Teaching and learning for technology in South African rural high schools

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ABSTRACT: The aim of this study was to examine the teaching and learning methods of teaching technology in eight rural high schools in Mpumalanga Province, South Africa. Participants comprised 43 technology teachers and students. Concerning teachers, 53.8% were female and 46.2% were male. A mixed research method was employed. The means of collecting data were a survey questionnaire, semi-structured interviews and observations. The software, Atlas.ti, was applied to analyse qualitative data. Quantitative data were analysed through SPSS. It was found that the chalk-and-talk method of teaching was dominant. The results also revealed that about one in three (69.2%) of the teachers gave students projects to complete on their own. It is recommended that the schools be provided with adequate and relevant teaching and learning equipment, as well as material for technology. It is essential that each school be equipped with a technology workshop that has relevant and appropriate equipment for conducting practical work (MiniPAT).

INTRODUCTION

Technology is an integrated, experience-based subject. Technology teaching is intended to produce citizens who are knowledgeable about technology, its systems, techniques and uses, as well as the social and cultural significance of technology [1]. Technology is viewed as a means for providing opportunities for students [2] in time and material resource management. Ohemeng-Appiah argues that these skills offer a firm foundation for further education and training at grades 10-12 [3].

In South Africa, technology as a subject was introduced into the curriculum in 1998 for grades 4 to 9. In most schools, teachers were unqualified and volunteered to teach technology. A teacher-centred traditional teaching and learning approach was mostly applied in teaching technology. The literature revealed that these methods of teaching and learning often left students unable to see its real-world relevance [4]. Students also performed poorly in the subject.

It was opined that the direct teaching method was not appropriate for technology. Rather, it was critical for teachers to understand and apply constructivism theory. Constructivism theory places students at the centre of learning where they engage with, and take responsibility for, their own learning. Furthermore, technology teaching and learning requires students to engage practically with the subject. Hence, students need to learn the principles of investigating, designing, making, evaluating and communicating (IDMEC) as they solve technological problems when learning technology.

The IDMEC principles require a constructivist learning approach since it is student-centred in which students must construct ways to solve technological problems informed by their experience. Constructivist teaching methods tend to increase student learning, reflective decision-making, argumentation, and engagement [5]. Of course, teaching strategies that have demonstrations, enquiries, projects and assignments tend to improve practical skills [6].

An understanding of the application of constructivism in learning technology is critical for this study. Teachers need support to improve, adopt and implement improved teaching strategies. Furthermore, constructivism can assist teachers to understand how students learn, and hence how to improve student academic performance.

In a constructivist theory, learning is a social process that involves real world situations, interactions and collaboration among students [7][8]. Constructivism is an active learning approach, whereby the students personally construct and interpret information based on their experiences [9]. Piaget believed that constructivist learning is the organisation, assimilation and accommodation of information on how things work.

Assimilation is about incorporating new information and accommodation is transforming existing information or creating new information. In this study, a teacher was to organise work based on the content to be taught and introduce

it to students, so as to arouse their interest in learning. Students adapt themselves to the content based on experience. Through experience, students are able to accommodate the content.

Constructivism favours a learner-centred approach based on the notion that the learning environment should support multiple perspectives of reality, knowledge and experience-based activities [10]. In constructivist learning theory knowledge is constructed when individuals engage socially in discourse and activities about shared problems or tasks. The teacher's role shifts, from imparting knowledge to that of facilitating it.

The traditional teaching methods of technology could be supplemented by active learning, which is fundamental to constructivist theory. It was crucial for this study that teachers knew that learning does not occur in isolation, but is influenced by social context. Teachers have to create technology activities that cause students to construct their learning, supported by the teaching.

Constructivist learning theory and active learning techniques have the potential to improve the IDMEC approach, critical thinking, independence and deep learning of technology. The aim of this study was to examine the teaching and learning methods of technology, both theory and practical. Also, the aim was to support the teachers in techniques that employ the constructivism principles.

First, to determine teachers' teaching and learning methods in technology, observations were conducted at two schools to provide an in-depth insight about them. Second, teachers completed a survey questionnaire with open and closed questions on information about teaching technology, both theory and practical. Finally, semi-structured interviews were conducted with students to learn more about their perception of the teaching and learning methods in the teaching of technology, both theory and practical.

METHOD

The aim of this work was to determine the teaching and learning methods employed in teaching technology. To accomplish this, a mixed qualitative and quantitative approach was effected, to provide better understanding than either the qualitative or quantitative approach alone [11].

The survey instrument data were analysed with descriptive statistics that included frequency distributions, percentages, means and standard deviations. The SPSS was the means of analysing those data. The qualitative data were analysed with Atlas.ti.

