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Teachers' Pedagogical Content Knowledge in Technical Schools: The Case of Domestic Installation and Wiring Teaching

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ABSTRACT

Domestic installation and wiring are still a concern among the secondary central district schools of Johannesburg. Students reach the Grades 11 and 12 with signs of inadequate knowledge on the domestic installation and wiring concepts taught in 10. This is a qualitative research study involving six electrical technology teachers from schools within the central district of Johannesburg, South Africa. The teachers were purposively selected to take part in the study. The pedagogical content knowledge construct was used as a theoretical framework to underpin the study. Data were collected using face-to-face interviews with the teachers and by observing the classroom when teachers were teaching domestic installation and wiring concepts. Data were analysed using verbatim quotes for face-to-face interviews and descriptively for classroom observations. Findings of the study revealed that teachers are being negatively affected by lack of resources and of adequate training. The study recommends that more resources be sought so that teachers can fully teach the practical component with ease and confidence. Recurrent refresher training events are also recommended for teachers to keep up with the electrical technology concept.

KEYWORDS

Domestic installation and wiring; electrical technology; technical schools; pedagogical content knowledge; practical skills; teachers.

INTRODUCTION AND BACKGROUND

Domestic installation and wiring are concepts learned in of electrical technology, which Grade 10 subject that focuses on the understanding and application of electrical and electronic principles. Electrical technology, in turn, is offered from grades 10 to12 at a Further Education and Training (FET) level and focuses on three main areas of specialization, namely power systems, electronics, and digital electronics. Electrical power systems are also referred to as electrical applications where heavy currents from a main supply source are used in several applications (department of basic education, DBE, 2011). Students are introduced to the subjects Direct Current (DC) and Domestic Installations in Grade 10. The circuitry as found in a typical South African home, according to requirements of the South African National Standard (SANS) 10142, form a major part of the student's curriculum (Department of Basic Education, DBE, 2011), and it begins within the concept of domestic installation and wiring. An electrical technology student chooses to become an electrician and work in the manufacturing industry with a specific focus on maintenance and repair of electrical installations and machinery, where domestic installation and wiring concepts are of utmost importance. Students may expand their careers to electrical firms or even to the Technical Vocational Education and Training (TVET) College where one becomes specialized in electrical trade theory or industrial electronics. In addition, a student can also pursue a university career related to electrical technology, be it in education courses or electrical engineering fields. Therefore, electrical technology is one of the most important subjects for students, building the foundation of a student's paths. However, the experiences observed from grades 11 and 12 have shown a lack of basic knowledge of domestic installations and wiring. This poses a serious concern because students would be at risk of not choosing a relevant career path or not competing in electrical technology careers should they follow it.

Teachers are therefore expected to prepare students with the appropriate hands-on skills to enable the development of future skills. To achieve that, a more structured and enabling learning environment, as well as a competent teacher, are required. Surprisingly, most teachers in the Johannesburg technical schools often struggle with hands-on tasks that we assign in the quarterly workshops and training that our provincial education department arrange. Teachers end up not showing up for the entire workshop and when they do, the outcome of the tasks performed is unsatisfactory. Teachers often fail to display the knowledge on the subject required to make the lesson appropriate for students to grasp (Lam & Lidston, 2007). In addition, providing students with opportunities to fully engage in practical work is often a challenge to teachers (Ehikhamenor, 2013). Similarly, these challenges may be caused by reasons that range from the abundant infrastructural issues present in the educational system, overcrowding of the classes, and poor teacher development and training. Another challenge is the many young and recently graduated teachers who had little or no industry experience in the electrical technology field (Paryono, 2015). Researchers have observed a limited content knowledge (CK)

of the electrical technology teachers, particularly when it comes to the manual skills of the subject. This could cause the students' lack of manual skills to accumulate when they reach higher grades within the electrical technology course.

The preparation to teach domestic installation and wiring in both theory and practice requires better strategies for the skills to be learned (Ehikhamenor, 2013; Lam & Lidstone, 2007), hence this study. Investigating the challenges faced by teachers in domestic installation and wiring is necessary to assist teachers with relevant and better instructional practices, consequently increasing the performance, knowledge, and grades of their students. This would also enable students to make informed decisions concerning their career possibilities, which are aligned with both electrical technology and engineering fields. We, therefore, a grade 10 level because it is the level where the basic concepts of domestic installation and wiring are taught.

