The attainment of technological skills processes and learning outcomes in a Science Talent Quest project comparing two model boats

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ABSTRACT: In this article, the author presents a pedagogical analysis of an award-winning technological project presented by two students at the 2005 ESKOM Expo competition for aspirant young scientists and technologists from high schools in Cape Town, South Africa. Because the technology learning area in the South African curriculum advocates that students must be able to carry out practical projects using a variety of technological skills that suit different styles, and that they understand the concepts and knowledge used in technology, and use them responsibly and purposely, the focus of this article is on documenting students' successful attainment of technological skills and processes, as well as the technology curriculum learning outcomes. As an exemplar, the author analyses the content and presentation of a team project by two students – which contains elements of originality – within the South African national curriculum context. Data was processed using a content analysis research methodology.

INTRODUCTION

In South Africa, technology education strives for practical, solution-oriented learning. It provides opportunities for technological design processes whose elements include investigate, design, make, evaluate and communicate, and is cross-curricular, based on real-life contexts and value-laden [1][2].

In education, knowledge, skills and understanding of the impact of technology on the individual and society are fundamental. This includes the effective use of technological products and systems, the ability to evaluate technological products from functional, economic, environmental, ethical, social and aesthetic points of view, and the ability to design appropriate products to specifications set by, among others, learners [1].

In order to meet these challenges, the outcomes-based education helm of the South African school curriculum established the Technology Learning Area, which will contribute towards learners' technological literacy. The domain of knowledge understanding and the applications that a technology learner in general education and training must cover are as follows:

- *Learning Outcome 1*: Technological Processes and Skills: The learner will be able to apply technological processes and skills ethically and responsibly using appropriate information and communication technologies;
- *Learning Outcome 2*: Technological Knowledge and Understanding: The learner will be able to understand and apply relevant technological knowledge ethically and responsibly;
- *Learning Outcome 3*: Technology, Society and the Environment: The learner will be able to demonstrate an understanding of the interrelationships between science, technology, society and the environment [2].

These provide the basis for further education and training in which a school learner is introduced to three technology subjects (electrical and mechanical technology, and engineering and design) in the new National Curriculum Statement. As a result, the concepts of design and manufacturing form the backbone of these subjects. The subjects are fundamental for eventually producing highly skilful and knowledgeable technologists who can design and manufacture products that are traded worldwide [3].

In addition to these, the annual South African ESKOM Expo for Young Scientists has become a platform on which successful high school students in two categories, Grades 8-9 and 10-12, can demonstrate their inventiveness and innovation in the field of science and technology with the opportunity to proceed, on merit, from regional to national competition and, ultimately, participate in the international Expos [4]. Consequently, these annual competitions, held in 26-28 regions of South Africa, have been hailed as useful means for opening up students' horizons of science and technology. It is also claimed that the South African Department of Science and Technology intends to use the exposition as a *vehicle of scientific and technological empowerment*, particularly by unearthing the science and technology talent and potential of students from disadvantaged schools [4].

Therefore, in this article, the author has elected to investigate the efficacy of acquisition of technology education outcomes in one clearly demarcated, well-structured context in South Africa. It analyses the *viability* of ESKOM's Expo programme for young scientists for enabling Expo students to acquire, develop and demonstrate their acquisition and understanding of a wide array of technological skills and processes, as well as technology learning outcomes, in ways that may be not only personally satisfying for learners who participate, but which can also be sources of individual academic achievement, pleasure and reward.

BACKGROUND

In South Africa, the introduction of Curriculum 2005 (C2005), the Revised National Curriculum Statement (RNCS) for Schools, Grades R-9 (2002) and the recent National Curriculum Statement for Grades 10-12 (General) (2003) emphasised an outcomes-based education approach to school education:

> *Teaching practices, adopted through Curriculum 2005, require that learners participate in classroom activities, become more involved in the learning process, and take responsibility for their own learning. It is envisaged that teachers, as facilitators in their own classrooms, will use a range of strategies* [5].

