



**SHIFTING ELECTRICAL ENGINEERING LECTURERS' PERSPECTIVES AND
PRACTICES FROM TEACHER-CENTRED TO STUDENT-CENTRED APPROACH
THROUGH PROBLEM-BASED LEARNING**

by

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DECLARATION

I, **Mulaudzi Mbofheni Abbie (2021968629)**, declare that the Doctor of Philosophy's research dissertation entitled **Shifting Electrical Engineering Lecturers' Perspectives and Practices from Teacher-centered to Student-centered Approach through Problem-based Learning** that I herewith submit at the **University of the Free State** is my independent work and that I have not previously submitted it for qualification at another institution of higher education.



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DEDICATION

In loving memory of my dear parents (Mr Matamela Petrus Mulaudzi, aka Thavhagoza, and Mrs Mutshekwa Nthatheni Mulaudzi), whose unwavering belief in my potential continues to guide me from above. My supportive family, especially Yonder, Zwiada, and Bveledzanizwonakaho, and my two surviving sisters, Muthihi and Olga, whose encouragement and sacrifices have paved the path of my academic journey. Your love, strength, and enduring presence inspire me to persevere through the challenges and celebrate the triumphs of this PhD pursuit. This thesis is dedicated to you, my cherished guardians of light and pillars of unwavering support.

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ABSTRACT

In the following sections, an account and synthesis of ongoing and previous research in the fields of interest for the study are provided. The significant concepts adopted in the study are presented, as well as the arguments for selecting the research questions and the topic, or in other words, identifying a necessary gap to fill in Technical Vocational Education and Training (TVET) for Electrical Engineering education. The theoretical perspectives of the research were based mainly on pragmatic theories, Lewin's theory of planned change, and Heron's modes of facilitation, but primarily from a social constructivist perspective. Aspects from previous research have been presented as three different perspectives relevant to the study, presented in three distinct but related articles. Each article presents a related perspective on the overall research question, moving the discussion from the general to a more specific angle. The first article focuses on the professional development strategies aimed at improving the quality of teaching practices employed in TVET Electrical Engineering programs. The second article focuses on problem-based learning as a learning and teaching method that could shift TVET Electrical Engineering lecturers' practices. The third and final article presents a framework for TVET Electrical Engineering lecturers' professional development and strategies for the effective implementation of problem-based learning with an emphasis on the prospects and challenges of implementing PBL in a vocational teaching and learning context. The research revealed that Technical and Vocational Education and Training (TVET) lecturers generally lack prior experience in Problem-Based Learning (PBL). However, they do exhibit a basic understanding of its potential benefits for modern education in the 21st century. The study also revealed that three key components, namely the problem itself, the facilitator, and the students, are essential for the effective implementation of PBL. Each component is crucial in driving successful outcomes within the PBL framework. Another significant finding is the importance of a planned approach to lecturer development within the TVET sector. This structured approach is vital for successfully adopting innovative teaching methodologies like PBL. It ensures that lecturers are adequately equipped with the knowledge, skills and resources necessary to implement PBL effectively in their teaching practices. The study recommends developing and implementing a compressive training program tailored explicitly to TVET lecturers to

enhance their understanding and proficiency in PBL methodologies. These programs should focus on both theoretical knowledge and practical application, providing hands-on experience and opportunities for skill development. The Department of Higher Education should foster the creation of collaborative learning communities within TVET institutions where lecturers can share experiences, insights, and best practices related to PBL implementation. They should encourage peer-to-peer support and mentoring to facilitate continuous learning and improvement. Lastly, they should integrate PBL principles into the curriculum development process within TVET institutions. The Department must encourage interdisciplinary collaboration and alignment with industry needs to ensure that PBL experiences are relevant and meaningful for students. By implementing these recommendations, TVET institutions can create an environment conducive to the successful adoption and integration of PBL, ultimately enhancing the quality of education and preparing students for the demands of the 21st-century workforce.

Keywords: Electrical Engineering, Problem-based Learning, Professional Development, Social Constructivism, Technical Vocational Education and Training.

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LIST OF ABBREVIATIONS

CAPS	Curriculum Assessment Policy Statement
DBE	Department of Basic Education
DHET	Department of Higher Education
DoE	Department of Education
ICT	Information Communication Technology
NATED	National Accredited Technical Education Diploma
NCV	National Curriculum: Vocational
PBL	Problem-based learning
PSET	Post School Education and Training
TVET	Technical Vocational Education and Training
WIL	Work-integrated Learning

CHAPTER 1

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

In the following sections, an account and synthesis of previous and ongoing research in the fields of interest for the study are provided. The significant concepts adopted in the study are presented, as well as the arguments for selecting the research questions and the topic, or in other words, identifying a necessary gap to fill in Technical Vocational Education and Training (TVET) for Electrical Engineering education. The theoretical perspectives of the research were based mainly on pragmatic theories, Lewin's theory of planned change, and Heron's modes of facilitation, but primarily from a social constructivist perspective. Aspects from previous research have been presented in the three different but related articles as three perspectives relevant to the study. Each article presents a related perspective on the overall research question, moving the discussion from the general to a more specific angle. The first article (cf. Article 1, pp.25-45) focuses on the professional development strategies aimed at improving the quality of teaching practices employed in TVET Electrical Engineering programs. The second article (cf. Article 2, pp.46-68) focuses on problem-based learning as a learning and teaching method that could shift TVET Electrical Engineering lecturers' practices. The third and final article (cf. Article 3, pp.69-103) presents a framework for TVET Electrical Engineering lecturers' professional development and strategies for effectively implementing problem-based learning, emphasising the prospects and challenges of implementing PBL in a vocational teaching and learning context.

1.2 BACKGROUND OF THE STUDY

Globalization of the workforce and rapid technological advancements impact people's lives, including teaching and learning in the TVET colleges, globally (Salleh & Sulaiman, 2020; Mpu & Adu, 2019) and nationally (Papier, 2021; Teis & Els, 2021; Blom, 2016). Globalization of the workforce and technological changes render conventional teaching methods outdated (Salleh & Sulaiman, 2020; Majumdar, 2011)

and demand that the workforce acquire new sets of skills and knowledge, which can be regarded as adaptation skills (Majumdar, 2011). According to Basu (1997), technological advancements have necessitated increases in the quality of the TVET lecturer and the development of a multidimensional approach to teaching and learning. Gamble (2013) adds that technological advancements are changing how teaching and learning are organized. Thus, TVET teaching and learning should change drastically by changing the entire strategy of teaching and learning (Majumdar, 2011). This author asserts that lecturers must know how to transfer adaptability skills and teach their students how to transfer them in their work environment. In the South African (SA) context, research demonstrates that many lecturers do not have a formal qualification to teach in TVET (Van der Bijl & Oosthuizen, 2019; Blom, 2016; Gamble, 2013). The literature demonstrates that South African TVET lecturers have deficiencies in teaching capacities (Badenhorst & Radile, 2018) and lack ideas on shifting from teacher-centred to innovative student-centred approaches (Ngubane-Mokiwa & Khoza, 2013), like PBL. The literature posits several gaps in the capability of lecturers to develop the required soft skills to function appropriately in TVET.

In 2007, the SA Department of Higher Education and Training (DHET) introduced a new, in-depth curriculum called the National Certificate: Vocational NC(V)), initially intended to replace the National Accredited Technical Education Diploma (NATED), particularly N1, N2, and N3. (Kanyane, 2016; DoE, 2007a; 2007b). Badenhorst and Radile (2018) noted that the NC(V) programme was introduced to resolve the issues of poor quality and low significance of the NATED qualifications offered in Engineering disciplines, particularly the Electrical Engineering programme. The literature further suggests that the NC(V) programmes have a more in-depth platform, which includes both academic and vocational subjects (Mpu & Adu, 2019) as compared to the NATED curriculum and Curriculum Assessment Policy Statement (CAPS) that has engaged with 21st-century skills (Joynes, Rossignoli & Amonoo-Kuofi, 2019). Teaching and learning in TVET programs, especially vocational studies, differ from academic studies in that they emphasize skills in the labour market (Guthrie, Harris, Simons & Karmel, 2009). These authors pointed out that the workplace and real-world applications of knowledge and skills are linked to vocational education and training. They also asserted that the strategy for teaching and learning needs to change from emphasizing content to facilitating understanding and empowering students. This might present a

problem for lecturers accustomed to using more conventional approaches. As a result, lecturers with both academic expertise and industry experience are needed to teach this program. However, according to Mesuwini and Mokoena (2024), most lecturers in the South African context lack industry experience. According to Abdullah, Hoque, Ramlan, and Shafee (2019), effective lecturers who are qualified, competent, and efficient are necessary to fulfil the program's demand and accountability in the practice of advancing education, including TVET.

Curriculum changes brought about through the introduction of the NC(V) programme may have led to new demands on the TVET lecturers, as they are expected to demonstrate the required discipline-specific pedagogical content knowledge needed to develop relevant technical vocational skills for engagements and employment in complex technological driven context (MIT, 2013). Engineering lecturers are further required to demonstrate advanced subject content knowledge to inform their choice of pedagogical knowledge needed to cultivate the necessary hard and soft skills (employable skills). The shift in graduate attributes envisaged in the NATED programmes, as compared to before the introduction of the NC(V) programme, is significant and has implications for Engineering lecturers in formal TVET settings. This research argues that it is vital for Electrical Engineering lecturers to stay abreast with substantial developments at large and be competent and skilful in the transmission of industry-relevant teacher knowledge. These perspectives are supported by Ismail, Hassan, Bakar, Hussin, Hanafiah and Asary (2018) and Kheza (2020), who argue that TVET institutions are mandated to focus on developing the graduate attributes needed to enable students to engage and be equipped with complex technical activities while working with other human beings in the workplace. These perspectives on the educational purpose of TVET relate to a larger question in the educational sector: the significance of technical vocational education. Therefore, the research focused on educational strategies relevant to cultivating technological literacy.

TVET lecturers are required to apply teaching and learning approaches creatively by combining teaching and learning approaches that would meet students' needs to complete a task and enhance their soft skills fully. Teaching and learning in TVET should be applied with the best teaching and learning approaches for effective results. However, it has been found that in terms of teaching inputs and learning results, the quality of TVET is below expectations (Doherty & Aneyo, 2019; Mpu & Adu, 2019; Eze

& Okorafor, 2012; Majumdar, 2011; Basu, 1997). Based on these requirements and the critical gap that was highlighted in these studies, the research argues that the transformation of teaching and learning towards the development of hard and soft skills in TVET settings and at the level of TVET Electrical Engineering lecturer's competency is one of the critical aspects that facilitators of professional development should focus on. However, teaching and learning these skills are problematic to achieve, because of the teacher-centred nature of teaching and learning in TVET settings (Mokhothu, 2022); even though they are criticised for not effectively engaging students in learning, still dominate teaching and learning in Post School Education and Training (PSET) (Shatumbu, 2019).

In this study, teacher-centred approaches refer to teaching approaches employed by lecturers during the teaching and learning process, such as lectures and demonstrations (Johnson & Van Wyk, 2016). Numerous research studies have shown that teacher-centred approaches are inefficient in developing critical technical engineering knowledge, skills, and habits of the mind (Vogler, Thompson, Davis, Mayfield, Finley & Yasserli, 2018; Collaço, 2017; Gentelli, 2015; MIT, 2013). A critical balance of hard and soft skills is deemed employability skills and is in high demand by the technical and engineering industry (merSETA, 2019). Teis (2014:54) characterised technical engineering learning and teaching contexts as spaces that seek to “provide learners with an educational experience that combines rigorous academic study and the excitement of discovery”. Failure to develop relevant and employable skills through active engagement in learning experiences designed for the cultivation of the cognitive, affective, and psychomotor domains of technological development can result in an increased number of unemployed graduates (Autio & Hansen, 2002; Dyrenfurth, 1990; Layton, 1994). There is a need to close the gap between skillsets developed in technical engineering learning and teaching contexts and industry competency requirements. The research argues that a reduction in the unemployment rate of qualified Electrical Engineering graduates could be realised by shifting lecturers' perspectives and practices from a teacher-centred to a student-centred approach. In the context of this study, the student-centred approach provides students with possibilities for discussion, problem-solving, self-evaluation, and teamwork (Arwatchananukul et al., 2021; Šuligoj & Jerman, 2020). As defined by Hung (2009:119), such learning experiences represent engagement in a “student-centred

pedagogical strategy that poses significant, contextualized, real-world, ill-structured situations while providing resources, guidance, instruction, and opportunity for reflection to students as they develop content knowledge and problem-solving skills”.

There has been an increasing body of literature on the educational value of PBL, such as problem-solving, teamwork, and communication (Orji & Ogbuanya, 2022; Sousa & Costa, 2022; Okolie, Elom, Iqwe, Binuomote, Nwajuiba & Igu, 2020; Ali, 2019; Chen, Gao, Kong & Cui, 2018; Dahl, 2018). However, in the South African context, TVET Electrical Engineering lecturers have no prior experience with PBL as a teaching and learning strategy, as per their responses to the qualitative open-ended questionnaires, where all indicated that they did not have prior experience with PBL. It is crucial in the current study that the teaching practice needs to be explored to ascertain to what extent these lecturers use teaching methods that seek to develop the required technical engineering graduate attributes needed in the industry. Such research in the South African TVET context is limited.

Against this background, the primary purpose of this study was to explore the teaching practices enacted by TVET Electrical Engineering lecturers in their respective classrooms and to explore the challenges they might encounter that could hinder the adoption and effective implementation of PBL as a teaching and learning strategy. Based on the findings of this study, the researcher aimed to design a short professional development training program for the smooth adoption and effective implementation of PBL. These interventions will assist in responding to the six research sub-questions (cf. p.14) of this study: What teaching strategies do TVET Electrical Engineering lecturers employ to cultivate industry-relevant technical engineering knowledge and skill sets in South African TVET settings?

1.3 RATIONALE OF THE STUDY

This thesis is grounded on the transformation in the South African Technical Vocational Education and Training (TVET) curriculum, which led to the requirement for professional development amongst TVET lecturers (DHET, 2015). The demands on TVET Electrical Engineering lecturers have increased in South Africa and globally (WEF, 2017). Research in TVET education indicates that technical vocational lecturers have jobs that, in many ways, are more demanding than those of academic lecturers

(Yeap, Suhaimi & Nasir, 2021; Abdullah, Hoque, Ranlan & Shafee, 2019; Badenhorst & Radile, 2018; Field, Musset & Alvarer-Galvan, 2014). Accordingly, on top of subject matter and experience, they also need to know how to convey diverse packages of skills (21st-century skills) required in a particular profession. TVET lecturers, particularly Electrical Engineering lecturers, must continuously update their knowledge in response to changes in technology and working practice (Field et al., 2014). So, subject or content knowledge is necessary, and a range of teaching skills is essential in dealing with changes in the technical vocational education system. However, teaching and learning these skills are difficult to achieve as teacher-centred teaching approaches (lecturing and demonstrations) are criticised for being ineffective (Collaço, 2017; Gentelli, 2015). The 21st-century skills are regarded as employable skills that are highly demanded by industries from engineering graduates, particularly Electrical Engineering graduates. Failure to develop these employable skills may lead to an increased number of unemployed graduates. Therefore, there is a need to bridge the gap to reduce the high unemployment rate of qualified engineering graduates.

The South African DHET's introduction of a new curriculum in TVET education further necessitated the need for a paradigm shift in TVET teaching and learning with greater emphasis on teaching what (Wattanasin, Chatwattana & Piriya-surawong, 2021; Purnamawati, Usman & Saliruddin, 2017) referred to as the 21st-century skills, compared to the teacher-centred approach that dominated teaching and learning in the earlier NATED curriculum. The fact that many TVET lecturers were not adequately trained in pedagogic skills, and many did not have industry experience (Doherty & Aneyo, 2019; Badenhorst & Radile, 2018) is another reason for the researcher to focus on the teaching skills of TVET lecturers.

1.4 RESEARCH PROBLEM

TVET is regarded by Hiim (2020) and Mbagwu, Chukwuedo and Ogbuanya (2020) as a planned educational and training process to equip students with knowledge and skills for productive employment. However, many traditional engineering schools struggle to balance the calls to provide an innovative engineering education that meets the demands of graduates and their prospective employers (Mitchell, Nyamapfene, Roach & Tilley, 2021). Mitchell et al. (2021) further postulate that engineering industry

professionals are dynamic specialists who require various skills, knowledge, and attributes, including innovativeness, coherent thinking ability, leadership skills, and troubleshooting capabilities. These attributes necessitate a reform in the South African TVET teaching and learning context that requires a shift in technical engineering student development towards programmes that aim to cultivate effective graduate attributes across all engineering disciplines. A reform of the TVET system towards changing how teaching and learning are organised is necessary; this may result in some lecturers feeling or being regarded as no longer professionally qualified to teach with their existing qualifications (Gamble, 2016). Research further indicates that most South African TVET lecturers do not have a formal qualification to teach in TVET colleges (Blom, 2016; Gamble, 2013; Van der Bijl & Oosthuizen, 2019). In addition, the literature also highlighted that South African TVET colleges have deficiencies in teaching capacities (Badenhorst & Radile, 2018) and lack ideas on how to shift from a teacher-centred to an innovative student-centred approach (Ngubane-Mokiwa & Khoza, 2013) like problem-based learning (PBL). The literature posits several gaps in the ability of lecturers to develop the necessary mix of soft and hard skills for students or to develop the required pedagogic content knowledge for lecturers to function appropriately in TVET. Therefore, lecturers, in particular TVET Electrical Engineering lecturers, should be supported to modify their instructional beliefs and ability to align with more reformed-based beliefs about student learning and teaching (Lotter, Carnes, Marshal, Hoppmann, Kiernan, Barth & Smith, 2020). This necessitates the need for professional development, as suggested by Du, Kolmos, Ahmed, Spliid, Lyngdorf and Ruan (2020) when they mentioned that professional development programs are an enabler to lecturers' change and their readiness to change their beliefs, confidence, positive attitudes, and motivation about PBL as an essential factor influencing successful implementation.

1.5 THEORETICAL UNDERPINNINGS

Since all three journal articles of this thesis emphasize the empirical part of the research and the standard journal format is limited, less space has been given to the theoretical background. Thus, the links to theories of relevance to this study are presented below.

The theoretical basis of this thesis is based on two philosophical perspectives, namely pragmatism and constructivism. Pragmatism is an approach to examining philosophical questions (Bulleit, 2017). Korte and Mercurio (2017) posit that pragmatism emphasises practice and, therefore, focuses on the outcomes of our thoughts and actions. Menand (1997) adds that how we feel, not what we think, matters. According to Korte and Mercurio (2017), pragmatism bridges the contemporary gap between theory and practice by explaining the connection between ideas and actions. As postulated by Walan (2016), for the pragmatist, theory and practice are connected as two sides of the same coin. Therefore, it aligns with the chosen teaching and learning strategy, namely PBL, as it integrates theory and practice. Pragmatism and Engineering education share some significant similarities, as both consider practice more important than theory, and experience is crucial in each approach. According to Dewey (2008), the engineer is concerned with a practical subject that concerns things to be done (action) and ways of doing them. For this reason, according to Bulleit (2017), pragmatism aligns well with engineering education as engineers are also interested in the practical application of science and technology, which have practical implications for their work. Bulleit (2017) further asserts that engineers design and create artefacts and manufacturing processes based on incomplete knowledge. The prioritization of action remains at the heart of pragmatism, and engineering education would suggest that both offer theoretical apparatuses that are particularly well suited to philosophically questioning action-centric domains, such as PBL. In the PBL approach, students are inspired to act on their own (Arwatchananukul et al., 2021) by identifying a challenge or defining a problem and planning its solution after appropriate research (Higuera-Martinez, Corazza & Fernandez-Samaca, 2022). From the elaboration above, it can be concluded that PBL is pragmatic and suits Engineering education since they are all oriented towards doing. To engineers and pragmatists, foundational knowledge is interesting if it is advantageous in solving the issue at hand; consequently, if it is not beneficial, then it is not essential to study (Bulleit, 2017).

