 and the 2001 Science and Technology Policy for Malawi (National Economic Council, 2003; National Research Council of Malawi, 2002). Government strategies have also streamlined science and technology as a tool for economic growth and development as shown by policy direction that emphasises a shift from an importing and consuming country to a manufacturing and exporting nation (Ministry of Economic Planning and Development, 2012). Nampota et al. (2009) also argue that, there exists a strong relationship between science and technology and human capital development as this is attributed to growth and development among the East Asian tigers. Even if best practices are discovered, if there is lack of human capacity, development will always remain stagnant. Taking into account the Malawian policy direction, Aa curriculum that addresses the gap is hence strategic towards achieving such visions and readily positions citizenry to contributing towards a science and technology led economic growth and development.

The direction to which the Malawi government has taken is in line with Tthe Perth Declaration (UNESCO, 2007) which affirms the importance of science and technology for sustainable, responsive and global development. The declaration considers science and technology education as the essential means of bridging the gap between the roles for science and technology and the public's active understanding and participation in them. UNESCO (2007) also expressed concern about the current state of science and technology education worldwide and its failure to play its part in meeting the pressing societal issues of the 21st Century. One of the remedy to ensure that science and technology is playing its part in meeting global changes is through human capacity development. Therefore there is need for a policy change and to institute programmes that may help increase the number of students learning science and technology (Fensham, 2008). Thus, if in a society's there have been schooling programmes that leave its students unaware of the strengths and limitations of science and technology, they would indeed be reprehensible.

Due to increasing demands for relevant education, the Malawi government has prioritised science and Technology as a strategy to eradicate extreme poverty (Ministry of Economic Planning and Development, 2005). The government also instituted the Science and Technology Policy for Malawi (Ministry of Economic Planning and Development, 2012; National Research Council of Malawi, 2002). In order to address the national aspirations stipulated in the policy and the long term vision statement, science and technology was introduced as an integrated learning area in Malawian schools (Fabiano, 2002; Ministry of Education and Vocational Training, 2001b). The introduction of science and technology could consequently involve building capacity and developing teaching and learning materials. Other than provisions of teachers and learners guides (Malawi Institute of Education, 2007a, 2007b, 2008, 2009), it is not known whether teachers receive any professional support to teach the new subject; again, if there are any existing teachers' development programs to equip the existing teachers with necessary knowledge and skills. While the need for scientifically and technologically literate citizens is governments' strategic goal, teachers' understanding of science and technology has implications on their teaching practices and ultimately on student learning.

The paper reports on a study that attempted to develop an understanding of primary school science and technology teachers' knowledge and teaching practices. As science and technology teacher preparation in Malawi appears unclear, the understanding of classroom practices was deemed insightful towards the design of appropriate interventions that may be implemented to enhance teaching and learning of the subject in primary schools. Two specific objectives arose. These are:

a). To explore primary schools teachers' knowledge about science and technology.
b). To explore science and technology teaching practices in primary schools.

It is believed that a sufficient supply of science professionals is vital to the economy and to the health of the citizens (Fensham, 2008). Worldwide, science and technology experts are recognised everywhere as key players in ensuring that industrial and economic development occur in a socially and environmentally sustainable way. However, it is further observed that in many countries the supply of these experts is now dwindling and urgently needs to be addressed. The situation calls for a thorough analysis on the strategies to boost the supply of science and technology teachers ranging from teaching and learning, motivation (Aikenhead, 2005) and creating a conducing teaching and learning space. Countrywide, it is observed that there is poor participation and performance of students in science subjects at primary and secondary levels of education (Dzama, 2006) and this has a greater effect on the career options in tertiary education. The trend, therefore, creates a major gap of science and technology capacity in the country as compared to other disciplines. Records (Dzama, 2006; Mbano, 2003) show that schools register a large number of students but less are enrolled in science subjects. For instance, candidates for physical science in the national examination decreased from 5,171 in 1999 to 1,485 in 2003 (MANEB, 2004). Despite having fewer students enrolling in the sciences, Malawi National Examination Board (MANEB) records high failure rate in science subjects. Though there exists high failure rate and less participation, there are some schools that have a high enrolment rate in science subjects and performance of the students is also good. It may be that there exists a unique approach to teaching and learning of science subjects of which science and technology is no exception. Therefore, there is need to explore the strategies in teaching and learning science and technology in these schools in order to improve learning.

