

Full Length Research Paper

An approach for the implementation of technology education in schools in the North West Province

Tholo J.A.T, Monobe R.J. and Lumadi M.W.

North West University (Mafikeng campus), North West Province, South Africa

Corresponding Author's E-mail: JTholo@nwpg.gov.za, lumadmw@unisa.ac.za, ratau.monobe@univen.ac.za

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The study is about the implementation of Technology as a learning area with specific reference to the North West Province of South Africa. Technology Education needs approaches that build upon the best thinking in the field and take into account the needs of the learners and the educators. The approach needs to address the context within which Technology is offered. The main aim of the study was to design an approach for implementing Technology Education in schools in the North West Province. The approach developed in this study was shown to hold promise as a reliable and useful tool for implementing Technology. The potential benefits range from aiding the identification of capacity building approaches to assessing learners in the classroom. Without adequate assessment procedures, technology education cannot reach its full potential and it will continue to struggle for recognition and acceptance with the greater educational community. This article describes an approach developed for implementing technology in senior phase schools (12 to 14 year old learners) in the North West Province.

Keywords: Technology, technology education, curriculum, implementation, and approach.

INTRODUCTION

The national implementation of technology in South Africa is a relatively new learning area in the National Curriculum Statements (NCS) of the General Education and Training (GET) Band. This band comprises Grades R to 9 (7 to 14 years). This implies that schools are faced with demands pertaining to financial costs, human and physical resources. These are perceived as challenges in the implementation of technology education (Anckiewicz, 1995: 245; Hugh, 2003:1).

Technology was introduced in South Africa as part of Curriculum 2005(C2005) in 1998 (Potgieter, 2004:208) and subsequently became part of the Revised National Curriculum Statements (RNCS) and the first learners to have studied Technology will graduate in 2008 (Howie, 2001: 47). Technology is a new learning area worldwide (Senesi, 1998: 27; Zuga, 2002:16;), especially in developing countries of Africa, South America and Asia. According to Khumalo (2004: 4) and Pavlova (2005:199), Technology as a learning area can bring social transformation. Educators are desperate in implementing the curriculum changes (Chisholm, 2000:44). In South Africa the rate of implementation was too rapid and was not properly resourced (Chisholm,

2000:10). This transformation in the Technology perspective suggests the need to promote technological literacy, attitudes and interest in technological careers in view of the economic development of the country.

Technology is associated with many different fields. It has been linked with tools and machines, Applied Science and most recently has been equated with Information Technology (Mallet, 1997:1; Manitoba Publications, 2006:1). It is multi-faceted and no single definition of Technology would explain the concept. For the purpose of this study, Technology would be assumed to be the use of knowledge, skills and resources to meet human needs and wants across all cultures by solving practical problems.

The introduction of Technology as a learning area in schools has produced a challenging future for all those involved with every aspect of Technological education. This challenge is particularly relevant to the educators whose future responsibility will be to implement this exciting learning area as members of the school based Technology teams. Teaching Technology makes a unique contribution to the education of all learners. It prepares them to work in a rapidly changing

technological world by introducing them to the design methods and skills needed to produce practical solutions to real problems (Black, 1998:2). It is because of this reason that an appropriate strategy is essential in the implementation of technology education in schools in the North West Province.

The successful implementation of the Technology curriculum is dependent on educators at all levels having a solidly established personal construct of Technology, equivalent to that of the curriculum. The views of educators about the nature of Technology are of great concern to curriculum support specialists at in-service level (Nkotsoe, 2004:4). In an examination of the dimensions of Technology, Custer (1995:219) argues that there is a critical need for all individuals to develop at least minimum levels of the understanding of Technology as it has a profound influence on all parts of human life in the world. Technological literacy is becoming one of the backbones for development through education on a global scale.

Some form of Technology Education has been implemented in most countries of the world (Williams, 1996:266). However, as Technology is new in the South African curriculum, there are many questions that remain unanswered about its implementation. According to Mallet (1997:1) and Kumar (2003:2), this is mainly the case in developing countries or Newly Industrialized Countries (NICs). This study focused on the concerns about the quality of Technology education provided by schools. It explored the possibilities of developing an approach for promoting quality implementation of Technology as a learning area in the North West Province of South Africa. It is against this background that the main research question is formulated as follows: What is the appropriate approach in local context for the implementation of Technology Education in schools in the North West Province? The study on which this paper is based required an in-depth study and was conducted under the North West University (Tholo, 2007:12).