Participants

Participants were 43 teachers and students from eight rural high schools in Mpumalanga Province, South Africa. Of these, 32 were students. Table 1 shows the biographical data for the teachers only. Students' biographical data were not disclosed and kept confidential, as required by their parents. Nine (69%) of the teachers taught Grade 8 and four (31%) taught Grade 9. Most teachers taught other subjects as well as technology.

Table 1: Teachers' biographical data.

		Frequency	%
Gender	Female	7	53.8
	Male	6	46.2
Age in range	36 - 40	4	30.8
	41 - 45	1	7.7
	46 and above	8	61.5
Number of years teaching technology	Less than 1 year	2	15.4
	2 - 3 years	3	23.1
	More than 4 years	8	61.5
Other subjects taught	English	2	15.4
	SeTswana	1	7.7
	Mathematics	1	7.7
	Social science	1	7.7
	Natural science	1	7.7
	Arts and culture	2	15.4
	Life orientation	4	30.8
	None	5	38.5
Training in technology	Formal	8	61.5
	Informal	1	7.7
	Not trained	4	30.8

Instrument and Procedure

Observations were conducted at two schools to determine whether the principles of constructivism were employed during teaching and learning. Typical questions were: *List the teaching strategies used during the theory lesson. How does the teacher explain the concept of the MiniPAT* (mini-peer assessment tool)?

The survey questionnaire with open and closed questions was then administered to teachers to establish whether the theory of constructivism was employed. Section A comprised biographical information. Section B consisted of eight closed questions relating to technology teaching, both theory and practicals. The first five questions required responses on a 5-point Likert scale, (1 - strongly agree; 2 - agree; 3 - neutral; 4 - disagree; and 5 - strongly disagree). A typical question was: *Do you apply IDMEC principles in MiniPAT?*

The last three questions required teachers to rate on a Likert scale of 1 - 3 (1 - always; 2 - seldom; and 3 - never). The typical question was: *How often do you engage learners in the teaching process?* Section C consisted of two questions. The questions were: *Describe the teaching methods you use to teach technology;* and *What are the activities you use to engage students in technology in class? Explain*.

Finally, semi-structured interviews were conducted with the students. The interviews consisted of five questions. Three of the questions related to theory. Example of a question: *Please tell me, how is the teacher teaching technology?* Two of the questions related to practicals. Example of a question: *Do you apply design steps when doing practical projects? If yes/no explain.*

RESULTS

Table 2 shows teaching and learning theory and practicals results. In Question 1, teachers responded to a question: *Does the school have technology workshops to conduct practical classes?* The results revealed that most teachers, 84.6%, disagree or strongly disagreed. The results emphasise that most of the rural high schools do not have workshops to conduct technology practicals.

Concerning Question 2, teachers were asked: *Are you able to teach practical work in a technology class?* The results indicated that few, 38.5%, of teachers were able to teach practical work. It may be argued that because of a lack of workshops it was impossible for teachers to teach practical work.

In Question 3, teachers were asked: *Does the school have adequate resources for the students to complete their projects?* It was found that most teachers, 77%, disagree or strongly disagreed. It was clear from the results that rural high schools lack relevant resources to provide for students, as well as to the teachers so as to demonstrate.

In Question 4, teachers were asked whether they applied IDMEC principles in MiniPAT? It may be observed from the Table that less than half, 46.2%, of the teachers agree or strongly agree. This means that half of the teachers neglected the IDMEC principles when conducting MiniPAT.

In Question 5, teachers were asked whether they completed the MiniPAT according to the requirements of the policy or syllabus. It may be seen from the results that the majority, 84.7%, of the teachers agree or strongly agree. This suggests that the teachers followed the policy and the syllabus requirements as stipulated.

Table 2: Teachers' frequency distributions on support for technology practicals.

	Item	Strongly agree No.(%)	Agree No.(%)	Neutral No.(%)	Disagree No.(%)	Strongly disagree No.(%)	M	SD
1	Does the school have a technology workshop to conduct practical classes?	0	1 (7.7)	1 (7.7)	3 (23.1)	8 (61.5)	4.38	0.961
2	Are you able to teach practical work in a technology class?	3 (23.1)	2 (15.4)	4 (30.8)	2 (15.4)	2 (15.4)	2.85	1.405
3	Does the school have adequate resources for the learners to complete their projects?	0	0	3 (23.1)	4 (30.8)	6 (46.2)	4.23	0.832
4	Do you apply IDMEC principles in MiniPAT?	2 (15.4)	4 (30.8)	4 (30.8)	1 (7.7)	2 (15.4)	2.77	1.301
5	Do you complete the MiniPAT according to the requirements of the policy or syllabus?	5 (38.5)	6 (46.2)	1 (7.7)	1 (7.7)	0	1.85	0.899

Table 3 continues with teaching and learning theory and practical's results. Concerning Question 6, teachers had to indicate how often they engaged students in the teaching process. The results indicated that the majority, 92.3%, of the teachers always involved students in the teaching and learning process. It may be argued that teachers followed the constructivist approach, which emphasises student engagement.