LITERATURE REVIEW

The emergence of science and technology as a component of general education is one of the most significant curriculum developments in recent years in Malawi. Science and technology studies present an opportunity to develop scientific and technological foundations in the learners when their exploratory minds are not yet paralyzed with world thoughts. Eshach and Fried (2005) argued that children naturally enjoy observing and thinking about nature and manipulating it. Eshach and Fried (2005) emphasized that exposing children to science and technology develops positive attitudes towards the field as early exposure to phenomena leads to better understanding of the concepts and that the use of scientifically informed language at an early age influences the development of scientific concepts.

However, recognising the importance of technology studies in modern society, varying models have been adopted. Literature indicates existing confusion between science and technology (Pedretti and Nazir, 2011), and its consequences on teachers' lack of understanding. Much as the differences exist, an analysis of teachers' understanding is vital in mapping strategies for clearing any prevailing misconceptions. Davies and Rogers (2000) pointed out the influence of: individual teacher educational beliefs and how the terms (science and technology) have been described in curriculum implementation and related conceptual understanding of the terms. These influences are anticipated to have generated a basis for teachers' personal belief on science and technology and consequently the value attached to each term over the other. As a result, the belief is applied in their practices in which their content understanding is biased over one term than the other. This then creates further implications on teaching and learning methods as well as assessment strategies. Therefore, failure to understand the thin line between the two has proved to have practical and pedagogical implications in teaching and learning.

Existing models of science and technology education include incorporating technological areas into science curricula, while others have developed Science, Technology and Society (STS) to replace science courses and yet others have developed technology studies as an independent learning area (Layton, 1994). While all the models thrive in well resourced economies and education systems, philosophical and pedagogic underpinnings have tended to be underplayed. The philosophy of science education is well developed while that of technology education is recent but these influence the nature of teaching and learning in each area and follow distinct pedagogical processes and practices. The teaching of science follows the scientific process while technology is taught using the technological process and to mix the two processes requires experts' professional discipline which appears inadequate in the Malawi context.

The technological process is central to technological activity and requires the interaction of the hand and brain. This balance between thinking and doing is reflected in the technological process itself and in the results of that process. The technological process which is also referred to as the design process is a journey that learners should explore in search of a solution to a problem. Barnes et al. (2002) argued that the importance of young people experiencing the process of how decisions are arrived at and how we can evaluate and measure their appropriateness cannot be over emphasised. Barnes et al. (2002) asserted that society has passive consumers of other people's decisions and that we are likely to be confronted with more choices made on our behalf. Learning for technological literacy using the technological as well as design process seems the only answer for future consumers but the question that remains is how to help the learners get the best out of these processes. As coaches, role of teachers in this respect is critical as they are expected to encourage learners to adhere to the laid down steps in the design process for them to appreciate it besides giving them opportunities to explore the wider dimensions of technology, such as issues of sustainability and stakeholders' interests (Mawson, 2010). Usually, in the design process, learners rush into meeting the assessment requirements of the finished product which they just picture from their brains by relating the problem to some similar situations experienced in their life.

It is not uncommon for pupils to believe that, almost from the start of an activity, they have a complete solution in their mind and this often leads them to try to short-cut the process of development (Barnes et al., 2002, p. 141).

Through varying design pedagogy, learners should be helped and coached to understand that what matters most in the technological process is the process itself. By so doing, learners will be able to see likely problems in the final solution. The process gives chance to the learner to weigh different possibilities of the design solution before settling for one. However, Williams (2000) argued that the linear and prescriptive nature of the technological process does not allow creativity. This a reductionist approach which predominantly involves defining the problem or opportunity, gathering information, designing a solution, making the product, and evaluation and testing hypotheses (Williams, 2000). While pupils can be presented with a problem or need, and at times they identify a problem or need themselves, the emphasis should be to help learners discover that there are many possible solutions to the same problem. Pupils should be made to understand that there is no one right solution, some solutions are better than others. Pupils should begin to think for themselves and realize that they can design, make, and evaluate solutions to problems and if a less-than-satisfactory solution arises, there might be need to re-design, re-make, and re-evaluate. The design process requires the learner to design the solution while the teacher in the technological process facilitates learning activities. For instance, Barnes et al. (2002) argue that "Asking young children questions about what they are doing and what they will do next, and encouraging children to question is valuable teacher intervention" (p.116).