Theoretical framework

Constructivism is an approach to cognitive development in which learners discover all knowledge about the world through their own activity (Berk, 2000:645). It is based on a combination of a subset of research within cognitive and social psychology. Dewey is considered to be the founder philosopher of this approach (Huitt, 2003:1). In constructivism knowledge is not a fixed object; it is constructed by an individual through his/her own experiences of that object (Hsiao, 2007:3; Doolittle and Camp, 2007:17).

Dewey stressed the importance of having the learners' experience grow from experience. Knowledge and ideas came only from a situation where learners had to draw them out of experiences that had meaning and importance to them (Epstein, 2002:5). These situations

have to occur in a social environment, where learners could come together to analyze materials and to create a community of learners who held their knowledge together. Piaget believed that the fundamental basis of learning was discovery (Epstein, 2002:6).

The focus of Piaget's theory is the various reconstructions that an individual is thinking goes through in the development of logical reasoning. Vygotsky believed that children learn concepts from their everyday notions and adult concepts. He felt that learners need to be guided by adults, but he also thought that it was very important for the learner to be influenced by their peers as well as discover things on their own (Epstein, 2002:6). He termed this the zone of proximal development. These supports that learners receive from peers and adults are gradually removed as learners develop autonomous learning strategies, thus promoting their own cognitive, affective and psychomotor learning skills and knowledge.

Constructivism provided the theoretical framework for this study because learning by doing and simulations of occupations are the basis for much of the instruction in Technology education. Although constructivism is not a theory of teaching, it suggests taking a radically different approach to instruction from that used in most schools. The best way to learn is not from lectures, but by letting learners construct knowledge for themselves. Learners should have a constructivist educator along with a constructivist classroom to help them discover new things for themselves. Constructivism promotes increased social interaction and discussion in the classroom, both between educators and learners and between learners.

Method of investigation and analyzes

The study is framed within two methodological research perspectives of qualitative and quantitative procedures. Qualitative research stresses the validity of multiple meaning structures and holistic analysis (Burns, 1994:11). In this study using qualitative and interview methods, Technology experts, curriculum specialists (subject advisors) and learning area heads were asked to participate in individual interviews related to the implementation of Technology. The individual interviews included questions to reflect the seven primary research questions.

Quantitative research is all about quantifying the relationships between variables (Hopkins, 1998:2). In this study, two quantitative instruments were used to collect data from senior phase learners and educators. First a Likert-type survey, Learners' attitudes toward Technology, was administered to assess learners' attitudes related to Technology and to assess learners' conceptual understanding of Technology. Secondly another survey, Technology educators' questionnaire was administered in order to document the profile of

educators involved in technology education as well as determining In-service Education and Training (INSET) and other forms of support they receive.

Statistical procedures using the Statistical Programme for the Social Sciences (SPSS) were used to analyze responses to the Learners' attitudes and concepts of Technology survey. Learner scores were averaged across learners and by age, location, grade and gender. Qualitative procedures, including coding and scoring were used to analyze Technology experts, learning area heads and curriculum specialists' responses to the individual interview questions.

In this study the sampling frame consisted of 100 schools offering Technology in grade 7 to 9 from the five education regions in the North West Province. Both educators and learners were sampled from 5% of the schools in each region to respond to the questionnaires. The sample of learners and educators were 10830 and 344 respectively. Seven educators in charge of the Technology learning area (Heads of Department) were interviewed including eight Technology experts as well as eight subject specialists for Technology.

Literature study

A comprehensive literature study was conducted on various approaches to Technology Education implementation. Hall (2001:4) defines technological literacy as an appreciation of the scientific method. It is a powerful way of knowing, the ability to distinguish technology from Science but also to see the connections and an understanding that the world we live in is increasingly technological, not only in regard to products, but in the whole organization of modern life. Mawson (2005:2) argues that curriculum development has tended to be influenced by two differing approaches. These are functional technological literacy and critical technological literacy. This researcher identifies functional technological literacy as a set of abstract, value-free skills, which can be defined, measured and learned. These skills are functional to personal and economic development. It covers a wide range of technical specialized information providing learners with opportunities to gain practical ability, as being developed through doing hands on experience. He further argues that critical literacy identifies three interacting components of technological literacy that is, technological knowledge and understanding, technological capability, and Technology and society.