The constructivist perspective is rooted in pragmatism (both at conceptual and application levels). It advocates that knowledge is constructed in activities where people interact with each other during the learning process. In this perspective, an open-ended learning experience is promoted where the techniques and outcome of

learning are not conveniently measured and may not be identical for each student (Agda, Hamidi & Ghorbandordinejad, 2011). The highly significant implication of constructivism for teaching and learning lies in the shift from a teacher-centred approach to a student-centred approach. A student-centred approach means inverting the classical teacher-cantered insight into the learning process and putting students at the centre (Warnich & Meyer, 2013). However, the literature highlights two dominant perspectives: cognitive and social constructivism. In cognitive constructivism, knowledge is constructed by an individual through a personal process (Akyol & Fer, 2010; Lowenthal & Muth, 2008), and consequently, a student learns by mentally organizing and reorganizing new knowledge or experiences (Kalpana, 2014). Social constructivism focuses on knowledge and insights into the world that individuals develop jointly (Amineh & Asl, 2015; Akyol & Fer, 2010; Lowenthal & Muth, 2008). In this study, social constructivism was adopted as a theoretical lens, as it promotes learning through collaboration and knowledge sharing between the facilitator and students, between students and fellow students, and with knowledgeable others. Beck and Kosnik (2006) argue that some main features of a social constructivist perspective are as follows: learning is social, knowledge is experience-based and constructed by students, and all aspects of persons are connected. This aspect encompasses societal and cultural beliefs. Based on the above main features, social constructivism aligns perfectly well with some main features of PBL, as the reviewed literature dictates.

The thesis focuses on shifting TVET Electrical lecturers' perspectives and practices from teacher-centred to student-centred teaching through PBL, positioning this research within a socio-cultural perspective. During the change process, the TVET Electrical Engineering lecturers would interact with each other, and their interactions would also be affected by societal and cultural beliefs. It could be concluded in this study that PBL, as a teaching and learning approach, can be discussed using both perspectives, namely, pragmatism and social constructivism. However, several connections exist between pragmatic and social constructivism and the purpose of PBL, as they all focus on action to effect change for the better.

The change process comes with a negative impact, and leaders can buffer personnel from the adverse effects of change through planning (Feldmann, 2014). To change for better and for sustainable change, the change target, which in the context of the current investigation is TVET Electrical Engineering lecturers, should be prepared for

change and shaping the implementation of change with or through shared governance (Adelman-Mullally, Nielsen & Chung, 2023). These authors emphasised that how changes are introduced and implemented can form experience. They also mentioned that successful change requires thoughtful navigation from the current state to the desired state. In this study, Lewin's theory of planned change and his approach to solving social issues offer much inspiration to advance our thinking and action (Endrejat & Burnes, 2024; Adelman-Mullally et al., 2023). Lewin's theory of change is sometimes regarded as a three-stage model of change, which describes the present situation as the status quo with a proposed process of change that evolves into future desired states through three necessary stages (Tran & Gandolfi, 2020). The first stage is unfreezing, the second is change or moving, and the third involves refreezing.

The unfreezing stage requires confronting the present state or re-education process achieved through team building (Tran & Gandolfi, 2020), promoting social interactions between change agents and targets. Adelman-Mullally et al. (2023) posit that confrontation is done to break complacency. According to Schein (1999), the unfreezing stage creates motivation to learn but fails to control or predict the direction of learning. In this stage, the change target becomes unfrozen and motivated to change, and as a result, they are open to new information (Schein, 1999). During this stage, leadership and management are needed to identify the need for change and start the process while continuously providing resources and support (Adelman-Mullally et al., 2023).

During the moving stage (change stage), new behaviours, values, and attitudes are developed (Tran & Gandolfi, 2020). This is the critical stage of Lewin's theory of planned change, wherein change flows from group consensus on the need to change, and focusing on group change is more effective than focusing on an individual (Adelman-Mullally et al., 2023; Lewin, 1947), which supports collaborative learning. Endrejat and Burnes (2024) add that Lewin learned that training only one group member is unlikely to achieve the desired change. For example, training only one TVET Electrical lecturer per college would not produce quality TVET education. Therefore, if the leadership and management of the TVET colleges concerned want to enhance the quality of their graduates, all Electrical Engineering lecturers should join the training to modify their dynamics in a desired manner. Thus, Lewin's theory of planned change is a social constructivist by nature, making it suitable for this study.

Adelman-Mullally et al. (2023) emphasised that the moving stage is more effective with group consensus, and moving without group consensus might result in a danger to permanent change. Thus, according to Bushe and Marshak (2009), change should take place within a dialogical approach based on social constructivism and not on a diagnostic approach, resting on positivism. In the second stage, the change agents provide knowledge, explicitly define the change process, clarify misconceptions, and inspire the group (Hussain, Akram, Haider, Hussain & Ali, 2018).

The last stage is refreezing, which requires the new organisation to stabilise in a new balanced state to ensure safety (Adelman-Mullally et al., 2023; Tran & Gandolfi, 2020). The main point about refreezing is that the new behaviours must be, to some degree, consistent with the rest of the behaviours and personalities of the change target (Schein, 1999). In this stage, the new desired state should be implemented in TVET Electrical Engineering lecturers' classrooms, and the leadership and management should provide resources and support (Adelman-Mullally et al., 2023).

Drawing on Lewin's principles that individual roles and behaviours within a group affect various dynamics, this study recognizes that classroom members or participants in the change process maintain compelling psychological relationships and cohesiveness, thus influencing one another (Qiu, Long, Yu & Cheong, 2023). These authors further postulate that, despite shifting responsibilities from change agents to change targets, change agents must maintain an active role to a certain degree. Thus, the change agents might exert different influences on the change target when they assume different leadership styles to help change agents focus on common goals and encourage the change target as a whole. Heron's facilitation mode emphasises the change target's central role, positioning the lecturer as a facilitator across the six dimensions and three modes of facilitation, namely, hierarchical, cooperative, and autonomous (Qiu et al., 2023). These authors further propose that the change target would inevitably be influenced by the change agents and, in this study, by the learning process facilitator. This implies that they learn from or with each other, which supports social interaction. Thus, learning from or with each other is characterised by self-directedness and student-centredness, which align with the chosen teaching and learning strategy to shift TVET Electrical Engineering lecturers' perspective from teacher-centred to student-centred, namely PBL. Concerning the three modes of

Heron's facilitation, mode one is hierarchical, mode two is cooperative, and the third mode is autonomous.

In the hierarchical mode, the change agent does all the learning process planning, while interactions between the change target and the change agent are limited (Qiu et al., 2023). In the current study context, change agents are facilitators, and the change targets are TVET Electrical Engineering lecturers participating in the change process, particularly the moving stage of Lewin's second stage. This mode is suitable for change agents who are new to the teaching and learning strategy, such as PBL, to motivate them.

The second mode of facilitation is cooperative; in this mode, change targets are allowed to participate actively in group decisions. In this mode, the change agent works together with the change targets to design learning plans, while the change agent works as a guide or shares knowledge and experience with the change target (Qiu et al., 2023). These authors make an interesting point by stating that all learning process decisions are worked out through negotiation, and the change agent shares the influences, not the final view. This aligns well with the social constructivism theory that the change target should not merely copy their change agents' understanding but construct their understanding (McQuade, Ventura-Medina, Wiggins & Anderson, 2020). McQuade et al. (2020) furthermore mentioned that change targets learn on the scaffolding of other change targets provided by PBL, and through social interactions, their shared knowledge is reconstructed and validated until a meaningful resolution is found for the problem at hand. Once the change targets have mastered the two modes of facilitation, they can be exposed to an autonomous mode.

In an autonomous mode, planning and structuring the learning process is entirely done by the change targets (Galajda, 2012). Change agents create a space for change targets to develop self-determination and self-directed practice (Galajda, 2012). The autonomous mode of facilitation aligns with the requirements of a pure PBL approach. In this mode, the change agents' role is to create a conducive condition for learning to take place (Galajda, 2012). Masek (2019) adds that the role of the facilitator is to monitor the tasks carried out by the change target during their learning process. Masek (2019) also mentioned that although this mode focuses on the change target as a key player in teaching and learning, a facilitator (change agent) is crucial for guiding the change target to reach their learning goals.

During the change process, change agents, i.e., facilitators of the learning process, are necessary because guiding the change process requires change agents who have time to listen to change targets and understand and represent stakeholders. At the same time, they are detached from management (Adelman-Mullally et al., 2023). Schein (1999) posits that the true artistry of change management lies in the various tactics that change agents employ to create psychological safety. The current author believes that change agents should provide learning environments in which errors are embraced rather than feared, offer a positive vision, and provide online coaching, which reduces learning anxiety. Change agents, depending on the nature of the classroom dynamics, should be non-directive where possible because of the assumption brought forward by social constructivism. The assumption states that the best and most suitable solution will be the one the change targets invented themselves (Schein, 1999). Therefore, change agents, within the context of education, should create suitable learning environments, including the curricula, given tasks, other change targets, and change agents. According to Baden and Major (2004), the role of change agents (facilitators in the case of the current study) is not to dispense knowledge but to provide change targets with the opportunity to build their understanding. Therefore, constructivists value collaborative learning and other components of PBL, facilitating the change targets' ability to construct their knowledge. Knowledge occurs when the change targets interact with the environment. Thus, knowledge is acquired as the change targets negotiate social situations and evaluate their own understanding under the guidance of the change agents. Therefore, facilitation by the change agents is another unique component of PBL compared to other teaching and learning strategies that become the change agents' central role, if not the only role (Cho, Cho, Cho, Jeong & Cho, 2021).

In conclusion, the change process requires intentional planning rooted in a theory of planned change that focuses on group consensus. Change targets should be task-oriented and process-oriented (Heron, 2006), which aligns with the principles of PBL. The PBL process is a facilitated learning process based on social constructivism, which stresses the role of the change target as a key figure in the learning process and change agents as facilitators who should apply all three modes of facilitation (Heron, 2006). Masek (2019) recommends that effective facilitation could be supported by switching between different learning strands and a creative, holistic

course design. This implies that an effective change agent is one who is flexible and can switch between different types of leaders' behaviour, depending on the given situation. For these reasons, this research poses a critical question: To what extent *do TVET lecturers employ inquiry-based teaching strategies to enhance learner-centred teaching through PBL in electrical engineering classes?*

1.6 SUB-RESEARCH QUESTIONS

The research is guided by the following six (6) sub-research questions:

1. What challenges do TVET lecturers face when adopting and implementing Problem-Based Learning (PBL) as a student-centred strategy in Electrical Engineering education? (cf. Article 3, pp.69-103).
2. What are the current teaching practices of lecturers within a purposefully selected TVET Electrical Engineering programme? (cf. Article 3, p.85, and Article 1, pp.38-40).
3. What are the key components of Problem-Based Learning (PBL), and how do TVET lecturers understand their application in shifting pedagogical approaches within the Electrical Engineering program? (cf. Article 2, p.57).
4. How do these lecturers perceive and prioritize professional development strategies to enhance teaching effectiveness and support the transition to student-centred learning in Electrical Engineering? (cf. Article 1, pp.37-38).
5. How do TVET lecturers evaluate the alignment between their perceptions of learning outcomes in the Electrical Engineering program and the actual program outcomes? (cf. Article 3, pp.83-84).
6. How can TVET lectures facilitate effective PBL pedagogical practice integration to ensure a student-centred Electrical Engineering learning experience? (cf. Article 3, pp.90-92).

1.7 OBJECTIVES

By answering the above-mentioned sub-research questions successfully, the study attains the following central study objectives:

1. To identify and analyse the challenges lecturers face in adopting and implementing Problem-Based Learning (PBL) as a teaching and learning strategy within the context of Electrical Engineering education and to propose strategies for overcoming these challenges.
2. To explore and document the current teaching practices employed by lecturers within a purposefully selected TVET Electrical Engineering program.
3. To analyse the feasibility and suitability of the identified professional development strategies for implementation within the TVET Electrical Engineering education context.
4. To propose recommendations based on the findings to enhance the professional development opportunities for TVET lecturers and improve teaching practices within the Electrical Engineering program.
5. To explore TVET Electrical Engineering lecturers' perceptions of an Electrical Engineering program's nature and learning outcomes, juxtaposed with the actual program learning outcomes.
6. To develop a framework for a short learning program aimed at the continuous professional development of TVET Electrical Engineering lecturers, focusing on the effective adoption and implementation of PBL as a pedagogical approach in their classrooms, informed by an understanding of the nature of Electrical Engineering and its learning outcomes.

1.8 RESEARCH DESIGN AND METHODOLOGY

1.8.1 Research Paradigm and Research Approach

The research approach refers to how the researcher planned to conduct research (McNiff, 2016). Informed by the interpretive paradigm, the present study employed qualitative approaches to explore the teaching practices enacted by TVET Electrical Engineering lecturers and the challenges they might encounter if PBL is adopted as the teaching and learning strategy in Engineering Education in South Africa. Paradigm is a dominant framework that researchers use to shape the research process by providing research rationale and committing the researcher to choose a particular method of collecting and analysing data (Sedibe & Buthelezi, 2014; Hammond & Wellington, 2013). Paradigms are a set of beliefs that the researcher brings to the

study that influence how the researcher will undertake the study (Creswell, 2015; Guba, 1990). According to Creswell (2015), these beliefs are related to the type of evidence that the researcher may use to claim knowledge (epistemology) and knowing (ontology). They are based on the researcher's beliefs and those belonging to the community of practice (Feilzer, 2010). In this study, the researcher has adopted an interpretive paradigm, which focuses on exploring participants' subjective experiences based on their beliefs about knowledge and knowing. Panhwar, Ansari, and Shah (2017) assert that there is no absolute truth when studying human actions and behaviours. Therefore, the researcher constructs reality or knowledge when trying to understand a phenomenon under study by interacting with the participants' experiences. Thus, the researcher constructs meaning by interacting with the phenomenon under study by analysing their own experiences and those of the participants in the study (Adom, Yeboah & Ankrah, 2016). This study collected subjective qualitative perceptions and experiences through observation notes and open-ended questionnaires supporting the interpretive paradigm.

The study was conducted following a three-step approach: exploring the current state of TVET college teaching practices, situation analysis and identifications of its crucial aspects (step 1), scoping the review to identify key elements of PBL (step 2), and lastly, exploring the TVET Electrical Engineering lecturers' perspective of the nature and the learning of the Electrical Engineering program (step 3). Based on the findings of this study, professional development training is proposed, informed by Lewin's theory and Heron's mode of facilitation, which facilitators could use to facilitate teaching and learning and the adoption and implementation of PBL in their respective classrooms.

1.8.2 Case study research design

The research design was adopted to seek the best answers to the posed research questions, which was a qualitative single-case exploratory research design (Hyett, Kenny & Dickson-Swift, 2014). This was done because exploratory research designs emphasize qualitative components (Bishop, 2015). Silva and Mercés (2018) suggest that a single-case study is advantageous since it is economical and less time-consuming than multiple case studies. Deploying a single-case study in research

enables the researcher to richly describe the phenomenon's existence in a particular context (Algozzine & Habcockm, 2016). Gustafsson (2017) regards a case study as an intensive study concerning a phenomenon used in complex situations when the solutions to the posed questions do not have a precise answer. Therefore, a case study could adopt various qualitative data collection methods to find solutions to a specific research question, e.g. questionnaires and interviews (Yin, 2017; Anand, Ali, Sen & Khanzode, 2009) and to provide depth and breadth to the phenomenon under investigation (Harrison, Birks, Franklin & Mills, 2017; Creswell, 2013). The researcher is aware that although the findings from a case study are either illustrative or confirmatory, such findings cannot be generalised to the larger South African TVET context, which is an inherent limitation of case study research design, followed in the current investigation (Gustafsson, 2017). However, the researcher has committed himself to utilise specific strategies to overcome this limitation when reporting the findings; for example, findings in the current study were reported as rich qualitative context and sensitive evidence in the form of figures and tables, supported by direct quotations of participants' responses, as evidence (Eisenstadt & Graebner, 2007).

1.8.3 Qualitative methods of data collection

Data collection refers to systematically monitoring one's activities and keeping records, such as diaries and correspondence (Efron & Ravid, 2020; McNiff, 2016; Norton, 2019). Data were collected through the following data collection instruments: a scoping review (cf. Article 2, p.55-56), a qualitative open-ended questionnaire (cf. pp.131-135), and an observation schedule (cf. pp.136-139).

A scoping review was used to identify key components in the literature related to PBL required for effective implementation of PBL as a teaching and learning strategy to shift TVET Electrical Engineering lecturers' perspectives and practices. The evidence gathered was then used to guide the design of a proposed professional development training framework (cf. Article 3, pp.90-92) for the adoption and effective implementation of PBL by the TVET Electrical Engineering lecturers in their respective classrooms. Inclusion and exclusion criteria were used to identify potential primary studies (Zakaria, Maat & Khalid, 2019). In the current investigation, only peer-reviewed

articles written in English were used for quality purposes and manageability (Daun, Grubb, Stenkova & Tenbergen, 2023; Boelt, Kolmos & Holgaard, 2022).

An open-ended qualitative questionnaire (cf. pp.131-135) was also used to gain a more comprehensive understanding of the phenomenon under investigation when TVET Electrical Engineering lecturers shared their lived experiences and perceptions in their own words. Accordingly, a qualitative research method involves an open-ended approach to data gathering (Hesse-Biber, 2010). For the researcher to answer the research questions in this study and to obtain an in-depth context-sensitive understanding of TVET Electrical Engineering lecturers' pedagogical approaches, participants completed an open-ended qualitative questionnaire.

The other research method used to collect in-depth information from the phenomenon under study was classroom observations (cf. pp.136-139). Classroom observations were done to analyse TVET Electrical Engineering lecturers' interaction with their students and document what occurred. Literature refers to observation as a process whereby researchers gather structured, first-hand information by observing participants in their full settings to collect data (Vogt, Gardner & Haeffele, 2012; Driscoll, 2011). According to Hammond and Wellington (2013), observations involve the researcher's direct experiences of the phenomenon and observing TVET Electrical Engineering lecturers interacting with their students during teaching and learning. In this study, the researcher was responsible for observing and collecting data and had no prior connections with the observed. During data gathering, the researcher assumed a non-participatory stance. Literature highlights that a non-participatory stance is when the observer visits the site and takes notes without being involved in the classroom activities of the observed participants (Donnelly, 2008; Creswell, 2005). Graziano and Raulin (2010) posit that conducting observation in a non-participatory stance helps the researcher avoid influencing the participants, allowing the researcher to see the whole picture of what takes place in the classroom environment. The observations in this study helped the researcher with detailed information concerning the location, artefacts, resources, and the environment (Hammond & Wellington, 2013).

1.8.4 Research participants and site selection

The selected population for the study was all the Electrical Engineering lecturers currently teaching Electrical Engineering at a purposefully selected TVET college campus in the Motheo School District of the Free State Province in South Africa. This study employed homogeneous purpose-driven sampling (Creswell, 2020; Efron & Ravid, 2020). With homogenous sampling, participants at a research site are intentionally sampled based on membership of the subgroup that exhibits the defining characteristics (Creswell, 2020). Thus, the researcher purposefully selected an available sample of participants at a particular research site to learn or understand their essential experiences and perceptions (Creswell, 2005; Hunt & O'Leary, 2017). These TVET lecturers were selected because they are participants who can best help me understand the phenomenon under investigation. In this study, the research site chosen was a purposefully selected TVET College Campus in the Motheo School District, which offers Electrical Engineering programs. All Electrical Engineering lecturers (n=14) were invited to participate in this study. However, due to the voluntary nature of the study, only n=4 lecturers took part.

1.9 QUALITATIVE DATA ANALYSIS

Data analysis involves the process of identifying, examining, and interpreting the data patterns to establish how these patterns assist the researcher in answering the research questions posed (Creswell, 2005). All qualitative data used in this study were included to form an integrated qualitative data set. Thematic qualitative data analysis was conducted (Efron & Ravid, 2020; Norton, 2019) to organise and group interrelated themes of qualitative data together to better understand the collected data (Norton, 2019).