The scientific and technological processes require both the teacher and learners to be active and interactive (Cowie and Bell, 1999; Mawson, 2003), which is often overlooked in primary school systems because of overloading of teachers. The importance of teacher's subject knowledge and understanding and its association with pupils' achievement as emphasised as subject knowledge is very strongly associated with high standards of pupils' achievement. Where teachers hold good subject knowledge, they are more confident in planning and implementing learning tasks, more skilled in asking relevant questions and providing explanations (Timperley et al., 2007). Teachers' lack of knowledge and self-confidence in science and technology studies make teachers feel insecure to promote interactive learning. Science and technology being a recent subject in the Malawi curriculum, it is not known how teachers respond to learning that demands students' thinking and creativity reminiscent with a science and technology process. Successfully managing children's learning through science and technology needs some clear teaching strategies. Pupils need to be guided and encouraged as they formulate own ideas as demanded by the outcomes based education (OBE) emphasised in Malawi's primary curriculum and assessment reform (PCAR). Hence, the role of the teacher in prompting and asking questions, as well as modelling, to enable children to explore ideas and relationships, is very important.

As the study involved multiple perspectives and units of analysis (Borko, 2004), a socio-cultural framework was therefore considered helpful in examining the social contexts of science and technology classrooms and patterns of participation in learning activities. Rogoff suggested apprenticeship, guided participation and participatory appropriation as inseparable concepts reflecting different planes of focus in socio-cultural activity at community/institution, interpersonal and personal level. The approach is based on consideration of personal, interpersonal, and community planes of focus in the analysis of development processes involved in the participation of individuals with others in cultural practices (Rogoff, 1995). Guided participation "…stresses the mutual involvement of individuals and their social partners, communicating and coordinating their involvement as they participate in socio-culturally structured collective activity" (p. 146). In the appropriation perspective, Rogoff views development as a dynamic, active, mutual process involved in peoples' participation in cultural activities unlike the internalisation perspective. In Fernandez et al. (2008), reification of the community of practice was seen as a black box. Lack of transparency limits the engagement of curriculum users and the negotiation of meanings is often curtailed. The teachers' reification of the curriculum document is critical to the ultimate direction of changes in practice. As there is no technology curriculum, understanding teachers' views of the meaning of science and technology helps to create an opportunity for discourse leading to mutual engagement for the negotiation of a shared and common identity (Rogoff, 1995; Wenger, 1999). A socio-cultural theoretical framework helps the building of strong professional communities (Borko, 2004) which can foster teachers' learning, enabling them to effect new classroom practices for enhancing learning in science and technology education.

Therefore, the study presents an account of the development and nature of science and technology studies in the primary classroom in Malawi. It shows how the science and technology learning process and the knowledge, skills and understanding associated with the subject can be developed by teachers. The study highlights some teaching strategies employed and recommends how to assist teachers of science and technology studies overcome challenges impacting on the teaching of the subject.

METHODOLOGY

The main purpose of this study was to explore strategies in teaching and learning science and technology education in primary schools. The study adopted a qualitative research design in order to obtain in-depth information and also to develop a holistic understanding of the current lived experiences of the teachers during their interaction with pupils and the science and technology curriculum (Cohen et al., 2011; Creswell, 2007). A case study approach was used and involved in-depth and semi-structured interviews, and focus group discussions with the teachers. Classroom observations were also conducted to understand the teachers' engagement with their pupils. Participating schools and teachers were purposively sampled. A non-probability sampling technique was used in order to ensure quality data generation from reliably informed and experienced informants (Tongco, 2007) collect the most reliable data and also because it was not in the researcher's interest to generalise the results. Besides, limitations of funding made it difficult to reach more schools. Only two schools in Blantyre were chosen for the study and all science and technology teachers from those schools were requested to participate in the study. The data were analysed using grounded theory which involved constant comparison of data with emerging categories and theoretical sampling of different groups to maximize the similarities and the differences of information (Strauss and Corbin, 1998). Recorded focus group discussions conducted in each school were transcribed verbatim.