Purpose and Rationale for the Study

The purpose of this study was to investigate the pedagogical content knowledge (PCK) of grade 10 teachers of domestic installation and wiring concepts of technical high schools in Johannesburg, South Africa. The grade 10 teachers have been observed to have deficient CK, which would be detrimental to student's knowledge as we have noticed by the limited knowledge and manual skills in domestic installation and wiring of the students at higher levels in the FET phase. This then places students in a difficult position to have a better foundation to build their careers and, to some extent, become entrepreneurs. The students' lack of skills could easily have been consequence of the limited practical skills, which are hardly ever taught at the school due to poor instructional practices from their teachers. We, therefore, outline the potential benefits of this study should teachers' instructional practice gaps be identified and dealt with. We believed that students would find domestic installation and wiring theory and practice easy in higher grades and be able to make informed career choices even in grade 10. And teachers would be confident in teaching the concept and would actively participate in seminars and refresher training that are often organized. Electrical technology, being a vocational subject, must prepare individuals to easily enter the job market after completion (Milio, Granizova & Shkreli, 2014), which does not occur in Johannesburg technical schools.

Problem Statement

The domestic electrical installation and wiring taught in technical schools have the potential of equipping students with the skills required for them to contribute meaningfully to national economic development, to be self-sufficient, and job creators, potentially reducing unemployment. The need for skilled workers, artisans, and technicians in South Africa has been reported many times in national strategies such as the National Skills Fund (NSF). Despite the increased emphasis given to the importance of practical work, teachers are still not confident in teaching domestic installation and wiring concepts.

Domestic installation and wiring can lead students to self-employment or entrepreneurship. It is precisely through the topic of domestic installation and wiring that one can become an entrepreneur. However, and most importantly, the topic itself serves as a benchmark to other topics in electrical technology. However, my colleagues often divert from the domestic installation and wiring activities that may be proposed in the quarterly training for electrical technology teachers in the Johannesburg Central District, thus further increasing the challenges experienced when teaching. Students in Grades 11 and 12 seem clueless regarding the domestic installation and wiring concepts. Therefore, this study investigated the grade 10 teachers teaching domestic installation and wiring concepts at the selected technical schools in Johannesburg Central District, South Africa. The main research question of this study is disclosed below.

Research Questions

The main research question is;

- What are the challenges in domestic installation and wiring faced by grade 10 teachers at the selected Technical secondary schools in Johannesburg Central District in South Africa?

The main research question was assisted by the following sub-research questions:

- How can domestic installation and wiring be facilitated in a grade 10 class?
- How are teachers assessing students on domestic installation and wiring?

THEORETICAL FRAMEWORK

The TVET College and the technical school sectors are one of the three main education and training sectors developed to address the shortage of manual skills in the South African education system (Mtshali & Ramaligela, 2020). The solution to this shortage requires a strong instructional practice that embraces both theory and practice where teachers understand their roles in leading the learning process. Practical lessons are a teaching and learning activity that requires students to observe and/or manipulate objects and materials at some point, with learning experiences where students interact with materials to check and observe a given phenomenon in a practical workshop (Madimabe & Omodan, 2021; Vilaythong, 2011). To merge theory and practice in engineering education, instruction should take place in a workshop or laboratory, following relevant methods (Rosa & Feisel, 2005). More importantly, teachers should be able to display their best instructional practices for learning to be successful.

The teaching and learning of practical skills in the electrical technology program in Nigeria may be achieved in the formal, and informal settings, but these skills are commonly attained through formal and informal education (Samson et al., 2013). According to the Federal Government of Nigeria (FGN, 2004), informal education is the functional education provided to young and adult individuals outside the formal school system such as functional literacy, remedial education, and vocational education. Electrical and electronic skills are equally taught

and learned in the formal education systems, where emphasis is placed not only on cognitive skills but also on psychomotor and affective skills needed by the students (Samson et al., 2013). This then shows the important role of resource availability in a laboratory.

Most teachers in South African schools are not professionally trained to implement technology education (Makgato, 2001). Educators should be well-trained by higher education institutions (HEIs) to conduct practical activities with students, equipping students with marketable skills that enable their contribution to a sustainable economy after the 12th grade (Maeko & Makgato, 2014). Technology teacher education and training should include regular exposure and visits to relevant industries for teachers to keep up with the latest technology development, and the supply of equipment to schools should be coupled with routine maintenance (Maeko & Makgato, 2014). Brunette (2006) states that high quality teaching derives from the following components:

- Well-prepared teachers with professional expertise and skills.
- Understanding and application of skills.
- Good citizenship and democracy.
- Sufficient textbooks and instructional materials
- Improvement of physical facilities, which include classrooms as well as laboratories and practical workshops.