Ankiewicz, Adam, de Swardt and Gross have supported the need for certain mathematical, scientific and environmental knowledge and skills in, for example, the implementation of technological education as a cross-curricular approach. However, they argued that the *implementation of C2005 has left teachers grappling with issues of outcomes-based learning, assessment, and the accompanying methodologies* [1]. According to them, the introduction of the learning area *technology*, for which there were very few trained teachers, had complicated the situation further. There was a lack of conceptual knowledge in technology education and *the impact is cascaded to the learners who also experience difficulty in sections that educators find difficult to teach (hydraulics is one example of the sections)* [6].

Recent research has also indicated that South African history has made a considerable impact on its education system. Probyn argued that the consistent effects of apartheid – which were distinct in, among others, the disparities in spending on white and African students – resulted in hugely different teaching and learning contexts. These included differences in infrastructure, teacher training (that might be associated with weak teaching qualifications), pupil:teacher ratios and teaching materials [7].

The organisers of the ESKOM Expo in its 25th year had hailed the need of exhibits to reflect *useful technological processes and development*. In the light of this, Alant studied experiences of Expo entrants from KwaZulu-Natal. She discovered and summarised that despite the entrants working under what she claimed as KwaZulu-Natal and national Expos' lack of *clear guidelines*, they had an overall proficiency in merging their interpretation of the technological process involved in the construction of their models into their presentations. From her perspective, this *hands-on/minds-on* approach merged a tacit knowledge of technological process with a series of practical *troubleshooting* skills [4].

Against this background, the annual ESKOM Expos for Young Scientists have recently been recognised as *potential contributors to a nationwide strategic intervention in science and mathematics education*, as well as technology [4]. They are considered as appropriate tools to expose the raw talent and potential of South African students, especially the disadvantaged for whom English is their second language. Hence, the present research study took an opportunity to evaluate the viability of Expo investigative projects to reflect the attainment of technological skills and processes, and knowledge, as emphasised in the current South African technology-based curriculum documents.

PURPOSE

This study is aimed at analysing the 2005 Expo students' written technological report to assess their accomplishment of curriculum-specified technological skills in articulation with their abilities to plan, conduct and present their investigation and their technological knowledge in their area of study – technology – and their ability to interpret, apply and/or construct that knowledge in their uniquely novel investigation.

METHODOLOGY

The study utilised a selected technology-based project of a team of two Expo entrants from a high school in the Western Cape with a competition age range of 13-18 years. The participants in this Expo competition held at the University of Cape Town (UCT) in Cape Town in August 2005 were chosen (over other learning areas, eg life sciences) because their project was the only one continuously available intact and relevant for technology education study.

The checklists utilised for the analysis of the project were based on the technological design process/skills: investigate, design, make, evaluate and communicate, and the technology knowledge domains reflected in the technology learning outcomes [2].

To control for bias in the analysis and interpretation, the researcher used blind reviews and content analyses of the students' written project with a jury of experienced technology and science teachers and lecturer in technology education. They played *devil's advocate* and critically questioned the researcher's coding and analysis.

The focus of analysis was on the students' written report because it provided useful information if the students were *asked to describe their observations, predictions, and plans, and how they carried them out* [8].

FINDINGS AND DISCUSSION

In the current study, two young aspiring science/technology students carried out an investigation on two boats that they designed for their project. As an example, Table 1 presents part of an in-depth analysis of the method section that encompasses the design and manufacturing process. They reported that they started by planning their investigation. Then they bought and gathered all the necessary materials. They designed sketches for the boats' prior manufacturing process in which they used the materials collected to make what they named boat X and boat Y. They were able to evaluate and discuss their work based on the experiments carried on the boats' speed, torque and acceleration and on the design process; hence, they provided evidence of the processes followed in their project.

In this method section alone, the students evidently developed and demonstrated skills needed for investigation such as experimenting, observing, comparing and classifying. They also used knowledge and skills in their design, for example, in planning, and in sketching two-dimensional and three-dimensional drawings. They used tools, equipment and materials (see Figure 4) to develop model boats, evaluating actions, decisions and results throughout the design process, and making improvements on the boats.