1.10 SIGNIFICANCE OF THE STUDY

The study makes an important contribution to the existing body of knowledge by providing real-life insights into how professional development training, which uses PBL as a teaching and learning strategy, should be intentionally planned for the adoption and effective implementation of PBL. Higher education and private training institutions that offer professional development training to preservice and in-service TVET

lecturers should benefit from this study. TVET lecturers, who are part of communities of practice and are open to learning, unlearning, and relearning, could benefit from the findings of this study during their informal professional development. Adopting and effectively implementing PBL in their classrooms will improve the quality of TVET education, and their students could benefit substantially. Improved TVET graduates' learning output can boost the country's economy and reduce the number of unemployed TVET college graduates.

1.11 ETHICAL CONSIDERATION

The gathering and reporting of all information in this research complied with the ethical regulations of the University of the Free State and complied with ethical research practices. The researcher sought approval from the University's Research Ethics Committee at the Faculty of Education (UFS-HSD2022/2018) before commencing this research (cf. p.124). TVET Electrical Engineering lecturers were informed about the nature and aim of this study and provided informed consent before participation. Thus, all inquiries complied with the principle of informed consent. The researcher ensured that TVET Electrical Engineering lecturers knew of their right to voluntary participation and their option to withdraw from the study at any stage or time. To assure them of confidentiality, the researcher also informed TVET Electrical Engineering lecturers that the study supervisor would have access to the information but would not share any information with anyone else unless required by law. To minimize any risk to TVET Electrical Engineering lecturers that may arise from this study, the researcher used codes in his reporting of the findings, e.g., lecturer A, lecturer B, etc., to protect the identities of participants, who indicated to remain anonymous (Rozsahegyi, 2019; Winwood, 2019). The list of codes and actual names of participants was kept in separate locations on the researcher's computer. All these terms and conditions were outlined in consent letters and were explained verbally to TVET Electrical Engineering lecturers. This study also sought permission from the Department of Higher Education, and permission was granted to conduct research in one of their TVET Colleges in Motheo School District in Free State Province (cf. p.125), namely the Hillside View campus. Participants' responses were collected using qualitative open-ended questionnaires (cf. pp.131-135) and through classroom observations (cf. pp.136-1139).

1.12 QUALITY ASSURANCE, INTERPRETATION AND REPORTING

Data from different datasets were validated to ensure the trustworthiness of the findings. Validating findings means that the researcher determines the accuracy or credibility of the findings through strategies such as member-checking, triangulation or external auditing (Efron & Ravid, 2020; Vanner & Kimani, 2017; McNiff, 2016). For example, data collected through qualitative open-ended questionnaires were compared with data collected from other datasets, in this case, classroom observations. The researcher deployed only peer-reviewed journal articles to add rigour to the information gathered through the scoping review. Peer-reviewed articles are often targeted to academic audiences, have met at least some standards for credibility, and are both relevant and current (Hunt & O'Leary, 2017).

According to Cresswell (2005), interpretation in qualitative research is the process of making sense of the findings. Therefore, interpretation means that the researcher steps back and forms some larger meaning about a phenomenon based on personal views and/or comparisons with past studies. Thus, interpretation gives meaning to the categorised or coded data, explains their importance, and gives meaning to the collected data (Efron & Ravid, 2020). Member checking was used to add rigour to the collected and interpreted data. Member checking is when the researcher invites study participants to check the accuracy of interpretation and requests them to provide feedback through interviews or in writing (Creswell, 2005). This was done to ensure that the information the researcher reports reflects the voice of participants in the reporting of interpreted data and to help eliminate the researcher's bias during analysis and interpretation (Anney, 2014; Govender, Mabuza, Ogunbanjo & Mash, 2014).

Two formats were adopted in this study to report the findings and their importance, namely, thematic and thick descriptions (Efron & Ravid, 2020). As a point of departure, the researcher introduced the themes, presented selected quotes from the datasets as evidence, and explained the meaning of these responses.

1.13 OUTLINE OF THIS THESIS

This thesis followed an articles-based research model comprising three (3) research articles submitted to accredited peer-reviewed academic journals (cf. p.23). The current chapter (Chapter 1) discusses the problem's background statement and

presents this investigation's aim and questions. The research questions are discussed jointly, along with the justification and purpose of the study. Since the thesis is article-based, the length of the three articles was restricted by the word count prescribed by the respective journals. The current chapter also provided information on the research design and methodology and how data were collected and analysed.

In Chapter 2, the three articles (cf. p.23), one published (Article 2), and two submitted to academic journals and currently under peer review (Articles 1 and 3) are presented. Each of the three articles was written using the format and referencing style required by each journal, where the papers were submitted for peer review and possible publication. Each article, therefore, comprises its reference list in its referencing style.

Lastly, Chapter 3 of this thesis summarizes the key findings of the research, answers each of the research sub-questions (cf. p104-108), discusses the implications for theory, practice, and future research (cf. p109-110), offers recommendations based on the study's findings (cf. p.110), and limitations of this study (cf. p.110).

1.14 CONCLUSION

The introduction and background in this chapter highlight the growing need for TVET lecturers to adapt educational strategies to better align with 21st-century learning demands, with PBL serving as a pivotal method for fostering student engagement and critical thinking, particularly within Electrical Engineering programs. The rationale of this study stemmed from the recognition that traditional teaching approaches used by TVET lecturers often fail to adequately prepare students for the demands of the modern workforce, especially within vocational fields such as Electrical Engineering. The following chapter (Chapter 2) presents the research study contributions.

CHAPTER 2

RESEARCH CONTRIBUTIONS

Table 2.1: Summary of articles

Articles	Titles	Journals
Article 1	Professional development strategies for effective Problem-Based Learning Implementation in South African TVET Electrical Engineering Classes.	Submitted to the Journal of Vocational Education and Training for Peer-Review and Possible Publication.
Article 2	Problem-based learning for shifting Technical Vocational Education and Training Electrical Engineering lecturers' practices: A scoping review.	Published in the <i>Journal of Vocational, Adult and Continuing Education and Training</i> , 6(1):1–16. http://doi.org/10.14426/jovacet.v6i1.311
Article 3	A Professional Developmental Framework for South African TVET Electrical Engineering Lecturers to Effectively Implement Problem-Based Learning.	Submitted to the International Journal for Research in Vocational Education and Training for Peer-Review and Possible Publication.

2.1 Article 1: Professional development strategies for effective Problem-Based Learning Implementation in South African TVET Electrical Engineering Classes

In recent years, the integration of PBL into South African TVET Electrical Engineering classes has emerged as a promising approach to enhance student engagement and skill acquisition. To ensure effective PBL implementation, targeted professional development strategies for lecturers are crucial. This article explores the various strategies that can empower Electrical Engineering lecturers in South African TVET institutions to successfully adopt PBL methodologies. By examining current practices, challenges, and the role of professional development, the article provides insight into how PBL can be better facilitated in these specific educational settings. These insights lay a foundation for the discussions in subsequent articles (cf. Article 2, pp.46-68 and Article 3, pp.69-103) on shifting teaching practices and designing a professional developmental framework for lecturers.

2.2 Article 2: Problem-based learning for shifting Technical Vocational Education and Training Electrical Engineering lecturers' practices: A scoping review

The shift towards PBL in TVET Electrical Engineering programs has prompted a need for a deeper understanding of how such pedagogical changes affect lecturers' teaching practices. This scoping review systematically examines existing literature to explore ways PBL influences the approaches and practices of TVET Electrical Engineering lecturers. By identifying key trends, challenges, and outcomes associated with the adoption of PBL, this review offers a comprehensive overview of the impact of this teaching strategy. The findings from this article contribute (cf. p.58) to the ongoing conversation on how professional development can support lecturers, as explored in the subsequent article (cf. Article 3, pp.90-93), which focuses on designing a developmental framework for effective PBL implementation.

2.3 Article 3: A Professional Development Framework for South African TVET Electrical Engineering Lecturers to Effectively Implement Problem-Based Learning

To effectively implement PBL within South African TVET Electrical Engineering classrooms, it is essential to establish a structured professional development framework that equips lecturers with the necessary knowledge, skills, and support. This article proposes a comprehensive framework (cf. pp.90-93) to guide lecturers in adopting PBL methodologies, addressing the specific challenges faced within the South African TVET context. It emphasizes the importance of ongoing professional development and provides practical recommendations for institutional support to enhance teaching practices. Building upon the findings from previous research on the effectiveness of PBL, this article offers actionable insights for improving educational outcomes in Electrical Engineering programs, further contributing to the discourse on PBL integration within TVET.

In conclusion, the research employed a phenomenological inquiry to explore the extent to which TVET Electrical Engineering lecturers integrate/apply problem-based learning strategies to develop technological literacy in their Electrical Engineering classes.

The following section (Section 2.4) presents the three research journal manuscripts in the format and requirements of the peer-reviewed academic journals identified for and submitted to.

2.4 Articles

2.4.1 Article 1

**Submitted to the Journal of Vocational Education and Training for Peer-Review
and Possible Publication.**

Topic

**Professional development strategies for effective Problem-based learning
implementation in South African TVET Electrical Engineering Classes**

Abstract

This research examines the use of problem-based learning (PBL) as a pedagogical strategy within a South African TVET College, specifically within an Electrical Engineering program. It explores professional development strategies aimed at improving teaching practices in response to recent curriculum changes and the growing need for alignment between educational methods and the demands of business and industry. A qualitative case study was conducted to explore current teaching and learning strategies and identify opportunities for enhancing the educational experience. The findings reveal that lecturers in the Electrical Engineering program have limited experience with PBL methods, although they recognize the potential benefits of such approaches in technical education. The study underscores the importance of integrating problem-based strategies to bridge the gap between industry needs and educational experiences, thus improving the quality of technical education. The research concludes by recommending the promotion of professional development through collaborations with subject-matter experts and industry professionals and participation in sustainable communities of practice. It highlights the essential role of TVET instructional leaders in transforming education and emphasizes the importance of both formal and informal professional development initiatives to ensure industry relevance.

Keywords: Communities of practice, electrical engineering, problem-based learning, professional development, TVET education.

1. Orientation, problem statement, and research aim

Design thinking reflects on complex processes of inquiry and learning that designers perform in a system's context, making decisions as they proceed, often working collaboratively on teams in a social process, and “speaking” several languages with each other (and to themselves). Assessment data on these characterizations are also discussed, although some of that data derives from studies in contexts other than design. The literature on engineering education for change suggests that greater curriculum emphasis on the design process seeks to enable technical engineering graduates towards greater independence while simultaneously increasing their ability to work in teams to solve problems and design solutions (Dym et al. 2005; Felder, Brent and Prince 2011; National Academies of Sciences, Engineering, and Medicine 2020).

Introducing a National Curriculum (Vocational) in South African Technical Vocational Education and Training (TVET) constitutes a drastic change (DHET 2013; Terblanche and Bitzer 2018). These curriculum policy developments and ongoing calls for technical and engineering education learning and teaching experience reform towards a process-oriented teaching focus emulated this research on teacher knowledge competencies. Consequently, the change affects the teaching strategies significantly and necessitates adopting new pedagogies (Eze and Okorafor 2012). Nonetheless, most lecturers in TVET colleges continue to use outdated methods despite the necessity of the new pedagogies (Okolie et al. 2020). To adapt to a change in curriculum and engineering education philosophies, lecturers must also modify their current methods of instruction (Taole 2015; Teis 2014). These authors claim that lecturers' underlying teaching and learning philosophy must be altered to implement the curriculum change successfully. However, Adelman-Mullally, Nielsen, and Chung (2023) caution that altering one's habitual behaviours is difficult; hence, this research focuses on the need for renewed teacher knowledge. It is challenging to get lecturers to radically change their current teaching methods and belief systems, as Chance, Duffy, and Bowe (2020) concur. The lecturer's teaching methods and belief systems could be successfully altered through professional development intervention strategies. However, David (2023) discovered that the scarcity of professional development opportunities significantly contributes to the challenges lecturers face in implementing curriculum change. As a result, TVET lecturers lack adequate preparation (Paryono 2015; Yeap, Suhaimi, and Nasir 2021), mainly using new pedagogies to develop technological literacy. Despite lecturers' lack of preparation, Higher Education institutions emphasize persuading lecturers to use cutting-edge pedagogies to enhance student learning (Chance, Duffy, and Bowe 2020). Due to reliance on conventional methods of instruction, their pedagogies are causing increasing concern (Paryono 2015; Vimbelo and Bayaga 2023; Yeap, Suhaimi, and Nasir 2021). Against this background, this study aims to explore professional development strategies currently employed in TVET education and assess how they enhance practice, lecturers' competencies, and students' learning outcomes. The study examined the best practices in the TVET sector, particularly those promoting social interactions.

2. Social constructivism as a theoretical framework

Social constructivism serves as a theoretical framework for this study and a primary motivator for curriculum development for twenty-first-century learning (Khalid et al. 2023). These authors claim that social constructivism emphasizes effective communication, collaboration,

and group work. They also mentioned that social constructivism guarantees equality and inclusivity among team members. To promote collaboration and continuously improve the quality of students' learning in vocational education, lecturers should form design teams that include a variety of stakeholders who oversee curriculum matters in TVET sectors. Therefore, social constructivism has the potential to create communities of practice by socially bringing together TVET lecturers, who typically work in silos. This would allow team members to encounter different viewpoints through reflection, cooperation, negotiation, and shared meaning (Bariham, Yirbekyaa, and Bordoh 2022). Therefore, the professional development strategies that the study discusses support the selected theoretical framework as they can promote social interactions among team members.

3. Professional development strategies

There are two types of lecturers' opportunities for professional development: formal and informal. Formal lecturer training is provided by accredited higher education institutions and other recognized training sectors. On the other hand, informal professional development can be organized by different stakeholders, such as organized communities of practice and non-profit organizations. A group of interested individuals can organize informal professional development opportunities to share knowledge and accomplish a shared goal. For example, lecturers can learn and adapt their teaching methods through collaborative lesson planning (Park et al. 2023; Voogt et al. 2011). Lesson planning is a crucial component of practice and a valuable tool for regulating instruction and learning in the classroom (König et al. 2020; Zaragoza, Seidel, and Santagata 2023). Therefore, collaborative lesson planning promotes social interactions. Since learning is a social activity, professional development strategies that support student-centred or active learning were selected for this study. The methods include but are not limited to collaborative curriculum planning, problem-based learning (the focus of this case study), and work-integrated learning (WIL).

3.1 Collaborative curriculum planning and design

Park et al. (2023) view collaborative curriculum planning and design as a method for lecturers' or in-service teachers' ongoing professional development. According to the collaborative model, team members engage with one another while working on a task to gain knowledge from the task and other team members (Lavery and Thompson 2020). The collaborative model thus starts with creating a design team, which can be viewed as a particular kind of professional

learning community, to create or redesign educational or curriculum materials (Binkhorst et al. 2015). Therefore, lecturers should be encouraged to unpack their pedagogical knowledge collaboratively. According to Asgher et al. (2012), this establishment allows lecturers to create professional networks and platforms to exchange knowledge and cultivate a culture of excellence in curriculum development. For TVET teaching and learning to be high quality, design teams must work together to create lesson plans promoting active learning. Those with or without experience could gain from being a part of a design team. By exchanging knowledge and skills, collaborative curriculum design and planning can help lecturers advance their profession (Voogt et al. 2015). Collaborative curriculum design and planning foster social learning, claims Walker (1971). Therefore, social learning is demonstrated when each design team member contributes their values and beliefs about the goal and the curriculum structure. According to Walker (1971), this leads to a discussion that aims to elucidate significant issues, potential design options, and their advantages and disadvantages. Consequently, the interchange of information among team members reveals interactivity, which is the fundamental feature of design teams or teamwork (Volkova et al. 2021). Therefore, to strengthen TVET education, employers and education and training providers must work closely together to design training systems, including curricula, particularly for programs that offer vocational training (DHET, 2013; Mustapha, Saari, and Jalaludin 2023; Van der Bijl and Taylor 2020).

3.2 Problem-Based Learning (PBL)

Integrating theory and practice is essential to TVET instruction (Okolie et al 2022). Thus, problem-based learning (PBL) is crucial in engineering education (DBE 2011; Naji et al. 2020). The PBL tenet is that the knowledge and abilities to be acquired are structured around real-world issues or problems (Saqr et al., 2020). To effectively develop lecturers' pedagogical skills, the researcher views collaborative curriculum and planning as consisting of both the theoretical and practical components of TVET education, with WIL as the practical component. Therefore, the design team must ensure the two components are integrated by creating realistic tasks. Çakir et al. (2022) pointed out that to expose students to analogies of the methods used by Electrical Engineering specialists to address real-world industry problems, the problem-solving process should mimic the tasks industry specialists face. To ensure that problems mimic industry-related problems, the design teams should include TVET lecturers and Electrical Engineering industry specialists, and raise the standard of instruction in TVET. TVET students are expected to acquire knowledge and develop practical skills and competence before entering

the workplace. TVET instruction and learning quality must rise to fulfil this goal (Okolie et al. 2020). However, the work of Okolie et al. (2022) has disapproved of the widely held belief that the pedagogies employed at TVET colleges involve real-world problem-solving. Okolie et al. (2020) state that most lecturers at TVET colleges still employ traditional methods that do not encourage cutting-edge pedagogies such as PBL. Group learning, contextualized problem-solving through teamwork, learning social environments, and self-directed learning are some of the characteristics of PBL (Naji et al. 2020; Wosinski et al. 2018). PBL incorporates collaborative learning, which entails people developing the practical and social skills necessary to make meaningful contributions to their workplaces and communities (Okolie et al., 2020). Additionally, reflection is the key component of PBL (McQuade et al. 2020). Therefore, PBL involves ongoing reflection, in which groups assess their learning process at different times (Beagon, Niall, and Ni Fhlóinín 2019). For instance, to comprehend their growth during the learning process, team members must use reflective journals to reflect on their experiences (Çakir et al. 2022; Ulger 2018). Design teams should have ample time to reflect on the design and application of suitable teaching and learning strategies (Crawford, Obenland, and Nichol 2021).

3.3 Work-Integrated Learning (WIL)

WIL is a crucial activity that supports students' learning in TVET programs (Molele, Khoza, and Skosana 2024). According to Mesuwini and Mokoena (2024), the provision of the TVET program requires lecturers with the necessary prerequisites and industry-relevant skills. These authors claim that WIL offers TVET lecturers an opportunity to receive training from industry experts. Their study indicates that lecturers experienced learning from discussing the requirements and conditions of the tasks. Lecturers also learn from daily scheduled tasks, sharing artisans' feedback experiences, listening, communicating, and reflecting on previous experiences through different types of meetings. Studies by Mesuwini, Thaba-Nkadimene, and Kgomotlokoa (2021) show that lecturers accepted WIL well. They acquired real-world experience through networking, teamwork, and exchanging ideas and experiences with professionals in the field, which promotes social interactions. Improving the implementation of the WIL program requires an integrated approach, and stakeholder involvement is crucial (Ramli et al. 2024). These authors also recommended that the WIL program is effective when stakeholders share the responsibilities to ensure that the transfer of knowledge and skills during the WIL process achieves the quality that industries desire. David (2023) noted the urgent need for a national partnership between TVET training institutions and industries, which Mends-

Brew and Dadzie (2016) agree with. Therefore, creating systems or venues for lecturers to participate in WIL is crucial. Mesuwini, Thaba-Nkadimene and Kgomotlokoa(2021) emphasize the need for lecturers to periodically participate in industry WIL to maintain current practical skills.

4. Research design and methodology

This section outlines the research design and methodology used for the research, including information related to the research site, the sample participants, ethical considerations, and the data analysis technique utilized.

