Exploring technology teaching and learning approaches within South African high schools

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ABSTRACT: The purpose of this study was to investigate teaching and learning approaches applied in teaching the subject, Technology, in high schools. Participants were 13 technology teachers and 32 students from eight rural high schools in South Africa's Mpumalanga Province. More than half of the teachers were female (53.8%). A qualitative case study was used. Data were collected through interviews, observations and an open-ended questionnaire. The computer program, Atlas.ti, was applied in analysing the data. The findings revealed that the teacher-centred and traditional approaches were dominant, which led to poor performance of the students. It was also found that teachers applied various teaching strategies in the technology class, such as the textbook, the question-and-answer method, practical work and assessments. It is crucial that teachers apply what is known as the *STRONG Plus* framework to engage students in inquiry hands-on activities and to encourage collaboration, teamwork and problem-solving.

INTRODUCTION

Globally, technology as a subject is regarded as a crucial and fundamental component of any educational programme [1]. Literature reveals that technology, as a subject, was implemented in high schools in various countries, including Ireland, Hong Kong, Malaysia, Nigeria and South Africa [2-6]. Various terminologies exist for naming this subject; for instance, in Hong Kong high schools it is referred to as Design and Technology [5]. In Rivers State in Nigeria, it is known as Technical Vocational Education [2]. In Ireland, they refer to it as Technology Education [3] and in South African high schools the subject is known as Technology [6].

The aim of technology as a subject in high schools is to expose the students to the careers and university courses that produce engineers, technicians and artisans needed in modern society to improve the pace of the nation's technological development [7]. It is argued that the major motivation for introducing technology education in the South African National Curriculum in 1998 was the need to produce artisans, technicians and engineers required to develop a technologically literate society in the modern world [4]. In fact, it is pointed out that technology as the subject has the ability to stimulate students to be innovative, creative, collaborative and display critical thinking skills and nurturing teamwork [8].

The effect of technology is such that it teaches students to manage time and material resources effectively [4]. These skills offer a firm foundation for several further education and training (FET) subjects, as well as for the world of work. However, the performance of the students in technology in rural high school has not been satisfactory. In 2014, the pass rate of the students in rural high schools in Mpumalanga province Grade 8 was 41.33% and in Grade 9, 39.2%. In 2015, the pass rate in Grade 8 was 35.2% and in Grade 9, 31.7%.

This decline in students' performance in technology motivated the researchers to investigate the teaching and learning approaches applied in teaching the subject. The challenge in this study was this: despite the efforts made by the Department of Education during the inception of technology into the curriculum in South African schools, the performance of students to date has shown no improvement.

The objective of this article was to determine the teaching and learning approaches used to teach the subject, and support the teachers with the mechanism to apply what is known as the *STRONG Plus* framework. To establish the teaching and learning approaches adopted by the teachers, participatory observations were conducted in two schools. This was to generate an in-depth insight about the practical knowledge of the subject exchanged between teachers and students. Then, teachers completed an open-ended questionnaire to provide information about their perceptions of teaching technology. Finally, one-on-one semi-structured interviews were conducted with teachers and students to obtain more information about teaching and learning approaches.

RELATED LITERATURE

Importance of Technology as a Subject in High Schools

It is argued that the major aim in introducing technology education into the South African National Curriculum in 1998 for Grades 4 to 9 was to provide learners with the basic skills needed in civil, mechanical and electrical technology and engineering graphics and design [4]. In addition, learners gain an idea of the way engineers apply scientific principles to practical problems, as well as evaluation skills for product design [4]. The objective of the South African Government was the need to produce artisans, technicians and engineers, to develop a technologically literate society that can meet the technological needs of the modern world [7].