Kellner (2001:69) affirms that literacies are socially constructed in educational and cultural contexts. He further argues that we need multiple literacies for our multi-cultural society. These literacies need to meet the challenge of new Technologies. Sarlemijn and De Vries (2005:19) distinguish the following three types of Technologies:

- Scientific knowledge that is involved in experience-based technologies has been derived from engineering practice. This knowledge is practical and concrete.
- Macro-technologies, where scientific laws and concepts involved are the result of a mathematical deduction from basic equations. Steam engines were developed without knowledge of gas laws but theory helped in improving them.
- Micro-technologies, where scientific theories that are involved become even more abstract, as they deal with microscopic structures we cannot see (For example nano- technology).

Chinn and Kramer (2004:268) define an approach as:

“creative and rigorous structuring of ideas that project a tentative, purposeful and systematic view of phenomena”. According to McEwen (2006:26), an approach is defined as *“a systematic explanation of an event in which constructs and concepts are identified and relationships are proposed and predictions made”*.

The author goes on to argue that many approaches include a schematic drawing depicting the overall structure of or interactivity of the components. In other words, an approach is a set of statements or advices that help to explain or guide an action.

The implementation of technology education is dependent on a number of factors, including but not limited to the following: Profile of Technology educators; Attitudes of educators towards Technology; Available resources to deliver the curriculum to defined standards; Educator training; and the attitudes and concepts of learners towards Technology.

All the above factors need to be converted into an approach that would assist policymakers to ensure that implementation becomes successful at all levels of the General Education and Training (GET) Band. In the Further Education and Training (FET) Band (15 to 17 year old learners), there are four areas of specialization in Technology. These are Mechanical, Electrical, Civil Technologies and Engineering Graphics and Design is compulsory for any of the fields of specialization. These subjects were implemented as from January 2006.

Description of the Approach

Technology policy development

The development of a Technology policy should start at the National Department of Education. A dedicated team dealing with Technology issues should be established to liaise with the provinces. It is imperative that government supports the initiatives from universities and other higher education institutions by setting conditions that are conducive for the implementation of Technology in schools. Curriculum design is a dynamic process and