4.1 Design and methods of data collection

The study's research design was a qualitative case study. Data for the study were collected using two qualitative methods: classroom observation (cf. pp.136-139) and an open-ended semi-structured qualitative questionnaire (cf. pp.131-135). There were two research objectives for the study. The researcher began by exploring TVET Electrical Engineering lecturers' teaching methods to deliver the Electrical Engineering curriculum. The researcher then explored these methods with contemporary and cutting-edge pedagogical approaches. Secondly, the researcher explored informal professional development techniques that participating lecturers could employ to enhance and modify the standard of instruction in the TVET context of South Africa.

4.2 Research site and sample of participants

One carefully chosen TVET college campus in the Free State Province in South Africa served as the site of the case study. Along with logistical considerations, this TVET college was chosen because it provides an Electrical Engineering program that offers the National Curriculum: Vocational (NC: V) and the NATED programme (N-courses). All fourteen (n=14) of the TVET college's Electrical Engineering lecturers were invited to participate voluntarily and anonymously in the study. At first, all 14 lecturers expressed interest in the study and participated in the first orientation and planning session. The research survey was discussed at this session and distributed among all 14 lectures, but only four (n=4) took part by answering the open-ended, semi-structured qualitative questionnaire. The researcher can only speculate that the ten (10) lecturers who chose not to participate might have done so out of fear of being tested or evaluated. Nonetheless, the survey aimed to generate biographical data of the Electrical Engineering lecturers at the college with particular interest in their qualifications,

teaching and industry experiences, and the extent to which lecturers engage in industry-based learning. The researcher resolves to draw data from the four Electrical Engineering lecturers' classes as independent cases that produce the required data for the research.

4.3 Ethical considerations

Official approval was received from the TVET college's management, and ethical clearance [UFS-HSD2022/2018] was given by the University of Free State's Research Ethics Committee (cf. p.124). Participants were made aware of their right to withdraw from the study at any point during the research process, and participation was voluntary and anonymous. In addition to being informed about the nature and purpose of the study, participants received respectful treatment and an enabling teaching environment. The researcher is mindful of the fact that all research participants create meaning in diverse ways and seek to endure the uniqueness of each. After completing and signing an informed consent form, participants permitted researchers to explore their teaching practices, gather an understanding of their educational philosophies and how they create learning experiences and engage them, and share the results. The time and date for data generation were set up so as not to conflict with TVET College's regular academic operations.

4.4 Thematic data analysis

Classroom observations (cf. pp.136-139) and an open-ended, semi-structured qualitative questionnaire (cf. pp.131-135) were used to gather the qualitative datasets, then subjected to a qualitative thematic data analysis. Figures were used to visually represent the interconnected data themes created from the grouping and organization of the qualitative data. The following three figures (Figures 1, 2, and 3) present key themes derived from qualitative data, shedding light on various aspects of TVET lecturers' experiences and practices. Figure 1 focuses on the themes related to TVET lecturers' knowledge and prior experiences with PBL, highlighting their understanding and application of this teaching approach.

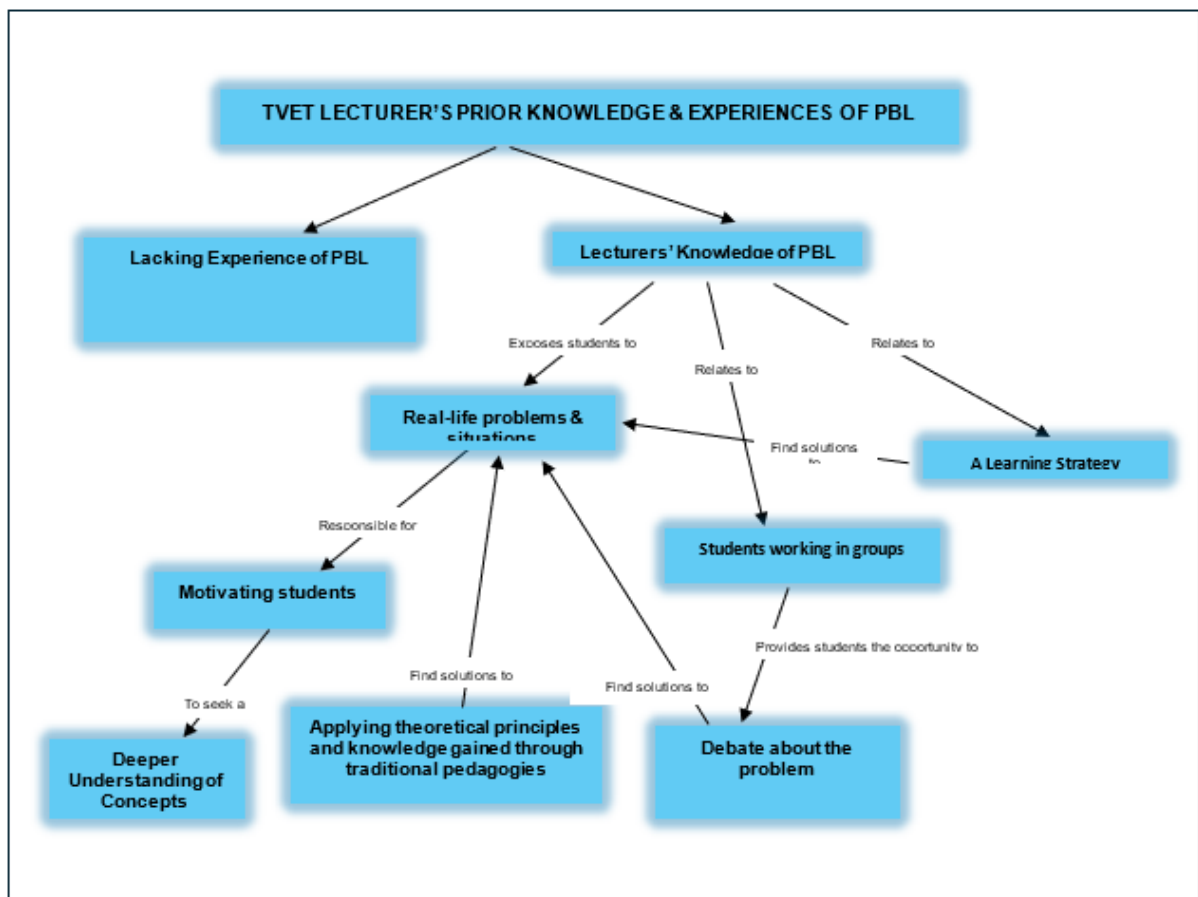


Figure 1: Themes of Qualitative Data About TVET Lecturers' Knowledge and Prior Experiences of PBL.

Building on this, Figure 2 delves into the themes concerning the lecturers' participation in Communities of Practice, illustrating how collaboration and professional networks influence their teaching methods and development.

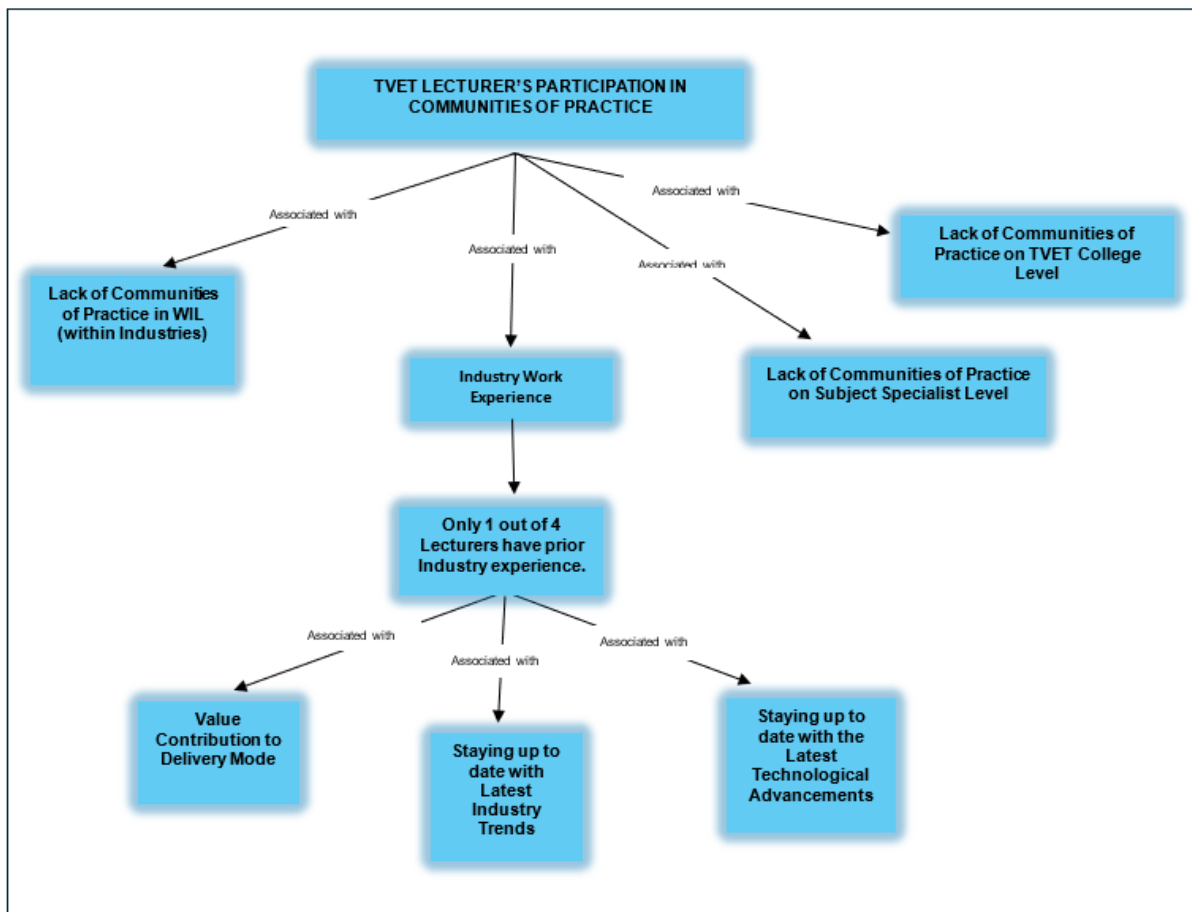


Figure 2: Themes of Qualitative Data Pertaining to TVET Lecturers' Participation in Communities of Practice

Finally, Figure 3 presents themes from observations made during TVET classes, offering insight into the real-time classroom dynamics and the implementation of pedagogical strategies. These figures provide a comprehensive view of TVET lecturers' professional journey, from theoretical knowledge to classroom practice.

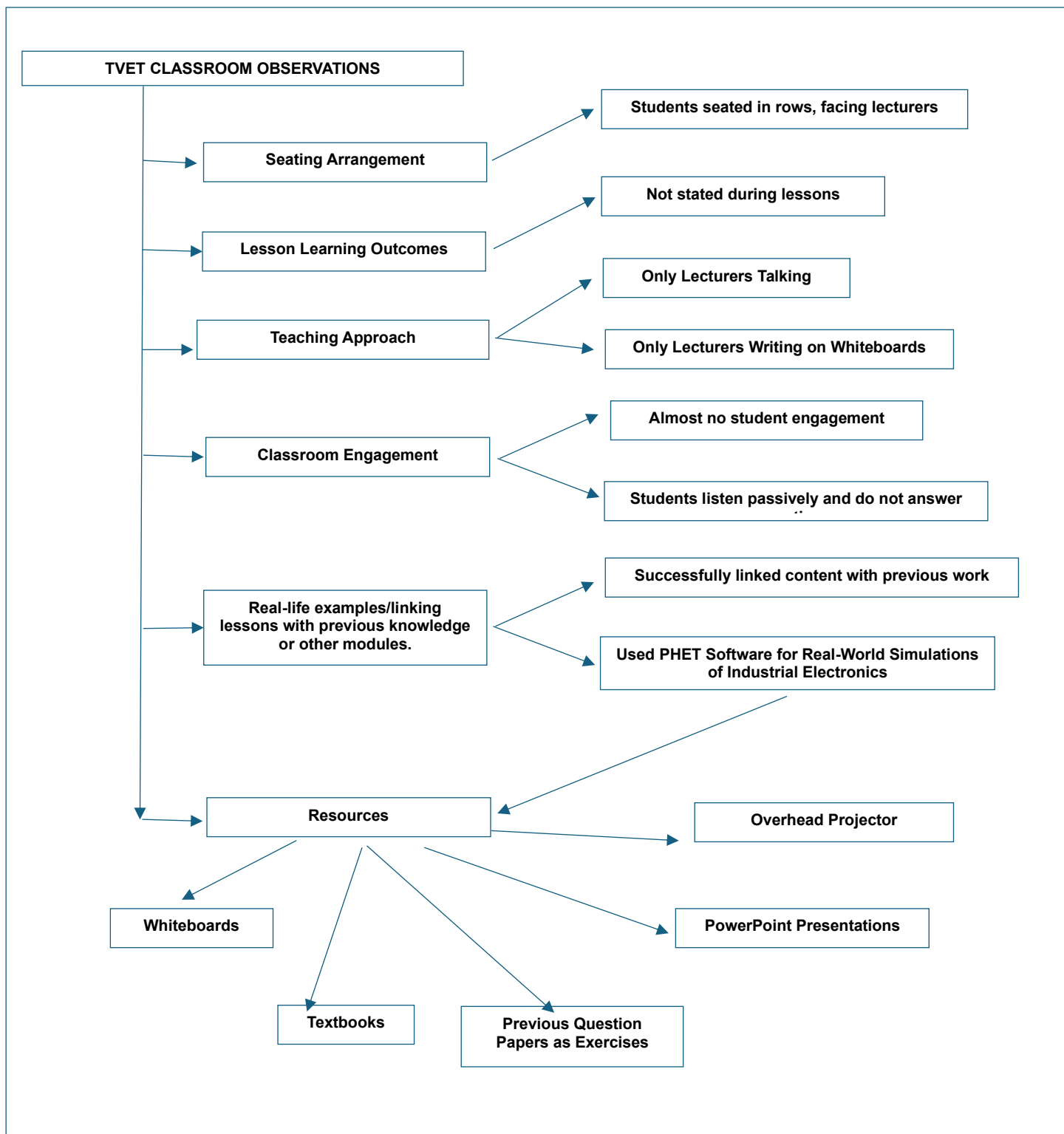


Figure 3: Themes of Qualitative Data About Observations Made During TVET Classes

5. Discussions

The purpose of this study was to explore and understand the various factors that shape the teaching practices of TVET lecturers, with a particular focus on their experiences and

knowledge related to PBL (cf. Figure 1 above), their participation in communities of practice (cf. Figure 2 above), and observations made during classroom interactions (cf. Figure 3 above). The qualitative findings from this study reveal insights into TVET lecturers' prior knowledge and experiences with PBL, highlighting how they perceive and implement this teaching method. Additionally, the study explored the role of participation in communities of practice, illustrating how these professional networks contribute to their teaching strategies and overall development. Finally, qualitative observations made during TVET classes offer a closer look at the practical application of pedagogical methods in the classroom, providing valuable context to the lecturers' professional journeys. These findings collectively contribute to a deeper understanding of the dynamic relationship between TVET lecturers' knowledge, collaboration, and classroom practices.

5.1 Qualitative findings on TVET lecturers' knowledge and prior experiences of PBL (cf. Appendix D, p.134)

The study's findings regarding the prior knowledge and experience of TVET lecturers about PBL revealed that none of the lecturers who took part had experienced PBL before. The possible explanation is that lecturers may have never used PBL as a teaching and learning method or received no training on PBL. Nevertheless, it is essential to note that they all acknowledged having some understanding of PBL's definition and potential for twenty-first-century education. Therefore, training for professional development could start with the lecturers' understanding of PBL. As an illustration, lecturer B stated: "Students are immersed in real-world scenarios where they must put all the concepts and information they have learned in theory into practice through PBL." But in response, lecturer C said: "PBL is when students work in groups and debate about the problem and sort it out and get a solution." Lecturer D views PBL as "...a method of learning where students solve problems themselves," in line with these responses.

Additionally, he stated that "...the problem must motivate students to seek a deeper understanding of the concepts" to demonstrate his grasp of the PBL concept. In PBL, this suggests that the problem's function is to inspire students to acquire new ideas while resolving the issues. Saqr et al. (2020) supported these findings and claimed that the core tenet of PBL is that knowledge and abilities should be acquired by organizing around a common issue. Therefore, in the context of this study, PBL fosters social learning and represents a lost chance to improve learning and teaching in TVET Electrical Engineering as a whole. Based on the findings of this study, TVET lecturers have a basic understanding of PBL, and each lecturer

has a unique perspective. These lecturers could pool knowledge, exchange, and discuss the benefits of PBL for enhancing their teaching methods by creating a community of practice. Lecturer B, for instance, stated that “students must apply all the principles and knowledge that they learned in theory and practice.” This point of view supports traditional pedagogies, in which students study theory first and practice later. This pedagogical practice does not align with the fundamental principle of PBL (Naji et al. 2020). However, at the heart of successful TVET educational practice, the integration of theory and practice is promoted (Okolie et al. 2022), which makes PBL crucial for the Electrical Engineering program. The TVET lecturers who took part in this study have the potential to effectively use PBL as a pedagogical strategy to improve teaching and learning in their Electrical Engineering classes, provided they receive the appropriate PBL training. This is especially true given that they already have some knowledge and interest in PBL. Implementing PBL in TVET Electrical Engineering education could help the college produce graduates with twenty-first-century skills and competencies, which would benefit industries and graduates alike and contribute to the socioeconomic development of our nation.

5.2 Qualitative findings on TVET lecturers’ participation in communities of practice (cf. Appendix D, p.134)

In terms of the qualitative data gathered from an open-ended semi-structured qualitative questionnaire about TVET lecturers’ involvement in communities of practice, the study’s conclusions showed that there are no communities of practice at various levels. The participants mentioned the absence of practice at the level of subject specialists, TVET college campuses, and the WIL industry. All participants responded in the open-ended questionnaire that they were not involved in any communities of practice. Only when it came to industry work experience did one participant report having previously participated in a community of practice, which he believes adds value to his delivery methods and helps him stay current with emerging technologies and industry trends. Lecturer B gave the following example: “Although I am not currently employed in the industry, my experience level has placed me in a favourable position. The encounter benefited my delivery method and allowed me to stay current with the trends.” Keeping up with industry developments and staying ahead with the new technological advancements are crucial, according to lecturer C. Lecturer C adds that things are moving quickly, so we can’t continue teaching students outdated materials. Lecturer D’s comments further reinforced this: “Having industry knowledge is important because it can help me stay

informed and add value to my teaching practice.” Consequently, it became evident that there was hardly any formal mechanism to deal with learning communities of practice.

Another chance for lecturers to impart their knowledge to stakeholders has been lost. Members of the community of practice can interact with one another through learning communities of practice (Geletu and Mihiretie 2023). Therefore, the development of lecturers' learning communities of practice is critical. Such an establishment could be referred to as ‘iron sharpening iron’ in the context of this study. According to Cojorn and Sonsupap (2023), they can all help each other grow by exchanging teaching experiences, guidelines, lesson designs, peer teaching, reflecting on and improving lesson plans, and more. For instance, in the study by these authors, participants’ confidence in creating interactive classroom learning activities had significantly increased because of their involvement in learning communities of practice, where they could gain valuable insights from the perspectives of others. Lecturers can effectively create interactive learning activities in the classroom that foster social interaction by using these communities of practice. The results of this study suggest that TVET Electrical Engineering lecturers’ teaching practices could be significantly enhanced if they could establish a learning community of practice, especially at the college or subject specialist levels. Enhancing teaching methods is essential in raising the standard of TVET instruction. Therefore, TVET lecturers can participate in curriculum matters and offer their opinions on how the subject should be taught by joining a learning community of practice (Nottingham and Mao 2023). The community of practice’s responsibilities include overseeing curriculum implementation in the classroom and actively participating in curriculum planning to enhance practice (Geletu and Mihiretie 2023). It is important to remember that “iron sharpening iron” should be used to supplement formal professional development rather than as a substitute for it (Nottingham and Mao 2023). Stated differently, this strategy could be employed “to fix the plane while flying.” However, universities and accredited private establishments in South Africa provide formal professional development. Some universities, which are among the few that the Department of Higher Education depends on, are reacting very slowly, while others are keeping quiet about the effort to train TVET lecturers properly. Therefore, establishing collaborative design teams capable of handling curriculum issues is desperately needed, and the quality of TVET education depends on closer collaboration among the various stakeholders.