It is pointed out that technology as a subject has the ability to stimulate students to be innovative, creative, collaborative, critical thinkers and problem-solvers, who value and nurture teamwork [8]. Furthermore, technology teaches students to manage effectively both time and material resources. These skills offer a firm foundation for several further education and training (FET) subjects, engineering courses at university level, and the world of work [4]. These skills are also required in the 21st Century and certainly in industry 4.0 [9]. The main objectives of teaching technical education were to prepare students for the world of work through the acquisition of theoretical and practical skills.

Teaching Technology in High Schools

The significant issues in teaching technology to students is to provide them with the opportunity to learn problem-solving by applying the design process, practical skills, knowledge and the application of knowledge [10]. This would be achieved through practical projects that drew on a variety of technological skills relating to investigating, designing, making, evaluating and communicating [10]. The skills are meant to accommodate various learning styles and approaches to learning.

In fact, the technology content taught in Grade 8 covers the following:

- Term 1: The impact of technology processing.
- Term 2: Mechanical systems.
- Term 3: Control.
- Term 4: Electrical systems and control [10].

The technology content for Grade 9 covers structures. They include:

- Term 1: Mechanical systems and control.
- Term 2: Electric/electrical systems and
- in Terms 3 and 4, processing [10].

The aim of these topics was to ensure that students become aware of the interrelationship between technology, society and the environment [10]. Students were expected to engage in a short, practical assessment task for each of the content areas, which is referred to as a *mini-practical assessment (MiniPAT)*.

It was crucial in this study that teachers understood the assessment principles required in technology, because assessment is an integral part of teaching and learning. Assessment assists the teacher in gathering, interpreting and using information for decision-making about the students [11]. The format of assessment applied in technology was clearly stated in the policy and curriculum [10]. It is argued that some tasks comprised more than one form of assessment, with various activities that support the form of assessment used [12].

Various types of assessment that were expected to be applied by the teachers in technology included: practical; demonstration; panel discussion; model making/plans/design; brainstorming/mind-mapping; presentation; research exhibition; project work; and investigation [7][12].

Performance assessment is based on real-life situations or simulation [12]. It was required in technology that each task consisted of at least two activities, in this instance presentation, as well as the performance-based task, which included a project, practical tasks or MiniPAT [7]. MiniPAT provides the students with an opportunity to develop and demonstrate their levels of ability [12]. MiniPAT assesses students' skills and application of knowledge, and forms part of the formal assessment [10].

Technology Teaching and Learning Approaches

Teaching approaches are the structured plan that assists teachers to adapt and adjust innovative teaching to accommodate students [13]. The authors posit it is crucial that teachers select a teaching strategy depending on the information or skills they want to convey to students. It is stated that teaching approaches play a major role in enhancing student learning [14]. There are several existing teaching approaches that teachers could use within teaching

and learning. These approaches may be in the form of a bottom-up or top-down student-centred strategy or teacher delivery, questioning techniques, physical models, lecturer movement, group work, experiential learning, discussion and inquiry-guided teaching [15][16].

Literature shows that the corpus of research on the integration of technology in K-12 education is fairly recent, dating back to the past 20 years [17]. In this regard, it was argued that the teaching and learning approaches in technical education were to teach the basic scientific knowledge, attitudes and practical skills necessary for self-reliance and national development [2]. What transpired was that the direct teaching of domain knowledge in sterile learning environments left students unenlightened and unable to see its real-world relevance [18]. This implies that the traditional teaching method was not conducive for technology. Therefore, the teaching methods that increased student learning, reflective decision-making, argumentation and engagement were identified as conducive for technology [17].

The most effective approaches of teaching practical skills are the demonstration, enquiry, project and assignment methods [2]. To teach technology effectively and in a manner conducive to the students' learning and development, diverse teaching and learning approaches are required [14]. The authors argue that new, innovative and effective teaching methods should be employed in technology. These teaching strategies include demonstrations, discussions, projects, guided discovery, inquiry, questioning, simulation, field trips and individualised instruction.