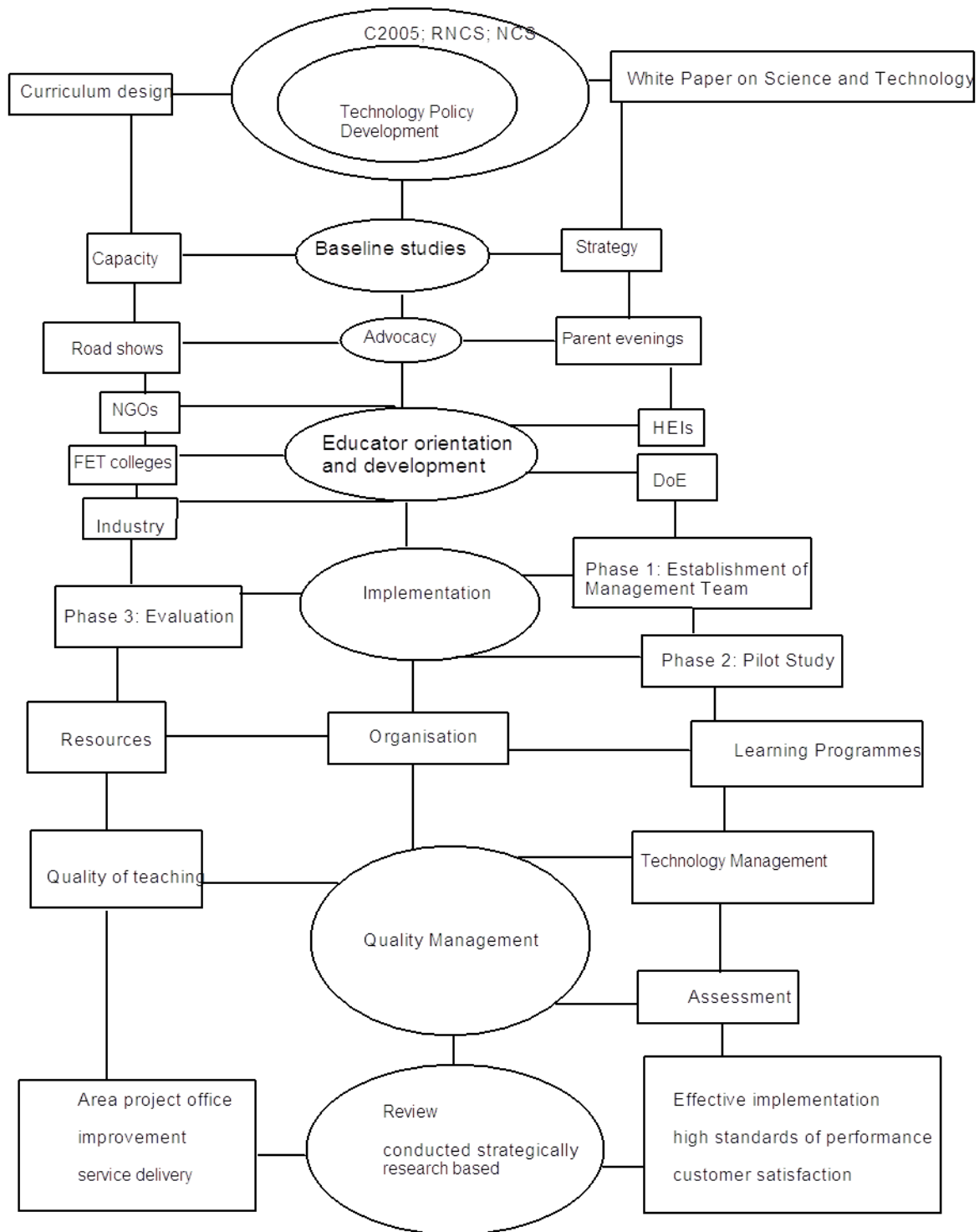


Figure 1: Technology education implementation approach in the North West Province

keeps on changing from time to time. In this regard, the policy team will ensure that the policies are aligned to meet the demands of the curriculum changes. Curriculum design should take care of the diverse needs of the South African society (Stevens, 2002:1) Figure 1.

The policy and white paper on Science and Technology should be utilized to feed on the curriculum needs of the school as well as those of the country. These have a bearing on the infrastructure and the resources. The Technology education policy makers

should be linked strongly with the Department of Science and Technology to ensure that their needs are catered for in the policy. International benchmarking should be conducted so as to learn what other countries are doing. The white paper on science and technology proposes partnership with a variety of stakeholders including the Department of Education in matters pertaining to research and development (DACST, 1998: 20).

Baseline studies/audit

It is very crucial that before any large scale study is ventured a pilot study be conducted or an audit in order to determine the needs of the people. Baseline assessment is used to determine what people already know and have in their possession. This study will help in establishing the state of readiness of all stakeholders. An audit related to crucial things in the implementation of Technology should be administered. These include educators, learners, subject advisors, curriculum developers and parents of learners. The study will also assess the capacity of the various stakeholders to implement Technology. An audit should also be conducted in terms of human, material and physical resources in order to establish the existing capacity (Polaris Marketing Research, 2007:2). These audits will then be used to develop a strategy for implementation.

Advocacy

An advocacy campaign should be conducted using various modes like workshops, road shows, newspapers, talk shows, and radio and television presentations as well as parent evenings. In workshops, presentations are made and participants are offered the opportunity to ask questions related to implementation. The road shows may include distribution of pamphlets to the community and display of artifacts. The talk shows would involve inviting experts to make presentations and demonstrations on Technology. This process will ensure that the learning area is well marketed especially within the parents' community who according to research has negative attitudes towards Technology. If they do not allow their children to do Technology there is no way that the schools can have sufficient learners. We need to win the parents in particular. The radio and television presentations could be made during the education slots and listeners or viewers could be requested to comment on the presentations. In the parent evenings, parents are invited to come and view learners' work including the projects and learners' interest in technological careers. The literature review has indicated the potential of Technology to improve the quality of peoples' lives. Ironically, the disadvantaged populations in general and women in particular, especially those in rural areas, do

not have access to information about these technologies (DACST, 1998:69).

Educator orientation and training

The advocacy should be followed by educator orientation and training programme. This should be done to selected schools as a pilot. Various stakeholders should be involved in the training of educators. The subject specialists should be involved in the initial training on generic Outcomes-Based Education issues. These should form part of the short courses that are organized by the Department of Education. This will also include the methodology and content regarding the learning area as well as support in schools. This will ensure that the trends in Technology which are dictated by the policy are promulgated and implemented. It was discussed in the literature review that the implementation of Technology as learning area in many countries has been undermined by the shortage of resources, educators and inadequate support (DACST, 1998:68).