With regard to Question 7, teachers had to indicate how often they asked questions in class. It may be observed from Table 3 that all teachers always ask questions. It may be argued that the question-and-answer method is supported by constructivists, because it promotes interactivity between teacher-student and student-student.

In Question 8, teachers had to indicate how often they employ technology workshops. The results showed that 69.2% of teachers never did. This suggests that about two in three of the teachers did not use technology workshops, because they were not available in the rural high schools studied.

Table 3: Teachers' frequency distribution on student engagement.

	Item	Always No. (%)	Seldom No. (%)	Never No. (%)	M	SD
6	How often do you engage learners in the teaching process?	12 (92.3)	1 (7.7)	0	1.08	0.277
7	How often do you ask questions in class?	13 (100)	0	0	1.00	0.000
8	How often do you use technology workshops with the learners?	0	4 (30.8)	9 (69.2)	2.69	0.480

Qualitative Findings

Open-ended questions were put forward to find out teachers' views on constructivist teaching and learning methods in technology. In Question 1, teachers were asked: *Describe the teaching methods you use to teach technology.* The findings revealed that most of the teachers identified various methods they adopted to teach technology, such as chalk and talk, direct instruction, demonstration, real life experience, as well as question and answer.

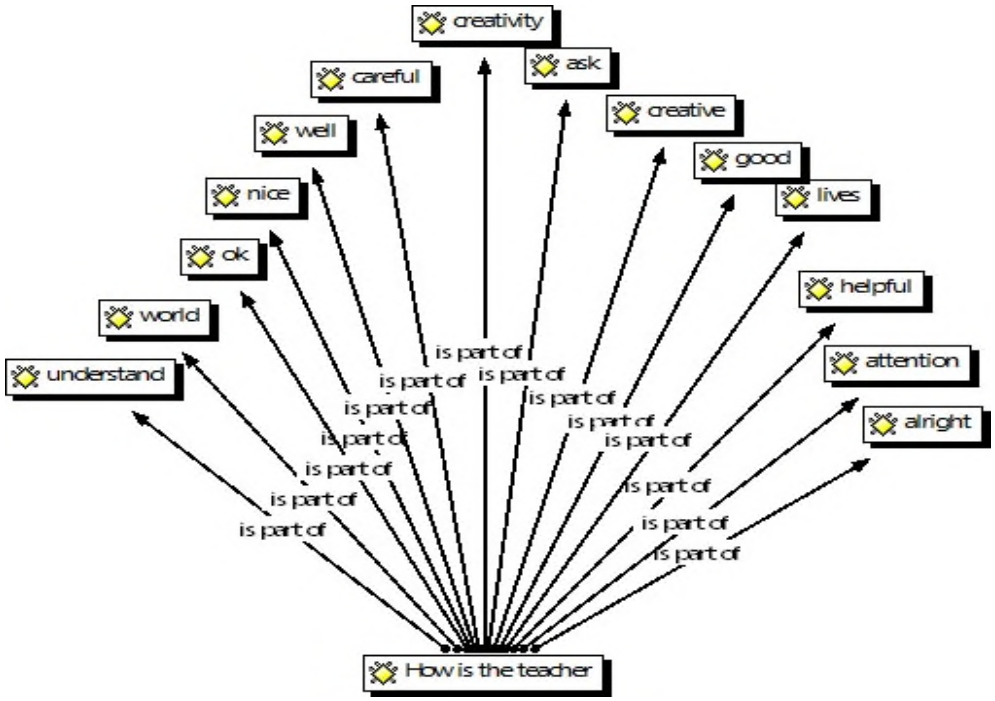

Figure 1: The conceptual network about the teaching methods adopted by the teachers for technology.

On the other hand, students were asked to indicate how teachers taught technology. Figure 1 shows the conceptual network about the teaching methods employed by the teachers. The findings show that students are supportive of the teachers' teaching. Student Sithembiso mentioned that *the teacher is teaching well and I enjoy his teaching.* Student Thembi opined that *I think he tells us that technology is about things happening in the world and how to create things.*

Students were asked: *Are the teaching strategies used by your teacher in technology understandable?* Student Jabu indicated that *teaching is ok. It makes us understand*. Student Thandeka revealed that *he teaches very well and I understand*. Other students felt that their teachers are good and they explain clearly. Student Mandisa mentioned that *he is a good teacher*.

In Question 2, the teachers were asked: *What are the activities you use to engage students in technology in class? Explain*. The findings showed that the theme of learning activities emerged. The learning activities identified by teachers were classwork, homework, oral questions, individual activities, group activities, projects, assignments and discussion.