If these approaches are implemented successfully, they tend to motivate students' learning, and promote student-centred learning that leads students to achieve and improve their academic performance [19]. So, effective teaching takes place when the teacher knows the approach to use in a particular situation, to meet specific outcomes of the lesson. In this regard, teachers select a teaching strategy depending on the information or skill they want to convey to the students [13].

STRONG Plus Framework

The STRONG Plus framework was developed to support technology teaching approaches [18]. The STRONG Plus framework strives to engage all students in a progression of guided inquiries using hands-on activities to facilitate their understanding of science, technology, engineering and mathematics (STEM). STRONG encourages collaborative work. In this instance, students work in teams, to solve challenging problems so as to accomplish various goals.

STRONG empowers students to talk, think and act innovatively. Students' flexibility in thinking and performing hands-on activities is a measure of their understanding. It is argued that in STRONG, students shift to higher levels of learning and become more active, self-directed students [18]. The authors argue that schools' responsibilities include teaching the students skills in observation, critical thinking, mathematical reasoning, communications and problem-solving [18][20].

METHOD

The objective of this work was to determine the teaching and learning approaches applied in teaching technology, and to support the teachers with the mechanism by which the STRONG Plus framework was employed in the teaching practices. A qualitative case study was introduced, which allowed researchers to elicit factual responses from the participants [21].

Participants

To choose knowledgeable participants, who have in-depth knowledge, purposive sampling was adopted [22]. The participants were 13 technology teachers and 32 students from eight rural high schools, in Grades 8 and 9 in Mpumalanga Province, South Africa. Four students from each school were selected to participate in the interviews. These students were minors. Their parents gave consent. Students participated in the interviews. The biographical data of the students were not collected, which was stipulated by their parents.

More than half of the participants were women, i.e. 53.8%, and 46.2% were men. Teachers' age distribution was 30.8% between 36 and 40 years; 7.7% between 41 and 45; and 61.5% were 46 and above. The teaching experience distribution showed that 30.7% of teachers had 0 to 5 years' experience teaching: 38.5% had 6 to 10 years; 7.7% had 11 to 25 years; and 23.1% had 26 years' experience and above. More than three-quarters or 76.9% of teachers, were in PL1 positions. About 61.5% had taught technology for more than 4 years; 23.1% between 2 and 3 years; and 15.4% for less than 1 year.

Instrument and Procedures

First, data were collected through observations in two schools. Non-participation observation was used since it allows the researchers to observe rather than take part in the lesson [23]. These observations helped the researchers to answer questions about the teaching and learning approaches, as well as learning activities in technology classrooms and workshops for completing practical work (MiniPAT). A typical question that guided the observations was: *Identify the teaching and learning approaches used during the lesson and in MiniPAT.*

Second, the open-ended questionnaire was administered to teachers. Section A of the questionnaire required the teachers to provide biographical information. Section B consisted of two questions on teaching and learning. The typical questions were: *Describe the teaching methods you use to teach technology? What are the activities you use to engage students in technology in class? Explain.*

Finally, the interviews were conducted with the teachers as well as the students. For the teachers the three questions were: *What are the teaching methods you use to teach technology? What are the basic technological principles you use to engage students in technology classes? How do you conduct the practical work (MiniPAT) in the technology workshop?*

Students were also required to respond to three questions: *Are the teaching strategies used by your teacher in technology understandable? Do you participate in technology activities in class? Do you do practical work (MiniPAT) in the technology workshop?*

Data were analysed using Atlas.ti. The hermeneutic unit called the *FAT Technology* project was created; it consisted of four primary documents. From these documents, 280 codes were created. The codes were then grouped into five networks. For an in-depth understanding of the analysis, these networks were clustered into three families relating to teaching strategies, teaching methods and learning strategies. The theme, teaching methods, emerged from these families.