Another stakeholder in the training of educators should be the Higher Education Institutions (HEIs). Data obtained from the educator questionnaires revealed that most educators are not having an accredited qualification in Technology. At the Advanced Certificate level they should deal specifically with the content and methodology of the learning area. This will ensure that educators get accreditation for the learning area they teach. Senior degrees will cater for advanced research in the learning area. All accredited teacher training in South Africa fall within the competency HEIs especially universities. The Department of Education should collaborate with universities to form a strong partnership regarding teacher training.

The FET colleges have a place in the training as well. They have well equipped resource centers for conducting practical work. Arrangements could be made with relevant authorities to place educators for a certain period in these institutions to allow them to acquire the required practical skills. Technology educators could also enroll for the National Certificate Vocational as part of the enrichment programme.

A strong partnership needs to be established between schools and industry. Industries normally invest money into schools by sponsoring learners' fees and donating equipment required to teach Technology. They also gain from the partnership by having learners joining industries after completing their studies. Industry also helps with the training of staff members. This could also allow for educator placements in industry. Industry needs to be encouraged by producing the kind of student that can be absorbed by these industries. The Department of Science and Technology (DACST, 1998:24) acknowledges that industries are fundamental to the financing and implementation of innovation in society.

Service providers (Non-governmental organizations) are very crucial to help the department with specialized training and support. Some of the NGOs receive financial backing from foreign countries with interest in Technology Education. These stakeholders could play a variety of roles in the implementation of Technology such as policy making, research and development, trainers and providers of infrastructure among others (DACST, 1998:25). The Department of Education does not have sufficient capacity to train and support all its schools. Various service providers should be appointed to train educators and service schools. The providers offer expert advice in the implementation of Technology and sponsor some of the ventures.

Implementation plan

The implementation of Technology should involve the following activities, in phases as described:

Phase 1: Establishment of the management team

All structures required for implementation, training and support should be put in place. It may involve the following activities:

- This phase may take six months. A management team should be created for implementation. Service providers should be appointed and the memorandum of agreement, business plan and budgets as well as timeframes should be approved and contracts concluded;
- Provincial, regional and area project officials should be appointed. Initial training of the officials should begin. These officials should be deployed as supervised trainers for educators in schools;
- Initial training and pilot study should be provided to lead schools in senior phase schools;
- A development plan should be created to oversee and review a complete Technology curriculum for use in grades 7-9. The team should include provincial officers, educators and service providers;
- The implementation will be the responsibility of the North West Provincial Department of education. It will also chair the management committee. They will work in partnership with major funders. The Department may also co-opt the involvement of other stakeholders, such as industry, other development agencies and community bodies;
- The department should identify education service providers and other educational institutions to provide specialist services as needed. These will be accountable to the department and will be represented on the management team. The department will decide on the process for the selection of service providers, based on its needs, on the track record of such agencies in

previous similar activities and on the capacity for such agencies to build capacity within the province;

- To the extent that departmental officials are selected for involvement, the department may wish to consider ways of ensuring that the skills developed are committed to the province for a minimum period of time. This may require participating officials to commit to minimum periods of service, to undertake additional educational responsibilities (within reason) and to participate in training.

Phase 2: Pilot study

After the establishment of the management team at provincial head office, and the creation of structures at the regional and area project office levels, the second phase could comprise of the following activities:

- This phase may take up to three years. After initial training of the programme in lead schools, the regional and area project officials will begin an extended training programme for educators in all schools offering grades 7-9, under the auspices of the department and service providers;
- Curriculum development will begin. This will include the development of a full grade 7-9 Technology curriculum relevant to the North West Province;
- New curriculum modules will be delivered to schools. These will be developed, piloted and then extended to all schools after lead educators have been trained;
- Simultaneously the province, regional and area project offices will be engaged in a training programme that also involves them in developing, adapting and implementing improved management and support systems. These will be aligned with national and provincial policy development in Technology, as they occur;
- Once all regional and area project office officials and lead educators are trained, they will cascade the new materials and systems into their regions and area project offices and the schools; and
- Initial evaluation will occur and be fed back to the various stakeholders for reaction and adaptation.

Phase 3: Evaluation

Evaluation should be carried out by the service provider accredited in evaluation and monitoring. This phase could involve the following activities:

- A full evaluation of the implementation will be completed and tabled. This phase may take six months.
- A review of human resource performance and lessons learned will be completed and policy recommendations tabled; and
- The project partners will begin on extensive review and planning for the extension of the new system and

procedure to other schools in the province.