This shows that the quality of teaching goes far beyond standing in front of the class and talking and should also consist of value in addition to facts. The researchers have personal experience in years as electrical technology teachers at a secondary school and teacher trainers at higher education institutions (HEIs) and have observed that teachers avoid practical lessons. Some educators go as far as rejecting electrical technology power system specialization posts, which involve a practical workshop. Qualified technology teachers are scarce, and those on the job have unsatisfactorily taught the practical component of technology education subjects (Kennedy, 2011). Practical classes are not ministered properly in schools internationally (Maeko, 2013). Teaching practical technology is encumbered by several factors that range from equipment shortage and material availability (key factor). This then drawbacks students from becoming familiarized with using equipment and making things with material (Maeko, 2013). Accordingly, this study is important to ascertain the grade 10 teachers' PCK in domestic installation and wiring concept in the schools around Johannesburg, South Africa is suitable.

This study was based on the pedagogical content knowledge coined by Schulman (1987). The theoretical framework introduced and described the theory explaining the research problem and is defined as a blueprint or guide for a researcher (Grant & Osanloo, 2014). According to Shulman (1987), PCK concerns the overlap of information on subject knowledge. Pedagogical knowledge (PK), on the other hand, is the knowledge of how to teach. A teacher may deeply understand a subject area but must also be able to facilitate the understanding of the subject or concepts for students. Thus, the theoretical framework chosen as the foundation

of this study is relevant based on the integration of theory and practical knowledge of electrical technology. PCK includes the most regularly taught topics in a subject area, the most useful forms of representing the ideas, the most powerful analogies, illustrations, examples, one-word explanations and demonstrations, a comprehensible way to represent the subject, understanding what facilitates or hinders the learning of specific topics, and the conceptions and preconceptions that students of different ages and backgrounds have of what helps them learn (Shulman, 1987).

The focus of this study was to establish how secondary school electrical technology teachers develop their PCK in teaching domestic installation and wiring. Our interest was to determine the teachers' PCK in the context of teaching domestic installation and wiring, thus determining how PCK is developed and used in teaching the domestic installation and wiring topic. In this study, the teacher's classroom practice in domestic installation and wiring was investigated through observations of lessons to explore the existing PCK and how the participating teachers demonstrate their PCK in the context of teaching domestic installation and wiring.

The use of PCK as a theoretical framework has provided researchers with a way to collect and analyze data on the teachers' knowledge or understanding (Hlatshwayo et al., 2022; Jong, 2003; Rollick, 2000**;** Toerien, 2011). The use of PCK as theoretical framework has allowed the researchers to focus on specific questions concerning the teacher's knowledge foundations. In this study, the teachers PCK in domestic installation and wiring teaching and the way they develop their teaching strategy were conceptualized as comprising content knowledge (CK), pedagogical knowledge (PK), and knowledge of students' preconceptions and learning difficulties in the context of teaching domestic wiring. The teachers' strategy to manage and administer assessment was also evaluated. According to Kultsum (2017), PK is related to the ability of teachers to deliver an effective teaching and learning atmosphere to all students. This could often be enhanced by the surrounding environment.

RESEARCH METHODOLOGY

The study has adopted a qualitative approach to explore teachers' PCK in domestic wiring and installation. In the qualitative approach, the researcher collects data following a specific set of steps, in so attempting to remain as objective and neutral as possible (Bless & Achola, 1990).

Research Design and Paradigm

The study used a case study research design due to difficulties in accessing several schools once the country was on lockdown due to the COVID 19 outbreak. Yin (1994) defines a case study as a puzzle that must be solved, and states that "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." All schools that were part of the study had similar characteristics, their teachers are in the same district, and

participate in the same seminars, thus making them part of the same case. Their students also struggle with the concept of domestic installation and wiring, as shown by their grades.