FINDINGS AND DISCUSSION

In terms of teaching strategy, it was found that teachers employed various teaching approaches in technology. The teaching approaches that were identified by the teachers were textbooks, question-and-answer and assessments. In this instance, teacher Zandi said: *…All the students have a textbook. I introduce the topic; I explain a bit more and provide information about the topic. We then go together through the textbook.*

It may be argued that teachers teach from the known to the unknown, i.e. deductively. Teacher Potgieter said: *…I ask about the prior knowledge of the learners and then teach the important parts where I see that the students are lacking. I will ask questions and assess them.*

The findings also show that teachers make use of other teaching strategies to engage the students during class. Figure 1 shows the conceptual network relating to the activities employed by which to engage students in the Technology subject.

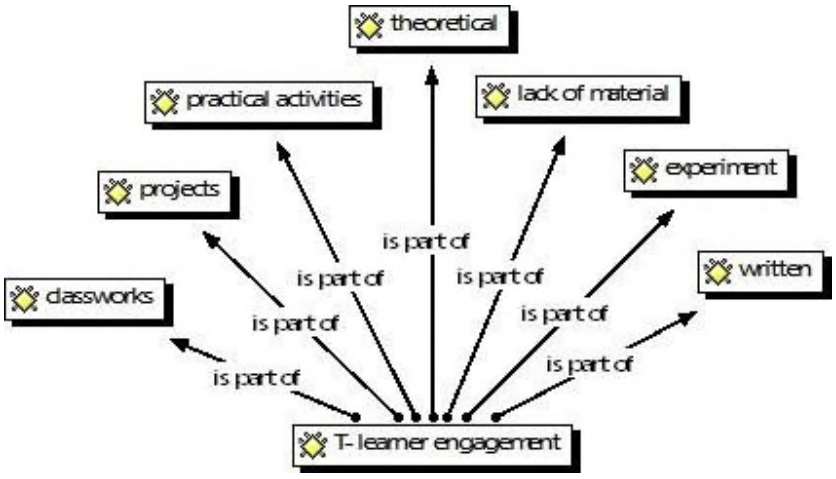

Figure 1: The conceptual network of the learner engagement by teachers in technology.

With regard to classwork, it was observed that *…students were given classwork at the end of each lesson.* It was also found that *…students were given projects to write at school in groups and some were done individually*. It was observed that students were given *…practical work at times to execute in groups and individually; pre-discussion and demonstrations were done theoretically*. It was discovered that it was not easy for teachers to conduct experiments because there were no materials and apparatus. It may be argued that a top-down strategy was more dominant. Teachers tend to follow the traditional way of teaching; students were passive, the teacher was at the forefront leading the teaching and learning process [13].

In this study, it was observed that the traditional strategies were dominant because the teachers most of the time explained the topic to students. Then they read through the textbook with the students. It is crucial that teachers apply a wide range of teaching strategies to engage the students studying technology [12]. In fact, it is opined that high school teachers have an obligation to teach students through a variety of strategies guided by inquiry hands-on activities [18].

The findings also revealed that students understood the teaching strategies that were used by teachers of technology. It was also found that most of the students indicated that they understood the teaching strategies used in technology. Student Zodwa mentioned that: *Yes, I understand when the teacher explains the concepts, because I can even do work on my own.* Simangaliso indicated that: *Yes, I always understand the teacher when he explains and discusses in class.* Dineo further said that: *Yes, it is very understandable, I understand everything he says.* Chantel indicated that: *Sometimes because he tells us how the thing is used.*

It may be observed from the findings that the traditional approach was employed to support the identified strategies. It is argued that lack of involvement by learners during the lesson is not suitable, particularly at the level of these students [24]. It does not promote interactive learning to increase student achievement in high schools [18]. As indicated in the literature, traditional teaching strategies in technology lead to poor performance by the students [25].

The findings revealed that some of the teachers applied various teaching methods, such as demonstrations, real-life experience, and case studies or scenarios. Teacher Sithole indicated that: *There is no specific method because I vary my methods*. It was also found that teachers in this study also made use of the demonstration method. The demonstration method implies that the teacher shows learners what they need to do [24]. This teacher further mentioned that the lesson incorporates multimedia presentations and activities to demonstrate. It is argued that the demonstration method is the most effective strategy in teaching technology and is one of the most relevant methods [2].