Internal evaluation

Internal evaluation should be conducted at the level of the school because schools are held accountable for their performance. This means that the school improvements are the responsibility of schools rather than of the Department of Education. This implies that schools have to identify the areas that need development and draw a comprehensive plan on how they could improve on those areas (DoE, 2001(e):5). A copy of the improvement plan should be submitted to the Area Project office for support.

The reports are then shared among the school, area project offices and the external quality assurance verifiers to establish a common understanding and an agreed course of action. On the basis of the internal and external evaluation reports, the school will develop a learning area improvement plan. The subject advisors will guide and support the school in developing and implementing the plan and intervention strategies. It is very crucial that they have diversified skills and professional competencies that can handle both curricula and extra-curricular challenges. The area project office must be able to monitor the implementation of the plans, provide the necessary support and promote a culture of continuous improvement.

Review

From time to time the implementation should be reviewed to check if everything is on track. This should be informed by research in the classroom as well as external evaluation. The reasonable interval at which this could be done is once in five years. At this stage a fresh approach will be followed based on the improvement suggestions and the latest trends in the learning area.

Summary

The proposed implementation approach that has been developed emanated from the findings and challenges identified in the study. Critical issues were identified and these included training, resources, advocacy and quality management. Since the inception of the new education system after the first democratic elections a number of policies have been developed. A lot of criticism, however, has been leveled at the lack of monitoring and evaluation of the implementation of these policies (EFA, 2006(a):20; EFA, 2006(b):2). The Quality Assurance Chief Directorate, therefore, has a responsibility to ensure that national and provincial education policies are complied with.

In compliance with the policy there is a need for a system that will monitor and evaluate the education provision to ensure quality service delivery. Quality

Assurance involves the establishment of processes to improve, monitor, evaluate and report publicly on the performance against predetermined goals and agreed outcomes.

The monitoring and evaluation strategies used in Quality Assurance are different from the inspections of the past, which focused on monitoring for quality checks. Those inspections served as policing mechanisms to entrench apartheid education policy, and had very little to do with assuring quality of education provision. The monitoring and evaluation mechanisms used in Quality Assurance, relate to a new democratic order, which involve approaches that are characterized by partnerships, collaboration, openness and transparency.

RECOMMENDATIONS

- Implement “train the trainers” programme.

Motivation

The Provincial Department of Education should employ trained officers in Technology to pass on their training to other educators in their schools and regions. This would most effectively be implemented in the context of the National educator in-service programme currently being implemented.

- Procure Technology materials and equipment for learners and educators.

Motivation

The Department of Education should procure the required materials and equipment so that the curriculum could be taught to defined standards. These equipment and models will help highlight connections in real world systems and processes. They will also provide an environment for interactive learner engagement in the classrooms.

- Hold advocacy campaigns.

Motivation

The different Education regions of the North West Province should hold advocacy campaigns for all school stakeholders. The schools should also hold parent evenings where Technology as a learning area will be popularized. This is because parents are the key stakeholders in the children’s education.

- Diversify assessment strategies.

Motivation

The North West Provincial Department of Education

should put mechanisms in place to ensure that assessment matches the nature of technological activities. It should incorporate performance assessment, project assessment as well as summative and formative assessment. This will ensure that learners are challenged in a variety of ways to meet the different learning styles.

- Adopt the integrated approach in implementing Technology.

Motivation

The relevant approach for the North West province is a combination of the five approaches. These are: design, practical capability, problem solving, engineering apprentice and technology-society nexus. Learning outcome one of the National Curriculum Statements addresses the design approach. Since Technology takes place within a particular context, the problem solving approach should be incorporated as well. Learning outcome two deals with the skills in Technology focusing on structures, processing and systems and control as content areas. These skills need to be addressed through the practical capability and engineering apprentice approaches. Learning outcome three that deals with the impact, bias and indigenous Technology should be addressed through the technology-society nexus approach.

- Accredite in-service training courses.

Motivation

The researcher recommends that the training of educators be recognized in a model of accreditation and certification. The researcher recognizes that this might be at a range of levels. There will be some educators without an undergraduate degree and who may wish to count their Technology training towards a diploma or undergraduate qualification. Equally there will be some with degrees who will wish to count their work towards a post-graduate diploma or a senior degree. Naturally the process of accreditation involves a validating body and this matter should be pursued with Higher Education Institutions.