5.3 Qualitative findings about observations made during TVET classes (cf. Appendix E, pp.136-139)

The primary purpose of classroom observations was to explore lecturers' teaching practices before, during, and at the end of the lesson delivery. The researcher used a classroom observation schedule to observe lecturers' teaching practices. The findings revealed that participating lecturers used traditional teaching methods despite overwhelming evidence that traditional methods fall short of meeting the demands of twenty-first-century learning (Handayani, Amrullah and Apgrianto 2023; Uy, Kilag, and Arcillar 2023). This observation is supported by Uy, Kilag, and Arcillar (2023) and Okolie et al. (2020), who conclude that TVET lecturers used traditional teaching methods. In this study, conventional teaching methods were characterized by the following observations: students in all classes observed by the researcher were seated in rows facing the lecturers and the whiteboards. Students were passive recipients of knowledge from the lecturers doing all the talking.

Vimbelo and Bayaga (2020) refer to such classroom seating arrangements as traditional seating arrangements that have the potential to hinder students' ability to interact with one another. According to Nufus, Muhith, and Sutomo (2023), classroom seating arrangements are crucial for twenty-first-century education. Handayani, Amrullah, and Apgrianto (2023) posit that instructional activities are successful when space is conducive to interactive learning. Thus, classroom arrangements can potentially promote lecturers' and students' interactions. According to Nehyba, Juhaňák, and Cigán (2023), the lesson's purpose determines the seating arrangements. Research outlines various strategies that allow lecturers to promote students' interactions during teaching and learning, such as U-shaped seating, circular seating, semi-circle, and group seating (Handayani, Amrullah, and Apgrianto 2023; Hayashi, Mochizuki and Yamauchi 2023; Nehyba, Juhaňák, and Cigán 2023; Nufus, Muhith, and Sutomo 2023). Papaioannou et al. (2023) add that creative seating arrangements encourage student-centred strategies such as PBL, increasing active participation and engagement. These authors add that open classrooms with soft seating, movable dividers, and adaptable learning areas encourage students' engagement and creativity. Therefore, this study suggests that lecturers' instructions could be changed from lecturer-based to student-centred using creative seating arrangements.

Another crucial observation made by the researcher was that none of the participating TVET lecturers included learning outcomes at the beginning, during, and at the end of the lesson. According to Uy, Kalig, and Arcillar (2023), learning outcomes are crucial foundations for good instruction, motivation, and engagement, especially specific and quantifiable learning outcomes. Possible explanations for lecturers in this study not to include learning outcomes might be that they were teaching students who would take a test the following week. The other

possible explanation might be that the traditional curriculum is content-driven and mainly concerned with what should be taught and what students should accomplish. This approach contradicts research on learning outcomes in giving students a clear path forward and identifying the skills that require development and evaluation (Muller and Hoadly 2019; Uy, Kalig, and Arcillar 2023).

The researcher in this study also explored how these lecturers use real-life examples and available resources while teaching their students. It was observed that lecturers in this study used real-life examples to connect lessons with students' existing knowledge. For instance, lecturer A effectively connected his lesson to earlier research and the power of mathematical content, which could improve students' learning. He effectively illustrated how mathematics can improve students' comprehension of graphical representations. On the other hand, lecturer B used a PHET simulation to simulate electrical components. The simulation allowed him to demonstrate and illustrate the difference between parallel and series circuits. However, he did not allow his students to use their cell phones as a teaching and learning tool even though they were readily available. All the students could do was watch in awe as he demonstrated using his laptop, and by so doing, the lecturer reinforced traditional teaching methods. As for calculations, some were supposed to have been given to students to independently perform calculations on the whiteboards, with lecturer assistance limited to helpful criticism. Therefore, resources could be used as teaching and learning tools if students can use them and not only observe lecturers.

6. Conclusions and recommendations for future research

In conclusion, this study explored the current state of teaching practices among TVET lecturers at a TVET college, highlighting key professional development strategies that can be implemented in the interim while awaiting formal training. One key lesson learned is the importance of fostering collaborative, self-driven growth through the concept of “iron sharpens iron,” where lecturers can create communities of practice to support one another's professional development. Lecturers can share best practices and enhance their teaching methodologies by establishing communities among lecturers and stakeholders like subject specialists, industry experts, TVET colleges, and the Department of Higher Education and Training. This research also revealed a significant gap in using PBL as an effective teaching strategy, particularly in Engineering education, which could greatly benefit from such an approach. Moreover, there

was a noticeable lack of formalized communities of practice that could connect TVET colleges, SETAs, industries, universities, and other training providers. A key recommendation for future studies is to explore ways of establishing robust communities of practice that support the shift from traditional pedagogies to innovative approaches, responding to the 21st-century's learning demands. This transition is essential for improving the quality of TVET education and training. Additionally, future research should investigate the impact of formal and informal professional development initiatives, emphasising informal methods, which are cost-effective and require only a commitment of time and expertise from the lecturers. This study reinforces the notion that the quality of TVET education is directly influenced by the proactive engagement of lecturers, who hold the key to driving improvements through both formal and informal development avenues.

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2.4.2 Article 2 (Published Research Article)

Authors. (2023). Problem-based learning for shifting Technical Vocational Education and Training Electrical Engineering lecturers' practices: A scoping review. Journal of Vocational, Adult and Continuing Education and Training, 6(1):1–16. <http://doi.org/10.14426/jovacet.v6i1.311>

Problem-based learning for shifting Technical Vocational Education and Training Electrical Engineering lecturers' practices: A scoping review

ABSTRACT

Problem-solving capacity is continuously gathering prominence within Engineering Education programmes of most institutions of higher learning. Embracing problem-based learning is necessary for Technical Vocation Education and Training Electrical Engineering lecturers to shift from teacher-centred to student-centred teaching approaches which engage students in the learning process. Despite this, research on the use of problem-based learning in Technical Vocation Education and Training by Electrical Engineering lecturers is limited. In this study, **the researcher** conducted a scoping review to identify key components which are necessary for the effective implementation of PBL in a TVET Electrical engineering programme. The results found that the problem, the facilitator, and the students, are the three components noted as essential constituents vital for the effective implementation of a problem-based learning strategy in the TVET Electrical Engineering programme. The results stress that, in addition to the three components, the type and nature of the problem, including the philosophy of the subject or programme, need to be considered for the inculcation of problem-solving capacities for Technical Vocation Education and Training Electrical Engineering lecturers.

KEYWORDS

Problem-based learning, Technical Vocational Education and Training, electrical engineering lecturer competence, student-centred, teacher-centred

INTRODUCTION

There has recently been a spate of interest in Technical Vocational Education and Training (TVET) globally (Šuligoj & Jerman, 2020; Wattanasin, Chatwattana & Piriyastrawong, 2021) and in South Africa (Blom, 2016; Badenhorst & Radile, 2018; Makhubele & Simelane-Mnisi, 2020; Teis Els, 2021) due to ever-increasing technical and technological advancement. As the development in technology is advancing rapidly, the delivery of an Engineering curriculum becomes more challenging for TVET Electrical Engineering lecturers. Technological expansion requires that TVET Electrical Engineering

lecturers deploy innovative ways of student engagement (Kereluik et al., 2013). It is crucial that TVET lecturers in Engineering devise a pedagogical shift from a teacher-centred approaches to a student-centred pedagogical approach, in which technology is integrated and adopted as a tool to mediate the teaching of 21st-century discipline-specific transformative learning experiences (Teis & Els, 2021). However, literature shows that the majority of TVET lecturers lack innovative pedagogy as well as not possessing ideas on how to shift from teacher-centred approaches to innovative student-centred approaches (Ngubane-Mokiwa, 2013). The likely reason for lecturers lacking ideas and pedagogy is provided by the literature. Most South African TVET lecturers lack teaching qualifications, and more than half have no industry experience (Teis, Els & Tlali, 2022; Bandenhorst & Radile, 2018; Field, Musset & Alvarez-Galvan, 2014; Abiddin & Ismail, 2014). The way these lecturers were sourced also contribute to their inability to apply innovative and transformative-based teaching approaches. For example, some of the current group of lecturers were sourced from industry, or upon graduation from universities or are TVET graduates who have an N6 qualification and as a result, a larger number of them do not have a professional teaching qualification or a qualification relevant to their field of expertise (Teis, Els & Tlali, 2022; Van der Bijl & Oosthuizen, 2019; Paryono, 2015; Field, Musset & Alvarez-Galvin, 2014; Abiddin & Ismail, 2014). Van der Bijl and Oosthuizen, (2019) assert that TVET lecturers, besides having to be professionally qualified, are also required to have subject content knowledge, pedagogy and workplace qualifications , such as trade test or artisan qualifications and workplace experience. Those recruited directly from university and TVET colleges might have the subject knowledge but lack experience and have little or no pedagogical training (Paryono, 2015, Field. Musset & Alvarez-Galvan, 2014; DHET, 2012), particularly vocational pedagogy knowledge. Vocational pedagogy is the science of TVET teaching that prepares students for working life (Lukas & Claxton, 2013) and involves choices, educational theories and teaching approaches (Widiaty & Ana, 2015). Vocational pedagogy is the student-centred approach which affords students the opportunity to be involved actively in the learning process (Šuligoj & Jerman, 2020; Widiaty & Ana, 2015). So, the principal aim of vocational pedagogy is to develop a flexible, competent, and educated individual who can work, create, and have the zeal to engage in continuous personal development (Ronzhina et al., 2017). Lecturers who were recruited to TVET colleges from the school sector are professionally

qualified, yet they lack knowledge of vocational pedagogy. In addition, these lecturers in general, do not have occupational qualifications or workplace experience and this may as a result in a failure to comprehend how to prepare students for employment in the workplace or industry (Van der Bijl & Oosthuizen, 2019; Badenhorst & Radile, 2018; Blom, 2016).

However, the relevance of TVET Engineering lecturers' knowledge is questionable as per research conducted by Manyau (2015) whose study revealed that there is little or insufficient training being provided to lecturers in the Northwest Province, even though the quality of lecturers teaching appears to be low. Surprisingly, Teis, Els and Tlali's (2022) study also established the same trends and they noted that their participants received in-service training which was not linked to the vocational pedagogy. This does not assist the TVET sector in terms of in-service and upskilling of lecturers in pedagogy, in particular vocational pedagogy. Further evidence in support of Manyau (2015) and Teis, Els and Tlali (2022) is provided by the literature (Blom, 2016; Bandenhorst & Radile, 2018; Van der Bijl & Oosthuizen, 2019). Teis, Els and Tlali's (2022) study strongly recommends that the Department of Higher Education and Training (DHET) and TVET colleges should provide lecturers, particularly Engineering lecturers, with relevant skill development programmes to keep them abreast of the current changes in their area of specialisations. Their study also proposes that there should be a philosophical shift from the current Engineering Studies curriculum delivery practices, to include a programme renewal strategy that seeks to stay abreast of rapid technological advancements, and deeper technical and non-technical knowledge. Therefore, it is necessary to have competent and properly skilled TVET lecturers for effective teaching and learning processes in TVET colleges, as the central focus is on equipping students with technical knowledge and skills required by the job market (Ismail et al, 2018). The process of creating improvements in TVET field requires the deployment of professionally qualified, competent, and efficient lecturers to carry out this responsibility (Abdullah, Hoque, Ramlan & Shafee, 2019).

However, as a strategy to improve Engineering studies, the DHET introduced the National Curriculum Vocational (NC(V)) in 2007, which necessitated that the renewal programme to run parallel with the Engineering lecturer professional development programmes. The NC(V) by the nature of its focus on

the learning outcomes, such as identifying and solving problems, dictates that Engineering lecturers shift their teaching and learning practices from teacher-centred to student-centred approaches. Although TVET Engineering lecturers have received in-service training in recent years and research conducted by Teis, Els and Tlali (2022) revealed that Engineering lecturers only received in-service training for courses unrelated to their area of specialisation, particularly that of innovative teaching and learning approaches appropriate to TVET Engineering programmes. Hence, in the South African TVET Engineering programme setting, there is a gap in Engineering lecturers' professional development in terms of the use of innovative student-centred approaches. Failure to fill this gap will compromise the DHET aspirations of producing TVET Engineering graduates who are competent in both technical and non-technical knowledge. One of the emerging innovative student-centred approaches receiving much attention in other disciplines including Engineering, is problem-based learning (PBL). PBL has been emphasised by scholars as an effective method to improve the teacher-centred paradigm as it endorses active learning based on social constructivism concepts (Allen, Donham & Bernhardt, 2011).

The literature demonstrates that South African TVET Engineering lecturers have deficiencies in their teaching capabilities (Badenhorst & Radile, 2018) and lack ideas on how to shift from teacher-centred to innovative student-centred approaches (Ngubane-Mokiwa & Khoza 2016), particularly with regards to PBL. This finding is not surprising as most of the South African TVET Engineering lecturers are not qualified to teach in TVET college settings. It can be assumed in this study that this cohort of Engineering lecturers were not exposed to innovative student-centred approaches during their training as the majority of Engineering lecturers were hired directly as newly qualified TVET college graduates, industry professionals, or that they possess only basic teaching qualifications which are not related to vocational teaching and learning (Van der Bijl & Oosthuizen, 2019). Therefore, it is of the utmost importance that these Engineering lecturers be exposed to innovative student-centred approaches. Chen et al., (2018) postulate that innovative student-centred approaches are a vital way to achieve the learning outcomes of a programme. Based on what is stated above, it can be assumed that TVET Engineering lecturers, particularly those who are teaching on Electrical Engineering programmes, were not exposed to student-centred teaching approaches during their schooling days. Therefore, their lack of exposure

to innovative student-centred approaches has led to a failure to develop in their students, the required non-technical skills, in addition to technical skills. The cornerstone of this study was conducting a scoping review to identify and analyse the key components of PBL that might assist in the design of a PBL intervention to help Engineering lecturers by exposing them to innovative student-centred approaches during an Engineering in-service training workshop. Yet, there are not many studies that have been done to help designers create high-quality PBL situations in the context of South African TVET. Against this background, the purpose of this study was to conduct a scoping review to identify key components of PBL to inform TVET Electrical Engineering teaching and learning practice. The identified components from the scoping reviews could assist the researcher when planning and designing the PBL interventions to expose the TVET Engineering lecturers, particularly Electrical Engineering lecturers, to PBL components during their in-service training. The main aim of this study is to identify and analyse, as well as to understand the key components of PBL and their respective roles during each phase of the PBL process. In this study these key components are regarded as the nuts and bolts of PBL. Subsequently, the research question guiding this study was: ***What are the key components of PBL that need to be considered for successful implementation of a PBL intervention or in-service training programme?***

PROBLEM-BASED LEARNING

Problem based learning (PBL) is a complete paradigm shift toward an innovative student-centred approach whereby students' learning is triggered by a real-life problem, in order to promote problem-solving thinking (Ali, 2019; Sekarwinahyu, Rustaman & Widodo, 2019; Arwatchananukul et al., 2021). Students are motivated to take action and come up with solutions to the issue at hand using this method (Arwatchananulul et al., 2021). They act upon it by identifying and defining the problem, followed by planning the solution and decision-making, after conducting research on their own (Purnamawati Usman & Saliruddin, 2017; Higuera-Martinez, Corazza & Fernandez-Samaca, 2021). Therefore, to resolve the problem, students must make decisions based on their analysis of the alternative solutions that they have uncovered (Wosinski et al., 2018). Hence, the capability of students to identify and define

suitable problems is central to PBL and aligns with the contemporary challenges faced by engineers (Zou & Mickleborough, 2015), particularly TVET Electrical Engineering graduates.

According to Dewey (2008), engineers deal with subject-matter which is practical in nature and are concerned with designing solutions to a problem through the design process. Engineers often design and make artifacts and processes to solve problems based on incomplete knowledge to be applied in a particular environment (Boelt, Kolmos & Holgaards, 2022). This implies that engineers are solution oriented and are often faced with ill-defined problems (De Vries, 2005). Hence, one of the learning outcomes of Engineering education, particularly TVET Electrical Engineering, is to produce graduates who can identify and solve problems in real-life (Department of Higher Education (DHET), 2007). Research indicates that the learning outcomes of the subject or programme can be achieved when approached through real-life problems and issues.

Therefore, PBL aligns well with TVET Electrical Engineering education because it models the way most engineers work in practice (Smith, et al., 2005). Zou and Mickleborough (2015) emphasise that students' ability to identify and solve problems is central to PBL, as it is to Electrical Engineering education. From the goals of the programme, it is evident that the skills associated with the social aspects of Electrical Engineering practice have become a vital aspect of our students' education which PBL claim to provide (Deep, Salleh and Othman, 2019). De Vries (2005) contends that there is a social ingredient in the Engineering programme which implies that future engineers should not only have gained knowledge of technical aspects of their field, but also non-technical aspects, such as problem-solving, collaboration and interpersonal skills. Teaching and learning methods applied in TVET Engineering programmes are often carried out through the traditional four-step approach, that is, describe, demonstrate, try-out and evaluate with feedback (Deep, et al., 2020). Through these methods, students are trained with technical skills, while they lack essential non-technical skills (Deep et al., 2020). Therefore, the application of PBL becomes handy in resolving the issue at hand, as research provides significant evidence of its ability to develop non-technical skills (Anazifa & Djukri, 2017; Tsalapatas et al., 2021; Sousa & Costa, 2022). However, the majority of TVET lecturers are not qualified to teach at TVET colleges and did not have any chance of being exposed to innovative student-

centred approaches, yet they are still tasked to train Engineering graduates who are supposed to have gained both technical and non-technical skills upon graduation. Recent research conducted by Teis, Els and Tlali (2022) shows no sign of lecturers receiving any training during their in-service training, particularly in using PBL. Therefore, the purpose of this study is to conduct scoping review to identify and analyse the key components of PBL and the garnered evidence will be used to design a PBL intervention that could be used to shift the teaching practices of TVET Electrical Engineering lecturers.

THEORY UNDERPINNING PROBLEM-BASED LEARNING

Significant evidence in literature has demonstrated that PBL as a teaching and learning approach works best in a constructivist environment, in particular a social constructivist environment (Sekarwinahyu, Rustaman & Widodo, 2019; Dupri et al., 2020; McQuade et al., 2020; Sousa & Costa, 2020). Social constructivism is based on Vygotsky's view of learning which puts more emphasis on the social environment in which an individual co-constructs knowledge in interaction with the other. Therefore, constructivists emphasise that collaborative learning facilitates students' ability to construct their own knowledge. To constructivists, knowledge construction is achieved as students negotiate social situations and evaluate their understanding. Thus, a constructivist learning environment allows students to take responsibility for their learning, which aligns with what a PBL learning environment could provide (Ulger, 2018; Okolie et al., 2020). Therefore, PBL puts students at the centre of the learning and develops independent thinking skills (Sekarwinahyu, Rustaman & Widodo, 2019). In PBL students work collaboratively in small groups to solve a problem given by the facilitator (Wosinski et al., 2018). Thus, students are provided with the opportunity to experience authentic ill-defined problems as well as collaborative learning formats that require teamwork, collective decision-making, and self-directed learning (Beagon, Niall & Ní Fhloinn, 2019), which is also consistent with social constructivist learning. Collaboration develops skills such as cooperation, negotiation, and communication, which can be useful for students' future and in practical life within a teamwork environment (Ali, 2019; Tsalapatas et al., 2019; Dupri et al., 2020). Students construct knowledge for themselves, make comparisons with their peers' knowledge, debate about the information they have found and learn, and refine their understanding (Alharbi, 2017; Wosinski et al., 2018; Deep, Salleh & Othman, 2019), all of which

support a social constructivist learning environment. Through social interactions, their shared knowledge is reconstructed and validated until a meaningful resolution is reached for the problem at hand (McQuade et al., 2020). Therefore, PBL promotes active and group learning based on the premise that successful learning occurs when students create or co-construct ideas through social experience and self-directed learning (Sousa & Costa, 2020). Sekarwinahyu, Rustaman & Widodo, (2019) posits that PBL commences with the assumption that learning is an active, integrated, and constructive process which is influenced by social factors. Thus, PBL is consistent with constructivist theory of learning particularly social constructivist learning theory.