Some of the teachers used real-life examples so that students were able to execute the task in class during MiniPAT. In this regard, teacher Steyn reiterated that: *Ok, let us say for example when teaching structures, I tell them to go outside and look for different types of structures. Then thereafter, they identify the type of structures such as used in a house, a classroom or relevant examples of the types of structure.* Real-life experience is when students are physically engaged in real-life experiments [12]. It is associated with a field trip or real-life situation and is regarded as a valid and reliable assessment instrument in technology [2].

It was also found that during MiniPAT some of the teachers gave case studies or scenarios for students to identify the problem to solve through the five steps required in technology. These steps are to identify, design, make, evaluate, communicate (IDMEC). Teacher Steyn further revealed that: *We go into the class, or sometimes we are doing MiniPAT. I give them the scenarios or a case study to identify the problem. In these scenarios which include a design brief, the learners identify the problem statement, and follow a design brief in terms of what they are supposed to do to solve that problem.*

This is supported in the literature: the teaching methods that increased student learning, reflective decision-making, argumentation and engagement were identified as conducive for teaching technology effectively [17]. It was also found that some of the teachers still use a teacher-centred approach, although they engage learners with questions and answers to check the understanding of concepts. In this case, teacher Jackson indicated that: *I use the direct instruction method and question-and-answer method*. It is argued that the teacher-centred approach to teaching domain knowledge tends to leave the students unenlightened and unable to see the real-world relevance [18].

It was found in this study that various learning strategies were used by students to learn technology. Learning strategies identified by the students were projects, classwork, homework, assessments, activities, asking and answering questions, as well as MiniPAT. These learning strategies correspond to those identified by teachers in this study. Figure 2 shows the conceptual network of learning strategies employed in technology.

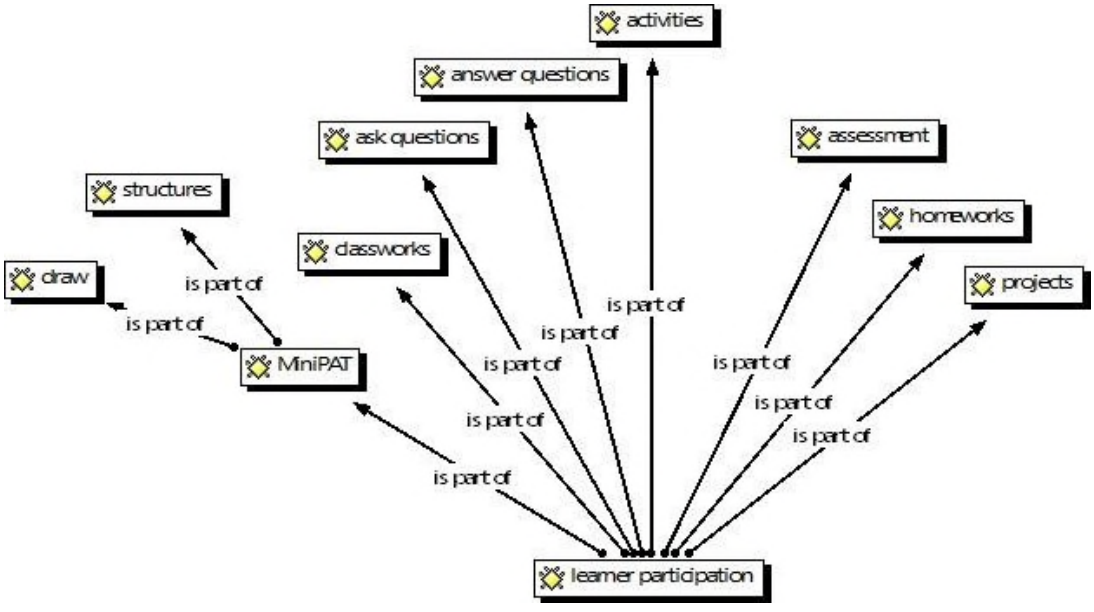

Figure 2: The conceptual network of learning strategies in technology.