- Establish Pilot schools.

Motivation

The researcher recommends that the Provincial Department of Education should identify pilot schools to act as area project office resource centres for the implementation of Technology education. Strategically, some variant on the buddy system should be developed, whereby experienced schools take one or more schools under their wing to help disseminate the practice.

- Appoint Technology subject advisors.

Motivation

The Department of Education should employ at least two subject advisors per area project office. This will ensure continued support and that professional development needs are addressed.

- Teach the technological process well.

Motivation

The learning area heads should ensure that the design process is taught in such a way that it is conceived by learners, as well as having them construct solutions to problems. There should be room for learners to be innovative in the use of inexpensive and locally available materials and equipment. However, much emphasis should be placed on cognitive skills as on technological literacy and capability.

- Advocate links between GET and FET Technology.

Motivation

The School Management Team should ensure that learners are informed about Technology programs in the FET band. These should include curricular offered in both FET schools and FET colleges. The reinforcement of these links in the school curriculum would enhance the Technology education offerings.

- Forge links between schools and industry.

Motivation

Links with industry are very important, not just for learner visits but with the potential for exchange programmes. Educators could spend short term secondments in industries to enhance their levels of technological literacy, in exchange with industry personnel to provide role models for learners. This may lead to increased levels of industry support for schools and should be initiated at the school level. This will afford educators from various educational backgrounds the opportunity to grow professionally and understand the type of Technology that is advocated by the policy

CONCLUSION

The implementation of Technology education in the North West Province is faced with a number of challenges. For an effective implementation of

Technology Education in schools a number of factors need to be taken into consideration. These include adequately trained educators and availability of resources to teach Technology. The recommendations made in this research serve as a foundation for schools which want to implement technology Education properly. It is the wish of the author that the study will be replicated in other provinces in South Africa.

The most urgent need in the context of the implementation of Technology education is training for senior phase educators. There should be room for learners to be innovative in the use of inexpensive and locally available materials and equipment. More emphasis should be placed on the development of cognitive skills as on technological literacy and capability. The approach should be used in the development of Technology education resources for the General education and Training Band.