The findings revealed that some of the teachers gave learners classwork. In this case, the researchers observed that *students were given classwork at the end of each lesson*. Teacher Zondo said: *I give them classwork and homework to engage them.* Teacher Stephina stated in regard to *oral questions: After the lesson I ask them questions and give them class activity to complete.*

It was also found that students were engaged in group and individual activities to complete the practical projects. The researchers observed that students were given *…projects to complete at school in groups and some were done individually*. Teacher Zandi mentioned that *I divide students into groups and give them practical assignments to do at home.* Teacher Rivombo revealed that *I engage students with group discussion; students read, discuss and write activities (classwork). Sometimes, when it is necessary, I lead the discussion giving clues that prompts responses.* Teacher Rebecca indicated that *I give students work in groups to design a model. This needs full participation in the group. This is a MiniPAT exercise*.

Students were also asked: *Do you participate in technology activities in class? Explain*. The findings revealed that students were given projects to complete either in class or as part of homework or on their own as a MiniPAT research project. In this instance, Student Zodwa said *yes, I actually do projects*. Student Tinyiko mentioned that *yes, we do project, sometimes we complete in class or in practicals*. Student Vitilo indicated that *yes, I do projects once per term*.

It was found that practical work or MiniPAT was completed quarterly. This means that students were given practical work to complete. The practical work covers the work done during the quarter in theory classes. Practical work forms 70 percent of the work in technology. It involves individual and group work. There is a technological or design process to be followed when executing MiniPAT.

It was found in this study that lack of resources to conduct MiniPAT posed a challenge to applying a constructivist approach to practicals. Teacher Zandile said *technology is full of practical work and without resources it is difficult to do.* Teacher Mabaso indicated that *I am supposed to do or teach MiniPAT without resources or materials, I find it more challenging*. Teacher Zandile further mentioned that *technology subject is more practical, it needs more equipment and know-how, to be able to make the subject interesting to students.* Teacher Stephina revealed that *with a shortage of resources, it is difficult to explain the concepts.*

It was also found that learners struggled to do MiniPAT, because of a lack of equipment. In this instance Student Lerato mentioned that *yes, we do MiniPAT, but there is not enough equipment.* Student Tinyiko revealed that *in MiniPAT we do it in class; we do not have the workshop or laboratory to do practicals.* Tendani mentioned that *yes, we do MiniPAT, but the teacher explains theory because they do not have the material to show us gears and other things*.

DISCUSSION

It may be argued that in this study the teachers did not fully apply the theory of constructivism in which students were given the opportunity to construct their own meaning through active engagement [12][13]. This suggests that the teaching methods employed by the teachers did not favour the learner-centred approach, but rather direct teaching.

In fact, the learner-centred approach is based on the idea that the learning environment should support multiple perspectives of reality, knowledge and experience-based activities [10]. It was also observed that because of a lack of resources and relevant equipment, the IDMEC principles were not utilised in full during the MiniPAT. This hinders the teachers in understanding the application of constructivism in technology teaching.

Teachers and students applied various learning strategies in technology. It was clear that students were unable to complete MiniPAT given as homework. Other learners did not have material to complete the projects at home.

It was found in this study that teachers gave students classwork and engaged them in answering oral questions. In this case, it was important for students to engage during the lesson and be given written work at the end of each lesson. This was to ensure that students displayed their level of understanding at all times. This is supported by the view of Mnisi that classwork promotes active learning, whereby learners are afforded an opportunity to actively participate by doing in the class and not just listening passively, i.e. classwork improves learners' understanding [14].

MiniPAT was usually completed once a term. This was supported by the technology policy that MiniPAT or practical enabling activities develop the knowledge, skills and values to the point where students are ready to be assessed [15].

CONCLUSIONS

In conclusion, it is imperative that rural high schools adopt the constructivist approach in teaching, to inspire and instil technology skills at an early age. This enables students to embrace technology, its evolution, systems, techniques, uses, social and cultural significance.

It was observed in this study that the IDMEC principles were partially applied during MiniPAT. Major constrains exist with the application of MiniPAT. It was seen from this study that rural high schools did not have workshops and appropriate technology material. Also, homework posed a challenge as students did not have relevant resources with which to complete projects at home.

RECOMMENDATIONS

It is recommended that teachers be provided with workshops on the application of the constructivist approach to teaching. It is crucial that the Department of Basic Education in South Africa provides the schools with adequate and relevant teaching, as well as learning equipment and materials for technology. It is essential that each school be equipped with a technology workshop that has relevant and appropriate equipment and materials for conducting practical work (MiniPAT). Further research could be conducted with a larger number of students and teachers.

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