Teaching practices in science and technology classrooms

This section presents results of the study generated through classroom observations and will comprise teaching practices in science and technology classrooms generated from the observation of four lessons. The teachers' existing classroom practices in science and technology education were generated through clinical observations using a protocol that included content knowledge, pupils activities, teaching and learning resources, methods of teaching, lesson sequence and any observable interaction between the teacher and pupils. Table 2 presents a report of the classroom observations.

The observation of lessons in this study has revealed the actual teachers' comprehension of the subject matter and pedagogical practices to teach content. It was observed that the transformation of content into appropriate representation and instruction seemed to focus predominantly on teachers' activities and was less concerned with possible pupil interactions and associated learning outcomes. The teachers were all qualified teachers with teaching experiences ranging from one to over ten years. Although all demonstrated some understanding of effective instructional strategies, their teaching practices may have been shaped by social, emotional and cultural processes. This was evident through the models or teaching aids that were also used by some of the teachers. Teachers' demonstrations and pupils using the chalkboard as a way of participation were common methods among the teachers. Two of the four teachers employed aspects of active learning through group work but there were gaps in their understanding, planning and implementation of the techniques. More detailed planning may help increase teachers' critical thinking about the selection of tasks, teaching approaches and possible learning outcomes arising from group activities.

The observation of the lessons delivered by the four teachers revealed minimal interactions in the classroom between the teachers and pupils. Instruction was teacher directed and focussed on lecturing; direct instruction and the pupils' main activities were answering questions and limited group or paired activities. This was typical traditional instruction (De Miranda, 2004) as pupils' participation, cooperation and peer learning were de-emphasised. Teachers needed to provide support and feedback during group work and also individualised classroom activities. Besides fostering the pupils' higher order thinking skills and sharing of social problems and expertise, the collaborative activities assist the teachers to monitor progress of the pupils. However, the group work was often not challenging and did not provide opportunities for pupils to think and discuss in meaningful ways. Complex tasks may help involve pupils in simultaneously interpreting, applying and evaluating given sets of instructions. Therefore opportunities for interactions availed by the classroom situations were hardly optimised. Group discussions were commonly used by the teachers but there was not much time for the pupils' discussions thereby limiting pupils' learning. Grouping pupils into small numbers would provide opportunities for personalised instruction, scaffolding and discussions so that all pupils contribute ideas during the course of instruction and such small groups should have been maximised because of space problems.

Teachers were restricted by limited resources, the nature of the curriculum and the emphasis on national examinations particularly in Standard 8. This resulted in a focus on content delivery without much consideration given to activities that would engage the pupils conceptually. Teachers extensively relied on lecture techniques that stifled the teachers' innovation and creativity for authentic assessment which may have enhanced learning, using locally available materials and any recyclable resources within and outside the school. However it was observed that due to resource constraints, teachers resort to the use of their artistic skills by drawing the item on chalkboard. Figure 1 shows a creative teaching and learning aid by a Standard 8 teacher. The picture shows the sun, a guitar, a whistle, the moon, a drum and a flute - instrument which the teacher used to identify sources of energy. However, poorly drawn items may create misconceptions which could cause confusion in the learners. A solution to the problem identified could be through the use of indigenous tools used in villages which could be used in the classroom instead of drawings which would remain abstract to some of the pupils. Since there would not be enough time for pupils to build these instruments, students could be asked to bring from their homes and communities already made tools. For example, there are locally made indigenous musical instruments which include for example *banjo, kalimba* and *karigo. S*ee picture of *Kalimba* in Figure 2 taken from Ebay (2013). These instruments like the one in Figure 2 are readily available in the communities, hence if the teachers could also involve the communities in providing the resources for learning purposes, it could simplify the teaching and learning of science and technology and consequently pupils' conceptual understanding.