METHODS

In this study, a scoping review was used to select previous studies related to the implementation of PBL focusing particularly on its key components. Scoping review is a valuable tool used to identify key components in the literature related to a concept under scrutiny that researchers may adopt to report on the kinds of evidence and to inform practice and the way research was conducted (Munn et al., 2018). A scoping review is a kind of knowledge synthesis that addresses exploratory research questions aimed at mapping key components and kinds of evidence, by methodically searching, selecting, and synthesising the available literature (Colquhoun et al., 2014; Chang, 2018). The purpose of conducting a scoping review in this study was to identify key components of problem-based learning with the intention to inform TVET Electrical Engineering education practice (Colquhoun et al., 2014; Munn et al., 2018). Thus, as a means of knowledge synthesis, a scoping review has the potential to influence practice, policy, and research (Colquhoun et al., 2014). However, it is significant to note that a scoping review is less likely to seek to address a specific research question nor consequently to examine the quality of incorporated studies, which might be perceived as one of its disadvantages (Colquhoun et al., 2014; Munn et al., 2018). Therefore, in this study, only peer-reviewed journal articles written in English were included in this study for quality purposes and the manageability of data (Boelt, Kolmos & Holgaard, 2022; Daun, et al., 2022). In this study, peer reviewed journal articles written in other languages were excluded because of the cost and time involved in translating articles from other languages into English. This exclusion was done for pragmatic reasons, and it is worth to note that

possibly relevant peer reviewed journal articles might have been left out because of this exclusion (Arksey & O'Malley, 2005).

DATA COLLECTION

The literature search was primarily aimed at national and international peer-review journal articles published from January 2017 to date. The search was undertaken on EBSCO as the primary database, resulting in a total of 56 studies of which 17 studies were included for thorough qualitative analysis (cf. Figure 1). The EBSCO database was used in this study because it provides access to multiple databases (Gusenbauer & Haddaway, 2020), is reliable and is a credible database which also includes other peer-reviewed journal articles covered by other databases (Oermann et al., 2021). The other compelling reason for using EBSCO was that it does not contain articles in predatory journals (Oermann et al., 2021). However, the EBSCO database included journals that required payment to access them, of which introduced a limitation to this study. In this study, to minimise this limitation, the researcher enlisted the services of a librarian with regards to accessing these articles. The librarian was helpful not only with the access to articles that required payment, but the librarian also during every step of the search process. The search terms for this study included PBL, PBL education, PBL in Engineering education and the implementation of PBL. Alharbi's (2017) process and procedure for data extraction and management was adopted for this study. Thus, during the scoping review, the abstract of each peer reviewed journal article was reviewed to make a judgment about the significance of the journal article to the study, particularly with regards to the key components of PBL, as an inclusion criterion. If the journal article met the criteria, then the citation was copied into a word document called "Draft" that was saved in PBL folder on the desktop. In a few words, comments were generated about the journal article before saving the pdf file in the PBL folder utilizing the last name of the first author if more authors were involved in writing the journal article. Lastly, saved data were exported to a Refworks account. In this study, several methods of managing data were adopted which include, but are not limited to, concept mapping and the use of Microsoft excel. However, if the information in the abstract did not encompass the key components of PBL, then before making decision as to whether the journal article was relevant, the following steps were followed: i) The researcher glanced rapidly at each

paragraph's sentence without attempting to comprehend every word; and ii) read the last paragraph, specifically if it had subtitles such as overview or conclusions. The figure below presents the flow diagram of the data collection procedure.

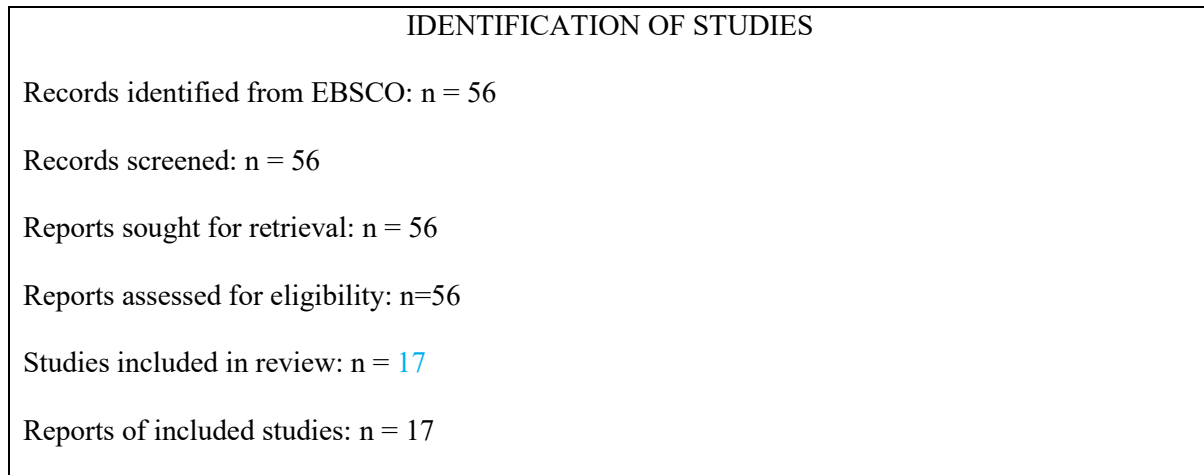


Figure 1: Flow diagram

DATA SYNTHESIS AND THEME GENERATION

Thematic analysis is an approach to qualitative data analysis which involves organising collected data into themes and categorising these to better understand the collected data set (Norton, 2019; Kiger & Varpio, 2020). Thematic analysis is one of the qualitative data analyses used by researchers in qualitative research. The researcher commences by familiarizing himself with the data set which entails repeatedly and actively reading through the articles included, which provided a valuable orientation to the data set. The researcher then undertook a preliminary synthesis to derive the broad themes inductively, which involved searching for the key components of PBL in the included articles. The choice of using thematic analysis was based on the purpose of the study based on Kiger and Varpio's (2020) assertions. The examination of repeated terms or concepts, concepts with closely linked meanings, text manipulations using cut and sort, and, in certain cases, text being highlighted with different colours for each topic, were all employed in this study to find themes in the data. After taking into considerations the core words in the research question, and going through the whole data sets accordingly, three main themes emerged, namely, the problem, the facilitator or tutor, and the students. Subsequently, sub-themes also emerged as shown in Table 1.

FINDINGS

Through qualitative data analysis, a plethora of components of PBL have been highlighted within the included studies. The selected studies were examined again to determine whether the highlighted components were included in each article. After extensive analysis, the final selection of PBL components is as presented in the table below.

Table 1: Key components of PBL and their respective sub-themes

PROBLEM	TUTORS/FACILITATORS	STUDENTS
Ill-structured	Scaffolding	Small group learning
Complex	Guiding questions	Team dynamics
Ill-defined	Prompts	Team learning
Contextual	Guide	Collective student engagement
Ill-structured	Provides problems	Dialogue
Not structured	Asking questions	Teamwork
Appropriate scenarios	Facilitating investigation	Student-regulated learning
Authentic	and dialogues	Peer support
Hypothetical scenarios	gives advice	Social interactions
Problematic situation	task setter	Collaborative learning
Shared problems	project supervisor	Groupwork
Open-ended	provides resources	Small group teaching
Issues	facilitator-student interaction	Group discussions
Student-driven	demonstration	Self-regulation
Role of the problem	managing behaviours	Small groups
	teacher-student dynamics	Role of students
	role of tutor	Active participation
		Reflection
		Evaluation

DISCUSSIONS

The findings revealed that the problem is a prominent component of PBL that initiates the interaction between the other two components namely, the tutor and students, using well-designed real-life learning activities. However, the design of these learning activities is not an easy task as many factors must be considered during the design of the learning activities, in order to foster the attainment of the desired learning outcomes. These factors include but are not limited to the type and the nature of the problem (Ali, 2019; Adamuthe & Mane, 2020; Naji et al, 2020; Du et al., 2021; Chan et al., 2022), particularly in relation to the open-endedness and real-life applications, and the nature of the subject or the programme (Zhao et al., 2020). Further evidence in support of the importance of these factors in the design of the learning activities is provided by Century, Ferris and Zuo (2020) and McQuade et al., (2020). These studies pinpointed the critical factors that the designer of PBL can use to shift TVET Electrical Engineering lecturers' practices from teacher-centred to student-centred. Besides the above mentioned factors, the other factor to be considered is that learning activities must be designed to focus on professional skills, as failure to do so might lead to lack of opportunities to develop a particular graduate attribute (Beagon, Niall & Ní Fhloinn, 2019) .

This study also found that the focus of PBL and the role of the problem must be made explicit during the design of the learning activities. Designers who explicitly understand the focus of PBL can design an effective learning activity with a clearly established purpose statement. The role of the purpose statement is to enable students to know what they are going to learn and how they will be expected to demonstrate their understanding of the learned content and non-technical skills (Frey & Fisher, 2011). Therefore, designers of PBL activities should be clear about the purpose of the learning activities. Frey and Fisher (2011) posit that by establishing a clear purpose statement, designers make their expectations for learning clear to their students. Thus, learning becomes visible to students and their motivation to learn can improve as well. The purpose statement makes connections between the learning activities and the role of the problem, thus making learning meaningful and relevant to students. From the focus of PBL and the nature of the subject, a well-established purpose statement can be crafted. Research indicates that the focus of PBL is to develop students' problem-solving skills through the application

of acquired content, but not the teaching of content (Adamuthe & Mane, 2020; Okolie et al., 2020). This is in line with the nature of the Electrical Engineering programme, namely the National Vocational Curriculum: Electrical Systems and Construction, which has one of its learning outcomes being to identify and solve the problem. It can be concluded in this study that the design of authentic learning activities relies on the type and nature of the problem, its appropriateness to the nature of the subject or programme, and a clearly established purpose for the learning activities. The conclusion above is supported by literature (Beagon, Niall & Ní Fhloinn, 2019; Naji et al., 2020).

The second key component of PBL is the critical role played by the lecturers who serve as a facilitator of learning during different stages of the PBL process. This finding is also supported by literature (Anazifi & Djakri, 2017; McQuade et al., 2020; Trullàs et al., 2022). These findings imply that the role of the facilitator during each phase of the PBL must be clearly stated during the design of the PBL learning activities. Research indicates that facilitators play different roles during each phase and also throughout the learning process (Anazi & Djakri, 2017; Beagon, Niall & Ní Fhloinn, 2019; Adamuthe & Mane, 2020; McQuade et al., 2020). For PBL to be effectively implemented, facilitators must wear different hats relative to each PBL stage while considering the purpose of the PBL learning activity. Therefore, it is crucial that the stages of PBL be identified during the planning process of the learning activities, which enables facilitators to organise their roles appropriately in a flexible manner. For example, what is the role of the facilitators, before students receive the learning activities, during problem analysis and reporting and during the reflective writing process? Proper planning and the deployment of appropriate roles during each stage of the PBL could contribute positively to the successful implementation of PBL that might lead to students achieving the learning outcomes of the subject or programme. The importance of facilitators' roles during each stage of the PBL is also supported by literature (Anazifi & Djakri, 2017; Beagon, Niall & Ní Fhloinn, 2019; Trullàs et al., 2022). The efficient fulfilment of facilitators' roles leads to the successful implementation of the PBL. This is also supported by Okolie et al., (2020) who posit that the successful implementation of PBL relies solely on the facilitators' competencies and capabilities in fulfilling students' attainment of the learning

outcomes. Therefore, it can be concluded that assigning the role of the facilitator during each stage of PBL is crucial for the success of the PBL and enables the facilitator to plan and act accordingly.

The last but not least of the components of PBL, is that designers of PBL learning activities should consider that students should actively engage with the learning activities in PBL environment through facilitated sessions. The role of students and what is expected from them should be made visible before the commencement of the PBL learning environment. One of the key roles of students in PBL environment, is to form small groups before they collectively engage with their learning process. The goal of group sessions is to facilitate the identification of problems or problematic situations, through social interactions (Trullàs et al., 2022). Through social interaction, students share knowledge, participate collaboratively, and contribute initiatives and ideas during group discussions (Naji et al., 2020; Du et al., 2021). Therefore, the students' active participation and the quality of small group interaction is of critical importance for the success of PBL, supporting collective and social construction of knowledge. The findings reveal that small group learning modes encourages student-student and teacher-student communication during the learning process. This finding is supported by literature (Century, Ferris & Zuo, 2020; McQuade et al., 2020; Naji et al., 2020). Therefore, the key ingredient for the successful implementation includes the learning and social environment, and self-regulated learning coupled with an active, engaged student working in small groups to construct and apply knowledge while exploring solutions to real-life problems (Wosinski, 2018; Du et al., 2021). However, the effective implementation of PBL, the role of group and the role of the student must be made explicit in all PBL tutorial sessions. That is, what is the role of student and small groups during the first PBL sessions, during self-study, during the second PBL sessions and during group presentations. If the roles of the student and small groups are explicitly established and followed without deviations, TVET Electrical Engineering lecturers' practices can be shifted from teacher-centred to student-centred. Thus, TVET Electrical Engineering lecturers could be motivated to adopt PBL as their new teaching and learning strategy. As a result, their adoption of PBL might result in their teaching and learning practices being shifted from teacher-centred to student-centred approaches. The adoption of PBL by TVET

Electrical Engineering lecturers could make significant contributions to their classroom practices and help their students acquire the desired non-technical abilities that are valued by contemporary industries.

CONCLUSION

The identification and understanding key components of PBL and their roles in accordance with each stage of the PBL process is of utmost importance for the success of PBL. In this study, three key components of PBL were revealed during the scoping review. Besides the three identified key components of PBL, this study also revealed other crucial factors that contribute to the successful implementation of PBL as a teaching and learning strategy. Therefore, the consideration of these factors when planning the design of PBL intervention is essential to the success of the PBL. The focus of PBL as a teaching and learning strategy, the type of PBL, the nature of the subject or program and its underlying philosophy, and lastly the competencies of facilitators who will be supporting students' learning are essential considerations for PBL intervention designers. These findings imply that, before designing a PBL intervention, the designers should seek to establish the alignment between the focus of PBL and the learning outcomes of the subject or programme. It is recommended in this study that designers of PBL interventions should first seek to understand the nature of the subject and the philosophy underpinning it, followed by establishing the focus and purpose of PBL as a teaching and learning approach. Lastly, designers of PBL should ensure that there is an alignment between PBL and the learning outcomes of the subject or programme. According to this study, it is strongly advised that facilitators who work with PBLs, obtain the proper PBL training so they may carry out their duties admirably and make a substantial contribution to students' learning. It can be concluded in this study that while the three key components of PBL identified in the literature and their roles during each stage of the PBL stages are crucial for its success, it is of equal importance to consider other factors that this study uncovered. Therefore, the design of PBL intervention has to acknowledge the existence of other factors which are also crucial in the successful implementation of a PBL intervention. Further research is required to determine how TVET Electrical Engineering lecturers felt about how a PBL intervention helped them change the way they approached their teaching methods, which PBL component was most important, and at which stage of the process.

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2.4.3 Article 3

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Topic

A Professional Development Framework for South African TVET Electrical Engineering Lecturers to Effectively Implement Problem-Based Learning

Abstract

Purpose: This study explored the adoption and implementation of Problem-Based Learning (PBL) in TVET Electrical Engineering education, aiming to explore lecturers' perceptions of the program's nature and learning outcomes, the challenges hindering PBL adoption, and the design of a framework for the continuous professional development (CPD) of Electrical Engineering lecturers.

Methods: The study employed a qualitative approach, analysing four lecturers' views on PBL, its challenges, and its potential impact on student learning. The research also utilized Kurt Lewin's theory of planned change and John Heron's dimensions of facilitation styles to frame the process of adopting PBL in the four participating TVET classroom settings. A framework for CPD in TVET Electrical Engineering was developed based on the findings.

Findings: The study found that PBL encourages active, collaborative, and self-directed learning while integrating theory with practical application. However, lecturers faced challenges in relinquishing control over the learning process, which created resistance to adopting this student-centred approach. The study further finds that the apprenticeship teaching and learning strategy embedded in TVET teaching may be its single most opponent for PBL. The study also identified the need for structured CPD programs to help lecturers overcome these challenges and shift their teaching methods.

Conclusion: The research concludes that successfully adopting PBL in TVET Electrical Engineering requires a well-planned, structured approach to lecturer development. Continuous professional development programs are crucial for shifting lecturers' beliefs and teaching practices, enabling the effective implementation of PBL, and enhancing the quality of TVET education by fostering industry-relevant skills and innovative teaching methodologies.

Keywords: Continuous Professional Development, Electrical Engineering, Kurt Lewin's Theory of Change, Self-directed learning, TVET education.

1. ORIENTATION AND RESEARCH OBJECTIVES

To meet the complex challenges of the twenty-first century, electrical engineers need professionals with various skills, knowledge, and qualities (Mitchell et al., 2021). Problem-based learning (PBL) has become a very successful teaching and learning strategy for giving students the essential engineering skills they need in response to these changing demands (Gumartifa et al., 2023; Van Barneveld et al., 2012). PBL is distinguished by its student-centred approach, emphasis on open-ended problems, and active student participation in resolving real-world problems (Hung, 2009; Li et al., 2019). According to these authors, PBL is a dynamic, integrated process that is impacted by a range of social and contextual factors rather than merely being a method of instruction. Furthermore, PBL promotes active and collaborative learning, according to Sousa and Costa (2022), who base this on the notion that deep learning happens when students collaborate to develop and hone ideas through social interactions and

Self-Directed Learning (SDL). PBL is intended to increase the relevance and impact of students' learning by immersing them in real-world issues that correspond with curriculum objectives (Gumartifa et al., 2023). By fostering an engaging and encouraging learning environment, PBL addresses prevalent matters in education, such as low student engagement and tense relationships between lecturers and students. However, PBL is a sophisticated pedagogical model that calls for lecturers, particularly those unfamiliar with this cutting-edge method, to acquire a wide range of skills (Goodnough, 2006). Facilitation is a crucial ability for PBL to implement successfully in electrical engineering education. Because PBL necessitates a change in power dynamics and involves students actively directing their learning, lecturers may find it challenging to shift from a traditional knowledge provider to a learning facilitator (Wilkie, 2004). The more dynamic, student-centred PBL approach and conventional, teacher-centred methods frequently clash due to this change (Bound, 2011).

Additionally, lecturers' preconceived notions about teaching and their ease in assuming new pedagogical roles have long been called into question by implementing PBL (Okolie et al., 2020; Errington, 2004). It emphasizes that instructors' choices to accept or reject PBL are impacted by both their convictions and the available resources. As the gap between the planned reforms and the current procedures grows, implementing a new strategy may cause conflict (Engeström, 2001). PBL adoption may also be hampered by reorganizing classroom procedures and altering the lecturer's roles in the learning process (Du et al., 2020). The beliefs, self-assurance, and motivation of lecturers significantly impact their readiness to implement PBL (Al Said et al., 2019; Sabah & Du, 2018).

The effectiveness of lecturers' implementation of PBL depends on their training and level of involvement in the process. For lecturers to effectively cultivate their students' 21st-century skills, they need to be proficient in PBL methodologies and possess these competencies (Suwastini et al., 2021). Having received adequate training, lecturers are better equipped to modify their methods to suit the needs of their students. This aligns with Lotter et al. (2020), who discovered that lecturers' content knowledge and inquiry-based teaching improved after attending professional development programs with a PBL focus. Also, in these authors' study, lecturers reported changing their views on teaching, becoming more reform-based and student-centred.