Denzin & Lincoh (2000) report that the qualitative approach involves an interpretative and naturalistic approach, meaning that "qualitative researchers study things in their natural settings, attempting to make sense or interpret phenomenon in terms of meanings people bring them." We used an approach where the teachers' responses were interpreted and the challenges, they faced in their classrooms concerning the domestic installation and wiring concepts were inferred. Therefore, we adopted the constructivist paradigm in this study, according to which a constructivist view is adopted to identify challenges faced by teachers teaching domestic wiring and installation in their classrooms. This was done through interviews and classroom observation. The intention was to make sense through interpretation of others' understanding of the world Creswell (2009).

Population and Sample

The population of the study comprised twenty-six-grade 10 electrical technology teachers, from six different technical high schools located in townships within a Johannesburg district, South Africa. Goddard & Melville (2001), define population as any group that is the subject of research interest. It is often not practical to study an entire population, and, in such cases, it is necessary to make general findings based on a study of only one sample of the population (Sharp & Howard, 2006). This study employed a purposive sampling method due to the possibility of handpicking information-rich research participants. The purposive sampling technique is a non-probability sampling strategy that is most effective when one needs to study a given cultural domain and has well-grounded expectations concerning it (Ma. Dolores, 2007). Purposive sampling is also called judgment sampling, which is also a deliberate choice of an informing due to qualities exhibited by the informant (Ma. Dolores, 2007). Purposive sampling was used to select six technical schoolteachers who teach grade 10 electrical technology as means of obtaining rich information from the participants.

Data Collection and Analysis

Data were collected through semi-structured face-to-face interviews with teachers of the subject electrical technology and classroom observation during practical classes addressing domestic installation and wiring. During data collection, the researcher waited for the participants to ring a bell that indicated safe working conditions and the availability of students since they were in a rotation mode due to the COVID 19 restrictions. Face-to-face interviews with the teachers enabled us to understand the teachers' PCK through questions focused on assisting the teachers with their instructional challenges. The face-to-face interviews lasted 20 minutes per teacher and were conducted under very strict conditions, adhering to the COVID 19 control protocol. Data were analyzed using verbatim quotes for face-to-face interviews with the teachers and descriptively for classroom observation. Pseudonyms were used for teachers and name of the schools to protect their images. Teachers were called by Teacher A, B, etc.

FINDINGS AND DISCUSSION

Four of the six teachers that were sampled were male, and two were females. Teachers' teaching experience ranged from 5 to 35 years, and only two of them were not initially qualified to teach electrical technology but became qualified through short training that they attended. The responses from the participants varied. When asked about the challenges in teaching the topic domestic installation and wiring concept, Teacher A responded "The first challenge is that we do not have enough equipment, measuring instruments and material. despite the lack of equipment and material, I can teach the content domestic installation and wiring concept."

A follow-up response from Teacher B was:

> The first challenge that I am having is that there are too many students in the workshop, the ratio according to the Department of Education should be 1:15, but we end up having 40 students which is not manageable in the workshop.

Teacher D added by saying:

> I don't have a problem with teaching domestic installation and wiring, but the problem starts when I teach practical. My workshop is not designed to accommodate the practical of domestic installation and wiring; we don't have enough space and my workshop is too small.

Others agree that issues with reduced resources and lack of expertise are a relevant factor, as supported by Brunette (2006), who stated that the availability of textbooks and instructional materials should be sought, in addition to improvements of physical facilities (i.e., classrooms, laboratories, and practical workshops alike).

When asked about their knowledge and skills in domestic installation and wiring Teacher D said "I had knowledge of domestic installation and wiring before, but now it has just disappeared. I was teaching electronics specialization, and now I am teaching power system specialization, and I have forgotten everything." A teacher from another school (Teacher E) said:

> Like I said earlier, I don't understand the concept of domestic installation and wiring because, for me, it is very difficult to teach, so my level of content knowledge is too little. The only thing that I know is just to connect the wires to the main supply then to the wall sockets.

Educators agree that they lack proper training for practical skills as alluded to by Maeko and Makgato (2014), who also state that educators should be well-trained by higher education institutions (HEIs) to conduct practical activities with students to prepare them with marketable skills and thus contribute to a sustainable economy after the 12^{th} grade.

When teachers were asked about the distinction between theory and practice of domestic wiring and installation Teacher C said, "I teach the theory part but with the late arrival of materials and components sometimes I don't teach the practice."

Teacher D added and said:

I can distinguish by saying theory teaches the students the basics of domestic installation and wiring, safety, and tools then the practical enhances their skills to what they have gained from the theory. I teach theory then later a practice, but I am not too strong.