Therefore, the teachers would need professional support towards enhancing their innovation and creativity to use locally available resources and materials. There is expertise in the villages that make and play such

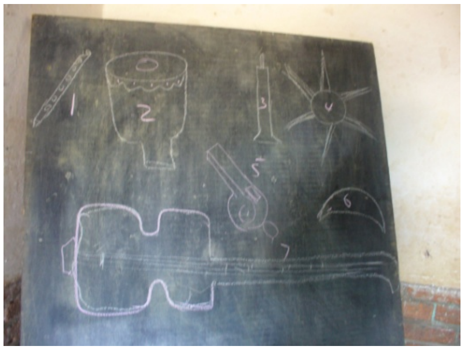

Figure 1. Teaching and learning aid with sketches of technologies that generate energy.

Figure 2. African Kalimba.

instruments and learners may learn from such local people around them. Such materials would help develop learners' meaningful experiences in which they learn science and technology concepts using familiar instruments and contexts in which such tools are useful.

Teachers' views about the meaning of science and technology

The purpose of the discussion was to learn from the teachers' views and their experiences in teaching science and technology toward improved ways of teaching the subject. The discussion was semi-structured and themes that emerged included the definitions of science and technology, innovations in teaching science and technology and the teachers' call for participatory curriculum reviews. The themes are briefly highlighted below.

Meaning of science and technology

While there have been efforts to bring coherence in the teaching of science and technology (Geraedts et al., 2006), diverse views about what it is and how to teach it remain unresolved. This study attempted to understand the teachers own meaning of science and technology as this has implications on teaching practices. The teachers viewed science and technology as different disciplines of study and the teachers' own distinct definitions of both science and technology attest to that assumption. Science was viewed as the study of nature or study of living and non-living things. See comments by respondents (RSP) 1 and 3.

Science is the study of nature and when we go to technology, it's studying of other scientific technologies which have been discovered by other scientists… RSP 1
…To my side science and technology depends on one's understanding. It's a study of living things and also non-living things… through observation, experimenting and also finding out new ideas or even new technologies…. RSP 3
Yes, learners get knowledge to investigate different things on their own. They do try to find answers on their own and they apply the knowledge they get at school in their homes. There are some topics which are taught in class which learners can practice in their homes e.g. modern technologies. For those without computers there are other things. R1

Technology was viewed as things, hardware and as new innovations that help change ways of doing things. Their examples were mostly in agriculture and also information and communication technologies (ICT). See comments by RSP 2 and RSP 4 below.

Apart from that, there is also technology related to propagation such as grafting…Use of fertiliser is also a technology... From history we use hoes for gardening but others invented ploughs…cultivators. Now there is roundup and bullet instead of weeding… it was studying nature leading to such technologies. RSP 2
Technology, nowadays we use cell phones, soldiers use nuclear materials…, use of fax machines to send messages quickly instead of writing a letter and the police use wireless messages. That's all new technology. We also have radios and television. RSP 4

The teachers' views of technology are therefore restricted to things and hardware. Their understanding of the technology also reflects the limited definition of technology provided in the Standard 5 teachers' guides, that is 'Technology involves the use of scientific knowledge and equipment in order to solve problems' (Ministry of Education and Vocational Training, 2001a p. 30). A primary school science and technology study book by Fabiano (2002) also emphasises the concept of technology as the use of equipment and some of the equipment is both modern and indigenous technologies. However, research (de Vries, 2009; Naughton, 1994) recognises technology as a broader concept than just hardware or machines. Technology is a practical activity where the goal is to solve problems using many forms of knowledge including theoretical knowledge gained from science, experience, craft and apprenticeship. Naughton acknowledged that technology need not necessarily involve the use of formal scientific knowledge and he used the illustration of the architectural construction of Durham Cathedral and the pyramids of Egypt. Without a clear perspective of the broad nature of technology, it is difficult for teachers to even choose appropriate technology tasks for students' learning. The teachers' views therefore affect how they approach teaching and learning in science and technology. Though, it appears, science and technology as a single subject was incorporated in the primary school curriculum as a means of teaching science using indigenous technologies and also as a way of mitigating resource constraints (Phiri, 2008).