The findings revealed that students were given projects to complete, either in class or as part of homework or on their own as MiniPAT research projects. Student Zodwa said: *Yes, I do, actually focus on projects*. Tinyiko mentioned that: *Yes, we do projects, and sometimes we complete them in class or during practicals.* Vitilo indicated that, *Yes, I do projects once per term*. Research shows that practical tasks in technology provide meaningful information as compared to written tests that penalise students on what they cannot do or do not know [12]. Students were given homework in technology. This implies that homework was also part of the learning strategy, to keep them actively involved while at home. Pleasure said that: *Yes, we are given 3 or 4 homework activities.* Busi revealed that: *Yes, we do homework twice a week*. Tendani mentioned that: *Yes, the teacher gives us homework, but some of the learners come to class without it. It becomes a problem because they have to complete it in class.*

The findings revealed that students were also involved in assessments for promotional purposes, meaning that accrued marks were added to the final examination marks. Themba indicated that: *We do write a test every semester*. Lerato mentioned that: *Yes, we do tests, though most of us fail, but I am happy that I pass all the tests.* It is also pointed out that assessment tasks provide students with an opportunity to demonstrate their gained competencies in technology [26]. In this regard, Mngunikazi stated that teachers should rethink and redesign assessment strategies, to generate innovative assessments that require various technologically advanced assessment types [12].

It was found that classwork was a daily activity given to the students to check their understanding of concepts. It was also found that students were allowed to ask questions in class. Student Dineo indicated that: *Yes, if we do not understand we are allowed to asked questions*. Busi said that: *Yes, we do a lot of classwork*. The findings show that MiniPAT was one of the strategies adopted to summarise the work carried out on a quarterly basis. The strategy contributed 70% of the work done during each quarter. It is pointed out that MiniPAT contributes to the formal assessments of students' skills and application of knowledge in technology [10].

This strategy accumulated marks by involving drawing structures in double vanishing-point perspectives and first angle orthographic projections. Student Bopelo said: *Yes, we do MiniPAT in groups*. It may be argued that teachers accidentally apply STRONG, which encourages collaborative work [18]. Dineo also said: *Yes, we do steps like investigation and research.* This was supported by the technology policy that indicates MiniPAT or practical enabling activities are to develop knowledge, skills and values to the point where students are ready to be assessed [10]. Research also revealed that the subject, Technology, places a heavy emphasis on psychomotor learning and motor skills [27].

CONCLUSIONS

It may be concluded that in South Africa the inclusion of technology as a subject in high schools was an effective initiative by which to allow the students exposure to a wider scope of engineering careers at an early stage. The authors' objective had been to investigate how the teaching strategies and approaches were applied to the teaching of technology, as a subject, in selected high schools.

It was observed in this study that the STRONG Plus framework was proposed as the framework for use by technology teachers. This will support the teachers, so that they are able to effectively apply IDMEC, as well as produce required results. It was noted in this study that teachers and students adopted various teaching and learning strategies. However, these strategies were applied in conjunction with the teacher-centred approach. There was a strong argument that Technology is an important subject; it should promote 21st Century skills and expose students to the jobs required in industry.

RECOMMENDATIONS

It is crucial that Technology teachers employ the learner-centred approach and apply the principles of the STRONG Plus framework in teaching the subject. It is crucial, too, that there is professional development of technology teachers to assist them with appropriate teaching methods and skills relevant for teaching the subject. Further research could be conducted applying the mixed method with a wider scope for sampling. A further study also could be conducted, to test the effectiveness of the STRONG Plus framework, students' and teachers' challenges with technology, and to test their perspectives of the teaching of technology.

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