This shows that the PCK of the teachers is far from being adequate as the teachers themselves admitted to the weakness of their approach to the domestic installation and wiring concepts (Shulman, 1987). Their responses to the challenges in the concept, also showed that their CK is also weak. According to Shulman (1987), if the teacher presents weak CK, the teacher's PCK would be affected regardless of the content (PK) is taught, once the three concepts are interrelated. Therefore, it was clear from some of the teachers' responses that they are challenged by the concepts being taught due to limited CK and because some teachers are not professionally trained electrical technology teachers but became teachers by attending seminars.

Data were also collected through classroom observation using Shulman's PCK notion. The aim was to ascertain the teachers' challenges in teaching the concept of domestic installation and wiring to their grade 10 learner s. Each teacher was observed once due to the COVID 19 restrictions that were imposed in schools.

Content Knowledge (CK)

We observed that three of the teachers had the content knowledge (CK) of domestic wiring and installation, particularly the theoretical part, as they displayed similar practices by introducing the concept very well. In turn, some teachers showed gaps in understanding the domestic installation and wiring concept and the issues due to lack of resources kept the morale of the teachers low. Teachers resorted to theoretical lessons due to the lack of resources and even those were not ministered at a level required for students to understand, once the teachers taught abstract concepts with which the students had no previous contact. None of the teachers conducted practical lessons on the concept and that was worrisome. This confirms previous observations that practical lessons are not properly conducted in schools internationally (Maeko, 2013). He argued that teaching practical technology lessons is hindered by several factors that include shortage of equipment and material as the key factor. This then brings a disadvantage to students who do not become familiarized with using the equipment and making things with the material (Maeko, 2013).

Pedagogical Knowledge (PK)

The availability of tools and resources was a big problem across all the schools evaluated. Teacher C of school C did not conduct practical lessons with his students because they did not have resources and materials. This affected how the topic was taught because they ended up theorizing a concept that needed to have been hands-on. The development of useful skills can be fostered by the appropriate selection and use of learning facilities and resources (Anyokoha, 1992). The facilities consist of workshop structure, working materials, teaching material, and workshop tools and equipment, which need better instructional practices that the teachers

failed to display (Anyokoha, 1992). The teachers that are not professionally trained electrical technology teachers could not even display the basic teaching strategies of linking the concepts and extending them to the outside world. This adds to previous reports of a shortage in qualified technology teachers and that those on the job have not been adequately teaching the practical component of technology education subjects in their school days, hence the continued challenges (Kennedy, 2011). In addition, Vilaythong (2011) concluded that practical lessons enable learning experiences through which students interact with materials to check and observe phenomenon in a practical workshop. However, in the case of Johannesburg technical schools, that was not the case because students were not exposed to practical work due to the lack of resources and electrical technology workshops. In contrast, Kultsum (2017) stated that PK is related to the ability of teachers to deliver an effective teaching and learning atmospheres for all students, which in this case could not be done once the environment in which the teachers and students found themselves had inadequate resources.

Pedagogical Content Knowledge (PCK)

None of the teachers taught practical lessons. In addition, their PCK could not be verified given the gaps observed in their theory teaching, where teachers showed poor CK. The concept of domestic installation and wiring is a practical, and it was worrisome to see teachers deeply lacking in the practical aspect, thus affecting their CK. Their PK also left much to be desired because even the introduction to technology was limited.

The key concepts that define PCK (see Shulman, 1987) were not observed among the teachers who confirmed the challenges they face in domestic installation and wiring. Shulman (2004) further adds that PCK is a combination of subject-specific knowledge and pedagogical knowledge that is important for teachers. However, what we observed was a weak association between the two.

CONCLUSION

The study aimed to evaluate the PCK of grade 10 teachers teaching of domestic installation and wiring. Findings of the study revealed that many of the teachers that participated in the study were not qualified to teach electrical technology, and that the lack of resources is a major issue. Teachers' PCK was lacking due to poor CK and limited PK. The study then recommends that schools should keep taking teachers to refresher trainings to keep them abreast of the new strategies of domestic installation and wiring. Issues of lack of resources especially concerning workshop tools and equipment need to be addressed in all the electrical technology subjects. More importantly, schools need to consider a serious process of recruiting qualified electrical technology teachers who would be able to teach both theory and practice of domestic installation and wiring concepts.

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