Resources constraints

Lack of resources in schools is a general problem that affects not only the teaching of science and technology but all other subjects at all levels of the education system in Malawi.

For technologies other than indigenous ones it is difficult to find resources. Things like cell phones, it is not possible to find cell phones for learning even in groups… how to write a message. But things like drums, catapult and all other local technologies can easily be found and mostly in villages. RSP2
Methods of cooking, drying, food preservation, roasting, refrigeration are also some of the things that can be applied in their homes. R3

Since resources are a problem, the teachers implement some limited innovations to generate learning situations or generate the required resources but this is impacted by lack of support. For example RSP1 said that visits to communities of practice are difficult to organise due to expenses required which schools cannot afford. Schools within the city centres may easily organise such trips to science and technology sites for students' learning. For example in Blantyre, there is only one Museum situated right in the heart of the city and rural schools may be hampered by distance as they are required to move with kids in covered vehicles and not open lorries and trucks.

The PCAR curriculum was designed to allow teachers involve students in generating learning situations including provision of teaching and learning materials. The teachers said:

The performance between rural and urban students will be distinct as urban kids will do better than rural kids. Kids from homes with facilities like fridges will learn better than those in rural villages...RSP1
They can bring local technologies from home but not all things. Some other expectations are unimaginable. It's not easy for parents to allow kids to carry a computer to school. RSP3.
Books are insufficient. The teachers' guides have little content. There are no examples …, without experience it's difficult to teach technology. RSP4
There is a topic on machines which involves the order of levers, examples given involve real things used in their homes e.g. in 1st order levers there is pliers. When they go home they are able to manipulate the pliers and understand better. In 3rd order levers, there is the fishing rod. When they go fishing they will be able to understand. R2

While resource constraints exist, the teachers' views above show the gaps in terms of knowledge and pedagogy suitable for supporting learners in such contexts. While it is true that kids in rural areas are not exposed to modern home technologies, there are ways through which families in such remote locations use to preserve food or water some of which are also associated with the people's beliefs and practices. However, the teachers are also limited by the nature of the syllabus where there is more emphasis on science than technology. In any case cognitive apprenticeship and learning in communities of practice (Brown et al., 1989; De Miranda, 2004) provide direction that needs exploration to enhance teaching and learning of science and technology. Learning through 'cognitive apprenticeship' could be seen as an attempt to introduce informal knowledge and skills learnt through a process of enculturation into the school environment. Extending the analogy of the master-apprentice or new guy-old guy into the classroom, the teacher progresses the student from embedded activity to generality also described as situated modelling, coaching and fading (Brown and Duguid 1991; McCormick, 2004). In this way, students learning by social interaction and collaboration that is situated in specific cultural contexts may help develop the learners towards becoming practitioners using the tools of the craft (knowledge).

Curriculum change

The teachers also suggested the need for them to be involved when reviewing and redesigning curriculum. Besides, they suggested separation of the two subjects into distinct learning areas covering pure science and pure technology. Participatory curriculum design, re-organisation or restructuring of the curriculum and providing appropriate infrastructure and teaching and learning materials were seen as the way forward to address the problems. Teachers' views from primary school 1 are shown in the discussion depicted below.

Separate science from technology. Science must be pure

as we learnt it ourselves in our school days…RSP1
They should provide materials for teaching science and technology; schools should have electricity, computers, and specific buildings needed for teaching science and technology. Sometimes we take sand into classes and that's not good for the classrooms. RSP4
…curriculum developers should include primary school teachers to share the experiences … curriculum developers adopt UK systems without considering local conditions. RSP1
Topic arrangement needs reorganisation. For instance the topic related to plants appears in several units offered at different times and levels. I suggest the topics can be taught consecutively till the whole plant is taught. RSP2
More difficult topics are also found in standard 5 when simpler ones are in higher levels e.g. from Standard 7. It's more difficult for pupils to understand the content. RSP3