Table 1: Part of the pedagogical analysis of a comparison between two boats, one using air propulsion and the other using water propulsion: an exemplar of a gold medal-winning project from the Expo 2005 competition for aspirant young scientists and technologists.

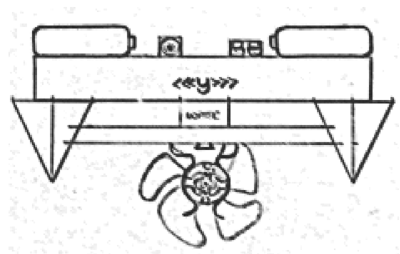
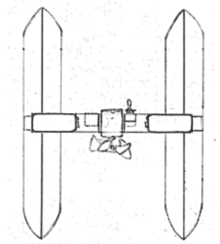
RNCS (2002) – Technology	Associated Educational Components in the Method Section of the Project	Experimental Evidence Derived from the Project Report
Technological skills and processes	*Design*: This requires the knowledge and skills related to graphics and managing resources. It involves making critical decisions, justifying the choices made and preparing drawings or sketches. These drawings should contain all the details needed for making the product or system – instructions, dimensions, annotated notes and so on. Testing, simulating or modelling the solution may be undertaken at this stage before final manufacturing is carried out [2].	The two students applied various skills to build the two boats. These included, among others, planning how to make the two boats, drawing 2- and 3-dimensional *design sketches* (Figures 1 and 2), *neat plans*, calculating, for example, scales, as they also managed their resources. Their final *neat plans* that contained, for example, dimensions were now ready for the manufacturing of the two boats.  Figure 1: Boat design sketch  Figure 2: Boat design sketch
	Making: This involves building, testing and modifying the product or system to satisfy the design specifications. The learners cut, join, shape, finish, form, combine, assemble, measure, mark separate, mix and so on. The making should be according to the design, although it is acceptable to make modifications if necessary [2].	They assembled all necessary tools, equipment and materials to be used, cutting balsa wood and a wooden rod for the boats' hulls and motor mounts, joining various parts with glue and installed electrical components. Furthermore, they ensured that essential improvements were done, eg repaired any leaks and included a motor switch (see Figure 3).  Figure 3: The assembled boats for the project.
Learning outcome	The thrust of *Learning Outcome 1* is on a core set of skills that can be developed through projects that are *needs driven* – that is, they are built around developing and implementing practical solutions to realistic problems or needs [2].	In the case of the design and manufacturing of the boats, they were able to develop and use technological skills such as investigating (they conducted experiments to compare two boats' and gain insight on their acceleration, torque and speed); designing (see part of design in Figures 1 and 2); making (they used tools, equipment and materials to manufacture the two boats, and during the process they, among other things, cut and joined materials); evaluating (they, among other things, made improvements by using waterproof acrylic paint and installing electrical components); and communicating (they presented evidence of the processes followed in their project using a written report, which contained diagrams/sketches, pictures of the boats, etc).

Figure 4: Tools, equipment and materials used in the manufacturing of the two boats by the two award-winning students.

Their project provided evidence of their ability to investigate, plan, design, draw, evaluate, analyse and communicate their findings. The evidence presented in Table 1 is part of a comprehensive analysis of the students' project. This more detailed study contains more elements of the South African curricula such as the other learning outcomes (*Learning Outcomes 2* and *3*), the critical and developmental outcomes.

CONCLUSION

The outcomes of this article on the implemented method of data analysis provide evidence of the attainment of the desired outcomes. The analytical techniques engaged show that it is possible to identify evidence of the Expo students' proficiency in acquiring, developing, demonstrating and understanding technological skills. The analyses of the students' work also revealed their noteworthy ability to perform systematic and logical inquiries and experiments regarded as essential for the acquisition and/or generation of new knowledge in education.

Furthermore, the analytical techniques engaged have also shown that it is possible to identify evidence of a high level of attainment of the specified *Learning Outcome 1*.

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