Providing ongoing professional development opportunities for lecturers through focused training programs emphasising industry-relevant skills and modern teaching methodologies

can significantly improve the quality of TVET education, especially in Electrical Engineering (Charles et al., 2023). According to Bound (2011), a learning process within an organization that promotes institutional change should include effective professional development. Therefore, lecturers in Electrical Engineering who pursue ongoing professional development can change their teaching philosophies and embrace new approaches like PBL (Du et al., 2020). However, it can be challenging to implement change, particularly in hierarchical organizations where ingrained behaviours might oppose novel approaches (Adelman-Mullally et al., 2023). Therefore, careful management and a clear vision are necessary to successfully transition from the current state to a more progressive one (Tran & Gandolfi, 2020).

To build on these insights, this study uses John Heron's (2006) dimensions of facilitation styles, which outline various approaches to lecturer facilitation, in conjunction with Kurt Lewin's (1947) theory of planned change, which has three stages. TVET is, as Hiim (2020) and Mbangwu et al. (2020) mention, a structured approach to education and training intended to give students the know-how and abilities required for successful work. The three goals of this study are to be considered in this context.

Therefore, the study aims to explore the perceptions of TVET lecturers regarding the nature and learning objectives of an Electrical Engineering program and compare them with the program's actual learning objectives. According to Mulaudzi et al. (2023), TVET lecturers' professional development should include teaching problem-solving techniques after a solid understanding of the program's philosophical underpinnings. The study also explored difficulties lecturers could encounter when embracing and using PBL and suggested ways to overcome these barriers. Finally, researchers developed a framework for a short learning program that will improve the ongoing professional development of TVET Electrical Engineering lecturers by focusing on the successful adoption and application of PBL in their classrooms. This was done based on a deeper understanding of the nature of Electrical Engineering education and its learning outcomes.

2. THEORETICAL FRAMEWORK

2.1 Principles of Problem-Based Learning

PBL's central tenet is that the subject matter and skills to be learned are structured around real-world problems (Saqr & López-Pernas, 2023). As a result, problems, not theory, serve as the starting point for learning in PBL (Golightly, 2018; Hallinger & Bridges, 2017). According to

Hallinger and Bridges (2017), using these problems as a starting point suggests that when PBL is employed as a teaching and learning strategy, the curriculum units are structured around problems or issues rather than subject disciplines. The subject's goal can be approached through problem-centred curriculum units through real-world issues and circumstances (Cobos-Torres et al., 2020). According to Khoon (2018), the purpose of PBL activities or scenarios is to assist students (in this case, TVET Electrical Engineering lecturers) in determining their learning needs as they try to comprehend the problem, work together in groups, gather and locate information, synthesize, and apply strategies to solve the problem. PBL thus offers the framework that encourages active group-based learning, as TVET Electrical Engineering lecturers will use Self-Directed Learning (SDL) and social experience to co-construct or construct ideas (Sousa & Costa, 2022). The PBL context is frequently intricate and poorly organized (Hung, 2016; Kolmos et al., 2021; Tan & Tee, 2021). This intricacy is consistent with the real-world engineering problems that engineers encounter, which are usually so intricate and bound by context that students must work together to solve them systematically (Kolmos et al., 2021). Thus, rather than being well-structured, the problem in PBL is ill-structured (Kolmos et al., 2021; Tan & Tee, 2021). According to Jonassen (1997), ill-structured problems are characterized by several factors, including but not limited to being vague, having multiple plausible solutions, and being unclear about the concepts or principles required to solve the problem. Conversely, problems with a clear structure have a single, definitive solution, well-defined objectives, and prescriptive arrangements of concepts and principles. Okolie et al. (2020) state that poorly structured problems allow students to combine theory and practice and build their learning. Arwatchananukul et al. (2021) and Higuera-Martínez et al. (2022) state that PBL environments encourage problem-solving by having students define a problem or identify a challenge and then plan a solution after conducting the necessary research. The PBL approach, which is founded on guided self-learning, transfers the learning process from teachers to students (Trullàs et al., 2022). Notably, PBL involves facilitating open-ended sessions involving students in solving real-world problems with no one correct response or solution (Golightly, 2018). Even when PBL emphasizes students exploring issues, facilitated sessions suggest that students are not the only ones involved. Thus, PBL is guided learning (Masek, 2019).

2.2 Problem-Based Learning Process

SDL skills can be developed, and problems or issues can be approached in an organized manner with the PBL process (Malan & Ndlovu, 2014). This methodology is beneficial because study

participants, i.e., TVET Electrical Engineering lecturers, would be more conscious of the applications of their newly learned material (Hallinger & Lu, 2011). A small, manageable grouping of lecturers is necessary before introducing them to the PBL process (Golightly & Raath, 2015; Ravindranath et al., 2016) to obtain instruction and training regarding the PBL processes and tenets. During these training sessions and orientation, lecturers receive notes about the PBL process, and expectations are made clear (Al-Drees et al., 2015; Ravindranath et al., 2016). Lecturers are given information about pertinent websites that could be used as learning resources and an explanation of effective group processes during the orientation and training period (Golightly & Raath, 2015). The basic process of PBL is as follows: Teams of TVET Electrical Engineering lecturers are given an authentic, complex, and unstructured problem with multiple interconnected factors and multiple solution pathways. This helps to anchor individual skills to a more significant and valued goal. For TVET Electrical Engineering lecturers, the following is a typical example of an unstructured PBL problem.

An Electrical System and Control student in one of your classes asked you the following question:

“Sir is it possible that you can be given two resistors, one known and the other unknown and be asked to determine the total resistance of the circuit”.

The student's question above is poorly structured because it is imprecise. It includes several unknown problem elements, possible solutions, and uncertainty regarding the ideas or principles required to address the student's issue. The task for TVET Electrical Engineering lecturers should be to define the problem and determine what they believe to be pertinent to it. They must also decide how they will learn and what they need to know. Finding the circuit's total resistance in this situation is challenging because there are two resistors, one known and the other unknown. Electric resistance is covered in the curriculum unit. The problem statement lacks specificity because it does not specify how the two resistors are connected. Do they have a series or parallel connection? It's unclear if the unidentified resistor has colour coding. Several approaches could be taken to solve this problem, assuming the following: If the unknown resistor is colour-coded, its value can be ascertained by selecting the connection mode after reading the values from a colour-coded resistor. The total resistance can be found if the two resistors are connected in series or parallel. The resistance of the unknown resistor can also be measured with an Ohmmeter if not colour-coded. After you know the unknown value, apply the parallel and series techniques. If fundamental electrical components are available, connect the circuit to a DC power source, connect the two resistors in series or parallel, and measure the circuit's overall current using an ammeter. By connecting both resistors to a power source,

the total resistance of the entire circuit can be calculated using Ohm's law without even knowing the value of the unknown. TVET Electrical Engineering lecturers can also use the PHET simulation application software to simulate the circuit above using their cell phones in the absence of actual electric components. The total resistance can also be measured using an Ohmmeter in both cases, eliminating the need for the formula for parallel and series circuits. With multiple solutions and several unknown problem elements, it is evident from the above explanation that the PBL scenario is poorly structured.

TVET lecturers should identify learning gaps and learning issues. The generated learning problems will also be used as a guide for independent research or self-study (Malan & Ndlovu, 2014; Moust et al., 2001) between the PBL tutorials. According to Al-Drees et al. (2015) and Carrió et al. (2016), TVET Electrical Engineering lecturers should conduct independent literature searches to pinpoint learning problems during self-study. They then present their findings to the rest of the team at the subsequent PBL tutorial. During this session, lecturers in TVET Electrical Engineering could develop solutions using both their previously learned material and newly acquired knowledge. To improve their abilities and skills, lecturers are asked to assess their PBL experience, learning, and teamwork at the end of the process (Litzinger et al., 2011). According to Naveh et al. (2022), this type of learning is called learning through activity, i.e., gaining knowledge by solving problems. Throughout the PBL tutorial sessions, lecturers will be guided by an experienced facilitator to help them accomplish their objectives and facilitate transition (Galajda, 2012; Masek, 2019). Heron's three modes of facilitation were incorporated into the seven-step PBL process to help with the transition (cf. Table 1).

3. HERON'S DIMENSIONS AND MODES OF FACILITATION

Learning, especially student-centred learning, is essentially a social activity in which groups gain knowledge through social interactions and peer learning (Qui et al., 2023). Learning from peers and learning from facilitators coexist in actual classroom environments. Peer learning, however, does not meet students' learning needs (Qui et al., 2023). Particularly when PBL is employed as a teaching and learning technique, students require the assistance of facilitators to meet their learning objectives (Masek, 2019). Qui et al. (2023) state that facilitators play a crucial role in directing peer learning and caution that an unduly controlling style may prevent students from interacting with their peers meaningfully. As a result, when facilitating the learning process during PBL, facilitators should balance their actions. Heron (2006) developed

the Modes and Dimensions of the Facilitation Model to guide the facilitators' actions and behaviours during the student-centred learning process. This model is appropriate for various educational fields, particularly student-centred learning approaches (Masek, 2019). This author asserts that Heron's model has three modes of facilitation: autonomous, cooperative, and hierarchical.

Regarding the three modes of facilitation, the facilitator guides students' learning by exhibiting various behaviours and actions based on the classroom setting. Accordingly, an effective facilitator must be adaptable and capable of switching between different facilitator roles depending on the circumstances (Galajda, 2012). According to this author, a facilitator is considered competent and effective in their role if they can use all three modes at the same time while adhering to predetermined educational scenarios. Lecturers can establish a dynamic and adaptable classroom by coordinating these facilitation techniques with the seven-step PBL process.

As a result, Table 1 highlights the facilitator's actions and behaviours within each of Heron's (2006) three modes of facilitation and successfully combines them with the seven-step PBL process. In this regard, PBL is a driving force behind the shift in teaching methods TVET Electrical Engineering lecturers use from conventional teacher-centred models to more dynamic, student-centred approaches. Although these modes of facilitation are interrelated and reinforce one another, it is important to remember that their implementation needs to be context-sensitive (Masek, 2019).

For facilitators to meet the diverse needs of their students, they must be skilled in using all three facilitation modalities. According to Masek (2019), facilitators should modify their strategy based on the situation and the participants' comfort level with PBL. For example, when students are new to PBL, the facilitator may assume complete control of the learning process in the hierarchical mode. As an equal partner, the facilitator guides and participates in the learning process with the students in the cooperative mode. In autonomous mode, the facilitator takes on a more supportive role, managing agreements, supervising the learning process, and encouraging students to take charge of their education. The transition of students from passive information consumers to active participants in their education is guaranteed by this dynamic range of facilitation.

As shown in Table 1, the facilitator's function as a change agent during the second stage of Lewin's theory of planned change is reinforced by the smooth integration of the three facilitation modes with the seven-step PBL process. Facilitators must model all three modes to encourage TVET Electrical Engineering lecturers to embrace PBL successfully. This will create an atmosphere where lecturers can see firsthand how these techniques can boost students' confidence when unfamiliar with student-centred learning approaches.

Facilitators must be adaptable in how they apply these modes, modifying their strategy based on classroom dynamics. In addition to promoting PBL's uptake, this adaptability is necessary to guarantee that it works as a teaching method in changing TVET lecturers' pedagogical viewpoints from teacher-centred to student-centred models. Further supporting this transformation process is the framework of Lewin's theory of planned change, which offers the conceptual underpinnings for directing and maintaining the change in teaching and learning methods.

Table 1: The 7-step PBL process and the three modes of facilitation

PBL process tutorial and steps		Modes of facilitation and action of the facilitator		
Tutorial session 1	Steps	Hierarchical	Cooperative	Autonomous
	1. Clarify terms and concepts	The facilitator acts on behalf of the group, oversees planning and arranging the learning process, and is responsible for managing the group's feelings and all learning dimensions. The facilitator has the final say throughout all the five steps of the PBL process.	The facilitator is the guide and shares knowledge and experience with the group members. They work together on planning and structuring the learning process. All decisions are worked out through negotiation as the facilitator only shares their influence, not the final say.	The facilitator gives the space for groups' self-determination and self-directed practice. Students are free to find their own way of dealing with things, resistance to group problems and planning and structuring their learning process.
	2. Define the problem.			
	3. Analyze the problem.			
	4. Discussion			
	5. Formulate learning issues.			
Out-of-classroom individual research	6. Self-study: Individual study and own research. There is no facilitator involvement.			
Tutorial session 2	7. Discussion of newly acquired knowledge.	The facilitator does everything for the group members.	The facilitator does it with group members.	The facilitator gives control of all the steps of the PBL process to the group members, manages the agreement, and monitors their progress.

4. LEWIN'S THEORY OF PLANNED CHANGE

Adelman-Mullally et al. (2023) state that altering people's daily routines is difficult and necessitates moving away from what seems natural and toward an uneasy state of uncertainty. In this case study, PBL as a teaching and learning method may cause discomfort for TVET Electrical Engineering lecturers unfamiliar with PBL. These authors have suggested that

preparing participants for the change and using shared governance to shape its implementation is essential. According to these authors, how changes are communicated and carried out impacts creating enduring memories. It takes careful navigation from the current state to the desired state for change to be successful. The researcher adopted Kurt Lewin's (1947) theory of planned change to address the new normal and guide the planned change process. The researcher chose Lewin's theory of planned change for three reasons, which were also noted by Tran and Gandolfi (2020). Firstly, Lewin's theory of planned change creates a lasting change for the unfreeze stage, giving the curriculum leader or training facilitator a specific amount of time to reflect. Secondly, Lewin's theory of planned change is easily implemented into the study's context, i.e. one of the key elements of PBL on the anticipated outcomes and makes appropriate adjustments to reach objectives. Thirdly, the methodical approach generates the impetus required for change since once a change is recognized and its urgency perceived, the degree of acceptance is raised. Three well-known phases or steps that make up Lewin's planned change model are unfreezing, change, and refreezing (Adelman-Mullally et al.,2023; Caldwell, 2023).

Burke and Litman (1992) further simplified the three stages as follows: unfreeze (accepting the need for change), change (transition to change), and freezing new ideas. The purpose of this study is to unfreeze the present views and beliefs of TVET Electrical Engineering lecturers regarding education and learning. i.e., changing the method of instruction from one that is teacher-centred to one that is student-centred. As a result, the researcher seeks to unfreeze the participants in this study who were anticipated to change (i.e. TVET lecturers in Electrical Engineering) to bring about some flexibility in the situation so that it progresses toward change (Endrejat & Burnes, 2024). According to Tran and Gandolfi (2020), the three-stage model of planned change characterizes the current state as the status quo, with the suggested change process that progresses through three necessary stages to the desired future state. According to these authors, confrontation or re-education through team building is necessary for the first stage of the current level (unfreeze). The organization's fundamental principles and values will serve as the foundation for the decisions made at this point. For instance, as seen in their individual classrooms, TVET Electrical Engineering lecturers continue to employ conventional teaching and learning strategies in the current study. TVET Electrical Engineering lecturers must comprehend what needs to be unfrozen before true unfreezing can occur. Some of the questions that need to be asked during this stage are: What values underpin the old methods, such as traditional approaches? How did these methods contribute to harmful or outdated

practices and the state that we are in today? This is necessary to ensure that TVET Electrical Engineering lecturers support the change and that everyone agrees on the reasons for the change and the values, beliefs, and procedures that need to be changed. Endrejat and Burnes (2022) assert that Lewin held that change is an active process that requires active participation from those who are expected to undergo it, aligning with the PBL principle, which encourages active involvement through its collaborative and social aspects. In summary, the TVET curriculum managers should determine the need for change, inform the TVET Electrical Engineering lecturers, and assist them in comprehending the rationale behind the change during the unfreezing stage.

To advance to the second stage, one must adopt new attitudes, values, and behaviours (Burke & Litman, 1992; Tran & Gandolfi, 2020). At this point, a well-defined strategy needs to be implemented (in this case, PBL) and shared, and the change needs to begin to take effect. This change needs to happen quickly, and everyone involved needs to be able to explain its how and why. During the transition phase, the TVET College should train TVET Electrical Engineering lecturers on the new teaching methodology, in this case, PBL. TVET Electrical Engineering lecturers would be moving toward a new method of teaching and learning at this point, which researchers saw as a process rather than a step. The change agents must keep reminding TVET Electrical Engineering lecturers of the purpose of the change and its advantages throughout this phase.

In the third phase, to guarantee safety, unfreezing aims to stabilize the organization in a new, balanced state (Tran & Gandolfi, 2020). Determining how long the change will persist throughout the organization depends on this phase. For example, implementing practices that ingrain the change into the organization's mindset and behaviours is necessary if long-term change is desired. For future lecturers of the organization to adopt the changes, TVET Electrical Engineering lecturers should modify the study materials and textbooks that do not support PBL as a teaching and learning approach. During the refreezing phase, TVET college leaders should support the use of PBL classrooms by TVET Electrical Engineering lecturers. They should oversee its efficacy and offer continuing assistance and training to guarantee its continuous success. Therefore, any changes made, such as the PBL approach, are institutionalized during this phase. Its goal is to ensure that lecturers of TVET Electrical Engineering feel secure and at ease with the new method of operation, i.e. PBL instruction.

5. RESEARCH DESIGN AND METHODOLOGY

This section outlines the research design and methodology used for this study. It provides information related to the research site, the sample of participants, ethical considerations, and the data analysis technique utilized.

5.1 Design and Methods of Data Collection

The study's methodology was a qualitative case study. Two qualitative data collection methods were used to gather the data: an open-ended, semi-structured qualitative questionnaire (cf. pp.131-135) and document analysis of the Electrical Engineering program, specifically the learning outcomes of the National Curriculum Vocational [NC:(V)]. The research had three objectives. Firstly, the researcher explored TVET Electrical Engineering lecturers' perceptions of nature and the learning objectives of an Electrical Engineering program. As indicated by the subject assessment guidelines, the researcher also looked at the learning objective for Electrical Systems and Control. Secondly, the study looked at several obstacles preventing lecturers from using PBL as a teaching and learning method and how to get past them. Thirdly, the researcher developed a training framework (cf. pp. 90-93) for a short learning program meant for the ongoing professional development of TVET Electrical Engineering lecturers on successfully adopting and implementing PBL as a pedagogical approach in their classrooms. This was done by drawing on the researcher's understanding of the nature of Electrical Engineering and its learning outcomes and challenges.

5.2 Research Site and Sample of Participants

The researcher specifically chose one TVET College campus in the Free State Province to serve as the site of the qualitative case study. Perspectives and practices of TVET Electrical Engineering lecturers served as the unit of analysis. This TVET College was chosen for logistical reasons as well as the fact that it offers an Electrical Engineering program that includes both the National Curriculum Vocational [NC:(V)] and the NATED programmes (N-courses). The qualitative case study approach enabled the research to generate data from the four participating TVET Electrical Engineering lecturers who voluntarily participated. The four participating Electrical Technology lectures provided sufficient perspectives that informed the research. Their Electrical Technology classes were independent case studies from which rich data were generated.

5.3 Ethical Considerations

Official approval was received from the TVET College's management, and ethical clearance [UFS-HSD2022/2018] was given by the University of Free State's Research Ethics Committee (cf. p.124). The study was voluntary and anonymous, and participants were informed of their right to discontinue participation at any point during the investigation. In addition to being informed about the nature and goal of the study, participants received respectful treatment. Each participant permitted the researcher to gather, examine, and report the results by filling out and signing an informed consent form. The time and dates for data collection were set up so as not to conflict with TVET College's regular academic operations.

5.4 Thematic Data Analysis

The collected qualitative data from document analysis and an open-ended, semi-structured qualitative questionnaire were analysed thematically. This paper focuses on document analysis and open-ended, semi-structured questionnaires (cf. pp. 131-135). The visual representations of the qualitative data were created by grouping and organizing them into related data themes. The following figures provide valuable insights into the perspectives of TVET lecturers regarding various aspects of the National Certificate (Vocational) [NC(V)] program. Figure 1 outlines the data themes associated with the learning outcomes of the NC(V) program as identified by TVET lecturers. These themes reflect the key areas and skills lecturers believe are essential for students' success in vocational education.