The views of teachers from primary school 1 were not different from those at the second school. While teachers curriculum plans at school 1 focussed on use of local resources teachers at school 2 suggested meaningful learning of classroom experiences of both science and technology. They viewed this as possible with the donation of computers which the school had received from industry partners. They also suggested removing some contents into own subjects to provide in-depth learning of concepts in those areas. Their views are shown below:

… So I thought that … we can learn science and then discuss with the students what was learnt and how to apply such knowledge in daily life. May be there should be that coordination. One unit should contain some Science and Technology. The way it is now, each unit carries a different aspect, Science, Health or Technology. There is no Biology in primary school. R1
Health education should be taken out of Science and Technology to Life Skills. There should be no duplication of topics. R2
Within the Science and Technology, Science and Technology should be taught separately. R1
The only challenge would be resources but there is equipment coming. Alliance media donated two computers. In standard 6 there is a topic on parts of a computer and they can be shown the parts. R2
There are some topics in science and technology that are found in other subjects like life skills e.g. HIV/AIDS, growing up. It is confusing to the learner because definitions for the same word differ in all the subjects. E.g. environment in science, and social studies, the definitions differ. The same teacher can come with different subjects and will give two contrasting definitions of the same word and this confuses the learner... R1

Science and technology are inextricably entwined and complimentary. However, these are both areas of study in their own right with too distinctive objectives and content (Banks and McCormick, 2006; Harrison, 1994). Integrating the two subjects makes delivery extremely challenging particularly in a context where curriculum development excludes the classroom managers and their induction is through the teachers' guides from which the content shown in Table 1 was extracted.

Curriculum change processes and discourses should be transparent so that teachers are accorded with opportunities to develop a framework for dereification of a curriculum document into their classroom practices (Fernandez et al., 2008). Fernandez et al. (2008) emphasize that without planning for teachers' participation in the negotiation of curriculum meanings, curriculum developers themselves become marginalized, and the cultural objects they have developed will be adopted in varied and unanticipated ways. The framers of the S&T curriculum designed it in such a way that teachers should use local knowledge, expertise and resources. However, the interaction between the teachers and such local sources of learning seemed to have been placed in the peripheral of the curriculum process. Teachers may need further professional development to be able to use such resources and knowledge and how to maintain curriculum symmetry across a country that has varied cultures and practices.

CONCLUSION AND RECOMMENDATIONS

Science and technology has been viewed as a tool to influence development in different nations. Despite the development of different policies and strategies, teachers' skills and knowledge on science and technology have been considered with little attention. The study therefore, aimed at exploring teacher practices and understanding of science and technology as they teach the subject. The study therefore, reveals teachers' traditional views and classroom practices emphasised learning of science concepts while technology was only viewed as things, machines or instruments for enhancing the development of students' knowledge of the nature of science. Hence, the teachers struggled to distinguish science and technology and the goals for learning the subject. The teachers' conceptualisation of science and technology is consistent with the content provided in the learners' as well as the teachers' guides of the subjects. In the guides technology is defined as an application of scientific knowledge which contradicts views obtainable in literature (Banks and McCormick, 2006). Furthermore, the study identified the knowledge gap in the teachers, disparities in the use of teaching and learning aids and inappropriate use of instructional methods that promote pupil understanding.

The paper proposes the establishment of a new pedagogy where learning focuses on enhancing student scientific and technological literacy as espoused in Vision 2020 (National Economic Council, 2003). Teaching and learning pure science and broad based technology education may help not only popularise science and technology among the students, but will also help build strong futures and pillars for Malawi's economic growth and development. However, the shift from the traditional practices requires a theoretical framework that will not only result in the reification of new classroom practices but also sustain and promote personal and institutional growth and development. The engagement of members of the community of practice during curriculum reification is considered an important factor in making a commitment to curriculum change (Fernandez et al., 2008). A framework therefore based on the three socio-cultural planes appears appropriate in this process in order to generate a discourse that may lead to an effective and meaningful science and technology curriculum design and implementation (Rogoff, 1995). From the teachers' perspectives, such discourse was not part of the development process for the science and technology curriculum.