REFERENCES

- Anckiewicz P (1995). The Planning of Technology Education for South African Schools. *International Journal of Technology and Design Education*, 5(3): 245 – 254.
- Burns RB (1994). *Introduction to research methods* (2nd Ed). Melbourne: Longman Chesire
- Berk L (2000). *Child Development*. Boston: Allyn and Bacon.
- Black P (1998). An International overview of curricular approaches and Models in Technology Education. Retrieved on 2005/09/03 at <http://www.scholar.lib.vt.edu/ejournals/JOTS/Winter-Spring-1998/black.html>
- Chen I (1995). An overview of Constructivist Theories. Retrieved on 2007/10/22 at <http://viking.coe.uh.edu/~ichen/ebook/et-it/constr.htm>
- Chinn PL, Kramer MK (2004). *Theory and Nursing: Integrated Knowledge Development* (6th ed.). St Louis: Mosby.
- Chisholm L (2000). A South African Curriculum for the Twenty first Century. Report of the Review Committee on Curriculum 2005. Pretoria. Department of Education.
- Custer RL 1995. Examining the dimensions of Technology. *International Journal of Technology and Design Education*, 5(1): 219 – 244. The Netherlands. Eindhoven University. Accessed on 2006/01/06 at: <http://scholar.lib.vt.edu/ejournals/JTE/v12n2/custer.html>
- Department of Arts, Culture, Science and Technology. 1998. White paper on Science and Technology. Retrieved on 2007/06/20 at http://www.dst.gov.za/publications/white_papers/Science_Technology_white_Paper.pdf
- Doolittle PE, Camp WG (1999). Constructivism: The career and technical education perspective. *Journal of Vocational and Technical Education*, 16(1). Virginia Polytechnic Institute and state University. Retrieved on 2007/10/22 at <http://scholar.lib.vt.edu/ejournals/JTE/v16n/doolittle.html>
- Epstein M (2002). Constructivism. Retrieved on 2007/10/22 at <http://tiger.towson.edu/users/melstel/research/paper.htm>
- Hall TJK (2001). Should technological literacy be a mandate for technology education programs? *Journal of Industrial Teacher Education* 38(2): 1-9. Accessed on 2006/01/06 at <http://scholar.lib.vt.edu/ejournals/JITE/v38n2/issue.html>
- Hopkins WG (1998). *Quantitative Research Design*. Retrieved on 12/07/04 at <http://www.Sportsci.org/resource/design.html>
- Howie SJ (2001). Renewal of secondary education curricula and assessment in South Africa. Paper presented at the World Bank regional workshop held in Mauritius, December 2001.
- Hsiao WDL (2007). The emergence of Theories of CSCL. Retrieved on 2007/10/22 at <http://www.edb.utexas.edu/csc/student/Dhsiao/theories.html>
- Huitt W (2003). *Constructivism*. Educational Psychology Interactive. Valdosta, GA: Valdosta State University. Retrieved on 2007/10/22 at <http://chiron.valdosta.edu/whuitt/col/cogsys/construct.html>
- Hugh E (2003). Tunnlng the bottom of Japan's Deflation trap. Accessed on 2006/11/28 at: http://bonoboathame.blogspot.com/2003_06_01bonoboathame_archive.html
- Kellner D (2001). *New Technologies/New Literacies: Reconstructing education for the new millennium*. *International Journal of Technology and Design Education* 11, 67-81, 2001. Kluwer Academic Publishers. Netherlands.
- Khumalo SB (2004). The implementation of Technology education as a learning area. Doctor Technologiae Thesis. Tshwane University of Technology.
- Kumar V (2003). Promoting the application of Science and Technology to meet the Millennium Development Goals. Accessed on 2006/11/28 at <http://stdev.unctad.org/un/e-research.html>
- Mallet D (1997). The identification of principles for the development and implementation of Technology education: A case study of Mauritius. Retrieved on 12/07/04 at <http://education.curtin.edu.au/waier/forums/1997/mallet/html>
- Manitoba Publications (2006). Technology as a foundation skill area. Accessed on 2006/11/28 at <http://www.edu.gov.mb.ca/k12/docs/support/tfs/using.html>
- Mawson B (2005). Factors affecting children's learning in technology. Accessed on 2005/12/19 at <http://www.aare.au/04pap/maw04115.pdf>
- McEwen M (2006). Overview of Theory in Nursing: Conceptual framework. Retrieved on 26/01/2007 at <http://connection.lww.con/Products/mcewen2e/documents/PDF>
- McEwen ZE (2006). Overview of Theory in Nursing: Conceptual Framework. Retrieved on 26/01/2007 at <http://connection.lww.con/Products/mcewenze/documents/PDF>
- Nkotsoe MF (2004). Investigating the perception of Intermediate and Senior Phase Educators on Technology Education in the Central Region of the North West Province. Mmabatho. (Dissertation – Bed Honors) 3p. North West University.
- Pavlova M (2005). Social change: How should technology education respond? *International Journal of Technology and Design Education* 15:199-215, 2005. Springer Academic Publishers.
- Potgieter C (2004). The impact of the implementation of technology education on in-service teacher education in South Africa. *International Journal of Technology and Design Education* 14, 205-218, 2004. Kluwer Academic Publishers:

Netherlands.

Sarlemijn A, de Vries MJ (2005). Design methodology in the context of the Eindhoven University of technology "technology and society program". Accessed on 2005/12/19 at [http://www.designresearch.nl/PDF/DRN1995_Sarlemijn_de Vries.pdf](http://www.designresearch.nl/PDF/DRN1995_Sarlemijn_deVries.pdf)

Senesi PH (1998). Technological knowledge, concepts and attitudes in nursery school. Idatec 98 Loughborough University. Pp 27-31.

Stevens AW (2001). The introduction of Technology Education into rural South

Africa: The case study of Stutterheim, Eastern Cape. Proceedings of the

International Conference on Technology education, pp 235 – 239. Cape Town.

Tholo JAT (2007). An approach for the implementation of technology education in schools in the North West Province. Mabatho. Thesis-DEd. North west Province.

Williams PJ (1996). International approaches to Technology education. In J.P.

Williams and A. Williams (Eds), Technology Education for teachers. South

Melbourne, Australia Macmillan. Pp. 266-304.

Zuga KF (2002). Relating technology education goals to curriculum planning. J. Technol. educ.. Accessed on 2005/12/19 at <http://www.scholar.lib.vt.edu/ejournals/JTE/v1n1/zuga.jte-v1n1.html>. pp 1-20