Based on findings discussed above, and in cognisance of a broadened science and technology subject matter, the study makes the following recommendations:

1. The teaching of science and technology in primary schools should be reconceptualised for effective students' development of scientific and technological literacy as espoused in Vision 2020 and the 2001 Science and Technology Policy for Malawi.
2. There is need to develop a comprehensive and coherent orientation program to address the gaps in knowledge for S&T teachers.
3. Allocation of more teaching and learning resources to schools by the government.
4. Schools need support with knowledge and skills in developing locally available materials for the effective teaching and learning of science and technology.

Conflict of Interests

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APPENDICES

Table 1. Content of science and technology for standards 8, 7, 6 and 5

Unit	Standard 8	Standard 7	Standard 6	Standard 5
1	Scientific investigation	Scientific investigations	Scientific investigations	Scientific investigations
2	The human circulatory system	Human development	Human skeleton	Worm infections
3	The human breathing system	The human nervous system	Movement in human beings	Food and health
4	Improving the nutritional value of food	Flowering and non-flowering plants	Sense organs	Indigenous technologies
5	Meals for invalids, convalescents, vegetarians and the elderly	Pollination fruit and seed dispersal	Common accidents	Technological innovations
6	Improving a traditional kitchen	Seed generation	Nutritional deficiency diseases	Problems of marketing
7	Improving the quality of products	Technologies that can be made in school for advertising	Food preservation	Technologies for sending and receiving messages
8	Food processing	Classroom technologies	Materials production	Classification of animals
9	Reproduction in human beings	The human digestive system	Information and communication technology	Types of energy
10	Solutions and mixtures	Vertebrates	External factors of a plant	Technologies for marketing
11	Methods of cooking	Invertebrates	Light energy	The relationship between plants and animals
12	Technology for conservation of the environment	Parts of a plant	Heat energy	Nutrition and health
13	Electricity and electric circuits	Methods of cooking	Sound energy	
14	Family size, income and food technology	Meals for sedentary workers and manual workers	Methods of cooking food	
15	Laundering cloths and bed linen	Laundering a shirt and a blouse	Kitchen hygiene and safety	
16	HIV/AIDS	Technologies for domestic use	Meal planning and presentation	
17		Properties of light, heat and sound	Machines	
18		Forces	Care of rooms in the home and surroundings	
19		Nutritional deficiency diseases	Laundry	
20		Dyeing materials	States of matter	
21		Machines	Parked meals	
22		Growing up	Improving the home and its surroundings	
23			Managing information and communication technologies	

(Source: Malawi Institute of Education (2007a, 2007b, 2008, 2009).

Table 2. Report of classroom observations

Concept	Observations			
	1 Technologies for sending and receiving messages Standard 5	**2 Energy Sources Standard 8**	**3 Sources of light Standard 6**	**4 Technologies for conserving environment Standard 8**
Content knowledge	Knowledgeable but with some gaps in scientific and technological concepts.	Knowledgeable but there were gaps in scientific and technological concepts. e.g. chemical energy in panadol	Gaps in scientific and technological concepts.	Knowledgeable and used relevant everyday examples.
Pupils' activities	Group discussion students made presentations	Not much except answering questions. Students rubbing hands to generate heat.	Answering questions; Group discussion; No reinforcement; Students present findings on board	Group work Responding to questions
Resources	Radio, whistle, drum, cell phone, chart with drawings of all these	Mobile chalkboard with drawing of energy technologies	No teaching and learning aids except chalk board.	textbooks
Methods	Q/A Group discussion Lecture	Lecture Direct instruction Q/A	Lecture/teacher talk; Group discussion	Q/A for introduction; Group discussion-checked pupil progress; Allowed students to ask questions Feedback provided
Sequence	Simple to complex but repetitive	Known to unknown and explored students' prerequisite knowledge, revision	No sequence observed, straight to new content	Known to unknown- pupils experiences of environmental issues
Interaction	Student involvement through paired exercises; No prompting; one usual volunteer	Questions spread; Not much student involvement, teacher was in control	Setting was good for group discussion but not much interaction was observed.	Students free to share experiences – relaxed mood; Teacher familiar with students.