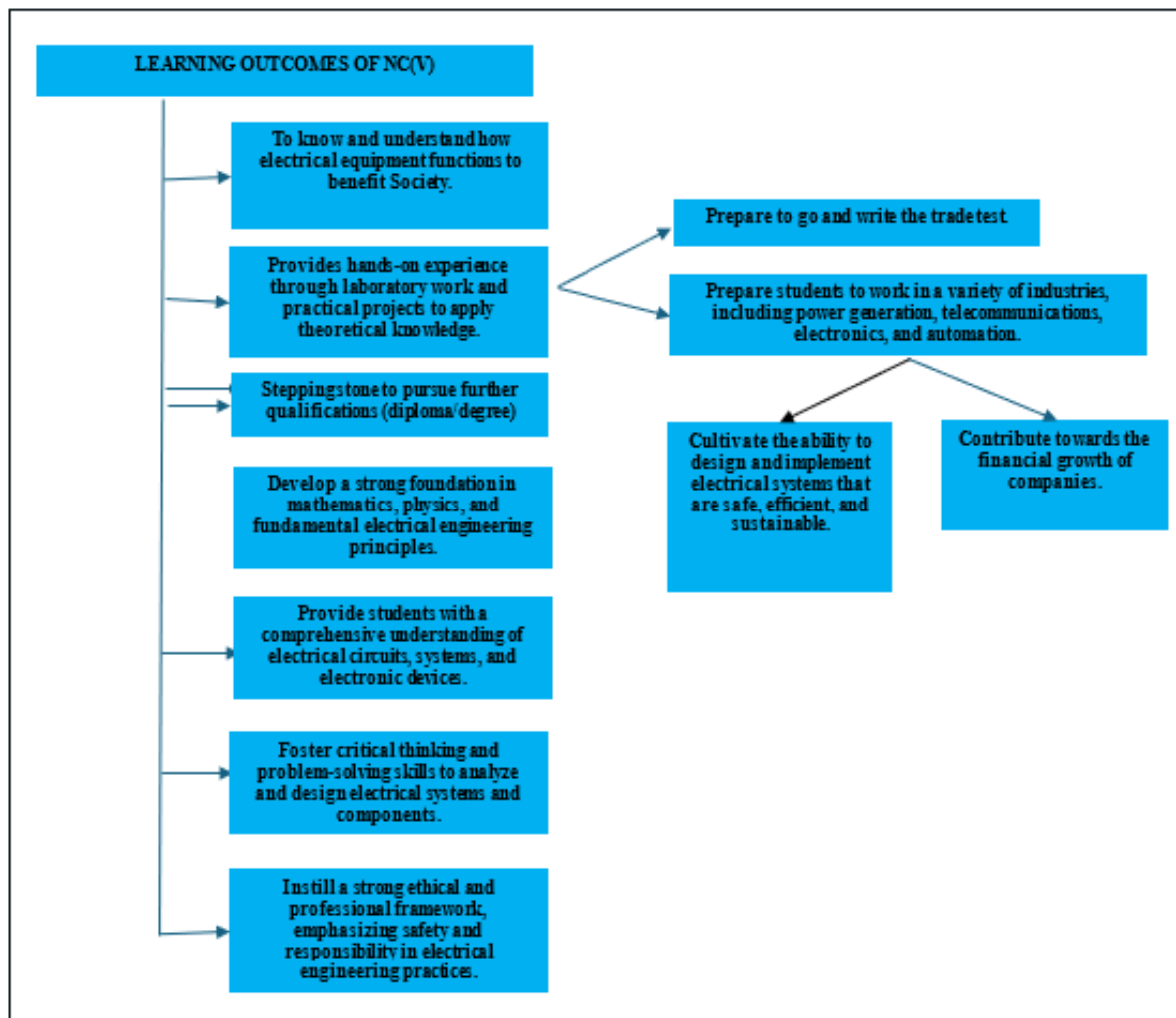


Figure 1: Data Themes Related to the Learning Outcomes of the NC(V) Program According to TVET Lecturers

In contrast, Figure 2 focuses on TVET lecturers' teaching approaches in practical training. It highlights the diverse methods and strategies used to enhance hands-on learning experiences for students. Together, these figures offer a comprehensive understanding of the educational objectives and instructional practices within the NC(V) framework.

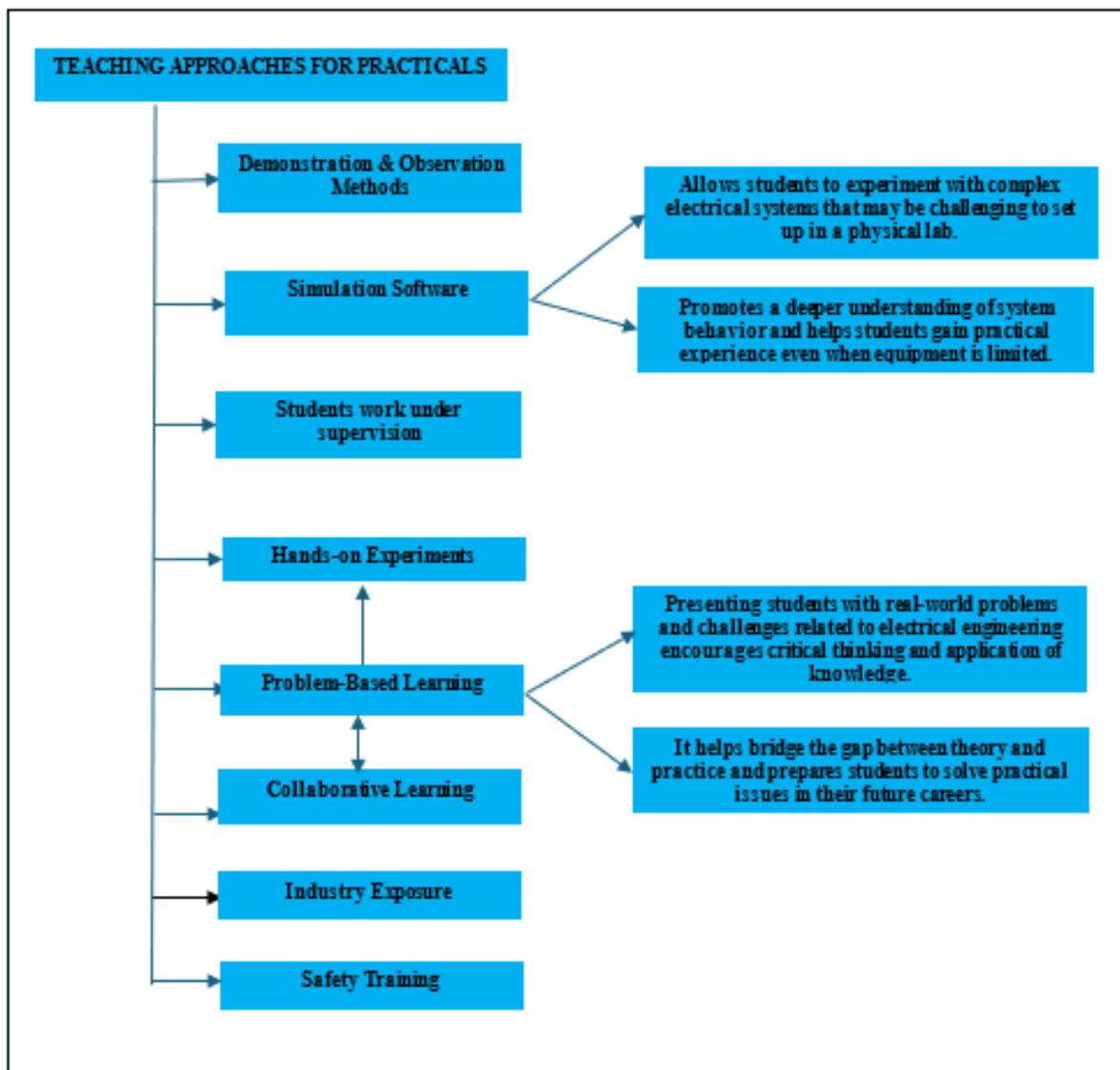


Figure 2: Data Themes Related to the Teaching Approaches that TVET Lecturers Use for Practical

6. DISCUSSION OF FINDINGS

The qualitative thematic findings from the qualitative thematic data analysis of TVET lecturers' open-ended questionnaire responses (cf. Figure 1 above) and data themes related to teaching approaches (cf. Figure 2 above) are presented in this section, along with suggestions for overcoming obstacles that could prevent PBL from being adopted and used as a teaching and learning strategy.

6.1 Learning Outcomes of the NC:(V) Program According to TVET Lecturers (cf. Appendix D, p.132).

Uy et al. (2023) consider the goals or learning outcomes as a pillar of successful instruction and learning that can inspire pupils to achieve academic success. According to these authors,

learning outcomes specify what students should know and be able to do by the end of the program. They have the potential to empower education significantly. Clarified learning objectives and facilitators providing progress reports greatly improved students' performance, claim Lin and Yu (2023). As a result, curriculum development has undergone a paradigm shift with an approach focused on learning outcomes (Uy et al., 2023). To meet the demands of industry and students in the twenty-first century, the program's learning outcomes should serve as the foundation for preparing students for the uncertain future. The focus on learning objectives has led to an increasing emphasis on student empowerment (Uy et al., 2023), focusing on the demands of contemporary society. According to Sawant et al. (2022), people must be able to solve complicated problems effectively. Therefore, electrical engineering education aims for students to be helped and encouraged by their lecturers to acquire adaptable and analytical skills that will enable them to generate significant learning outcomes by analyzing various scenarios (Sawant et al., 2022). The demands of modern society have, therefore, changed how lecturers instruct their students to consider this new environment. According to Dorimana et al. (2022), the new context requires that students solve an open-ended problem from the trigger material to learn the subjects, encouraging students to understand concepts and problem-solving techniques rather than memorize facts. Facilitators must recognize the connection between content knowledge and applying twenty-first-century skills to improve student learning and develop innovative ways to teach both (Walton, 2014). This presents a challenge for the new educational reform. The learning objectives of the TVET Electrical Engineering program, especially the NC:(V), are centred on the demands of future employers and students in the twenty-first century. The objectives of Electrical Systems and Control are in line with what businesses and students in the twenty-first-century need. Therefore, twenty-first-century students should be able to recognize and resolve problems (i.e., the NC:(V) program's learning objectives) and efficiently collaborate with others (i.e., identify situations that call for action and respond accordingly) as well as plan and coordinate their activities (i.e. follow the proper protocols for handling, storing, and maintaining tools, equipment, test equipment, drawings, and part).

According to the results, most TVET Electrical Engineering lecturers are, on average, cognizant of the demands of education in the twenty-first century. However, none of the lecturers mentioned the significance of group projects that allow students to solve real-world issues, a crucial component of contemporary teaching. A casual conversation with Lecturer B revealed that, given the current curriculum's structure, he finds teaching challenging with an

emphasis on learning outcomes. Without addressing structural barriers, lecturers may still use traditional teaching methods despite professional development. The focus on standardised testing in the current curriculum may be one reason for this. At the same time, it is anticipated that TVET lecturers will change to reflect twenty-first-century teaching methods (Pangeni & Karki, 2021). Currently, most TVET education is determined by exams (Bhagat & Chang, 2015), which could be problematic if new teaching strategies like Problem-PBL are implemented without considering these systemic constraints.

6.2 Teaching Approaches that TVET Lecturers Use for Practical (cf. Appendix D, p.133).

When asked about the teaching strategies they employ during practicals, the lecturers offered various insights. For instance, Lecturer A brought up demonstration and observation techniques. He clarified that these methods work because teaching is accomplished through experimentation, and the demonstration method involves showing and providing students with examples. Likewise, Lecturer C explained his methodology: "I demonstrate to the students first what is expected of them and what they are supposed to do. I then let them work under my watch to ensure they don't injure themselves." This demonstrates his emphasis on walking students through the first set of instructions before letting them use what they've learned in a secure setting. Conversely, Lecturer B, who has worked in the industry, provided a thorough list of instructional strategies, such as practical experiments, simulation software, PBL, group projects, exposure to the industry, and safety instruction. He went on to discuss the advantages and applicability of each approach within the framework of the Electrical Engineering program. In his closing remarks, Lecturer B emphasized the value of these strategies in developing a well-rounded curriculum by stating that "using these teaching techniques aids in the development of not only technical knowledge but also vital abilities like problem-solving and practical experience. This ensures that students are well-rounded professionals who can meet industry demands."

In summary, all lecturers emphasized the value of hands-on learning. Still, Lecturer B went into greater detail to describe the different teaching philosophies and their unique advantages, showing a greater comprehension of how these approaches fit into the curriculum and industry standards. In their TVET Electrical Engineering courses, Lecturers A and B use conventional teaching strategies that primarily rely on observation and demonstration techniques. With these methods, students observe and take notes passively. At the same time, the lecturer conducts the experiment and demonstrates how to complete the tasks, consistent with what Vimbelo and

Bayaga (2023) refer to as traditional methods, in which students watch as the lecturer speaks and writes on the whiteboard. Madimade-Mofokeng et al. (2020) also describe these methods as encouraging passive learning. This study suggests that many TVET lecturers still employ conventional approaches. Okolie et al. (2020) support this conclusion, stating that many lecturers continue employing conventional, planned pedagogical strategies emphasising rote memorization. Billett (2014) and Okolie et al. (2020) suggest that lecturers who employ conventional approaches should receive training in contemporary pedagogical techniques.

7. CHALLENGES THAT MIGHT HINDER THE ADOPTION AND IMPLEMENTATION OF PBL AND STRATEGIES TO OVERCOME THEM

There are significant differences between lecturer-based and PBL approaches. Because lecturers supervise the learning process, the lecturer-based approach encourages students to experience teaching and learning as a passive engagement process. On the other hand, PBL promotes students' active involvement in the teaching (peer) and learning process (from diverse perspectives and individually). Teis (2014: 61) noted that enquiry-based learning and teaching strategies stimulate “learner excitement of discovery” and support students’ intellectual growth as they engage with a diverse group of similarly eager learners and lecturers. Accordingly, PBL deviates from conventional teaching methods (Walton, 2014). Therefore, PBL necessitates a substantial mental shift in which lecturers serve more as facilitators than as the primary information source, upending established and cosy lecturer-based approaches (Okolie et al., 2022). Consequently, PBL encourages lecturers to adopt constructivist learning methodologies and rethink their conventional teaching roles (Nxasana et al., 2023). Using constructivist learning strategies like PBL necessitates reorganizing classroom procedures and conventional teaching responsibilities (Martinez, 2022), which may pose several difficulties for lecturers accustomed to the lecturer-based approach. The challenges that PBL may cause for instructors fall into the following categories: lecturer’s resistance and readiness, curriculum and assessment, resource limitation, and alignment with industry demands. The aforementioned challenges are not insurmountable and are discussed and addressed in the following sections.

7.1 Lecturer’s resistance and readiness

Lack of training and resistance to change are the leading causes of the lecturer's resistance and readiness (Sakala & Chigona, 2020). Insufficient professional development opportunities that allow lecturers to gain the skills, knowledge, and competencies required to carry out a particular teaching method or strategy are referred to as a lack of training. The research

participants indicated that they had never intentionally (lesson planning) used PBL in their Electrical Engineering classes before. They are, therefore, less knowledgeable (Liu, 2019) and unable to understand the ideas entailed in the novel teaching methodology (Labib et al., 2024). Conversely, reluctance to change is the unwillingness to embrace novel approaches, plans, or technological advancements despite their possible advantages. Because they are unfamiliar with the method or believe it will be difficult, lecturers may be reluctant to adopt PBL as a sign of resistance to change (Okolie et al., 2020). According to Aksela and Haatainen (2019), lecturers unfamiliar with PBL will likely oppose student-driven learning. Thus, a significant obstacle to TVET lecturers' adoption of PBL is their lack of training and resistance to change. Systematic changes and strategic intervention are required to address these issues. Investing in professional development is one strategy to get past this obstacle (Nkambule & Ngubane, 2023; Labib et al., 2024). Therefore, it should be a top priority for TVET institutions to give lecturers formal PBL training that focuses on the theoretical and practical aspects of PBL.

7.2 Curriculum and Assessment

The term curriculum and assessment describe the organized and planned learning objectives, subject matter, instructional strategies, and assessment systems established by educational establishments. The following factors contribute to these difficulties: the curriculum's inflexibility and the assessment's difficulty. The fixed structure of an academic program, where the objectives, teaching strategies, content, and assessment techniques are preset, standardized, and unchangeable, is referred to as curriculum rigidity. TVET programs frequently focus on learning particular technical skills (Asghar et al., 2012), which might prevent PBL's required flexibility. Significant changes must be made to curriculum guides, testing requirements, and teaching assignments to incorporate PBL into such a curriculum (Lotter et al., 2020). Lecturers may, therefore, find it challenging to make time or space for PBL activities within the set framework of their courses if the curriculum is rigid. *Assessment difficulty* is the term used to describe the difficulties lecturers encounter when assessing students' performance, especially when utilizing non-traditional teaching techniques like PBL.

In contrast to traditional examinations, PBL places a strong emphasis on group problem-solving, critical thinking, and knowledge application in practical settings. Due to these characteristics, TVET lecturers might face difficulties when creating and delivering assessments. The problem-solving abilities acquired through PBL might not be adequately measured by conventional assessment techniques (like tests). According to Aksela and

Haatainen (2019), lecturers unfamiliar with PBL might be unable to produce genuine assessments. Lecturers may find it challenging to create authentic assessments because it will take time and increase their workload (Slaughter, 2024). However, TVET institutions can help lecturers successfully implement PBL by rethinking curricula to fit the interdisciplinary, real-world problem-solving approach of PBL and by implementing adaptable, authentic assessment techniques that evaluate both process and product. Support from institutions is essential to overcoming these obstacles (Du et al., 2020; Gomez-Pablos et al., 2017), professional development, and dedication to reconsidering conventional educational models favouring more competency-based and student-centred methods.

7.3 Resource limitation

Resource-limited challenges include inadequate financial, human, and physical resources necessary for efficient teaching and learning. Problems with insufficient access to educational resources, technology, infrastructure, time, and professional assistance are examples of resource limitations (Aksela & Haatainen, 2019; AlBuali & Khan, 2018). Lack of real-world issues and inadequate facilities are two resource limitations discussed in this study. The absence of genuine, industry-relevant scenarios that can be utilized in instruction is referred to as a *lack of real-world problems*. In this study, engaging students and improving their critical thinking, problem-solving, and practical application abilities require real-world problems. When there aren't enough opportunities or examples to incorporate contemporary industry issues, procedures, or practices into the teaching and learning process, there aren't enough real-world problems. Because of this restriction, it is challenging to create context-driven, meaningful problems that complement the learning goals and provide students with a realistic representation of the kinds of problems they will face in the workplace. Although the absence of real-world problems significantly hampers lecturers' adoption of PBL, this obstacle can be addressed in several ways. For example, building stronger ties with business partners and professional associations is one of the best strategies to address the dearth of real-world issues (Charles et al., 2023; Nkambule & Ngubane, 2023; Wagino et al., 2023). Shared resources, like case studies and problem scenarios, can result from these partnerships and enhance the PBL experience (Badawi & Drăgoicea, 2023).

The absence of the proper physical infrastructure, tools, and technology required to facilitate efficient teaching and learning is referred to as *inadequate facilities*. Inadequate facilities hinder the successful implementation of PBL activities. PBL usually necessitates interactive

environments, real-world equipment, and cutting-edge technologies, all of which may not be easily accessible in institutions due to limited funds. Additionally, electrical engineering frequently calls for real-world, hands-on experience with tools and laboratory settings. PBL can be challenging to execute successfully without the required infrastructure or access to modern technologies. Therefore, a significant obstacle to the adoption and successful implementation of PBL is the lack of facilities (Aksela & Haatainen, 2019; Labib et al., 2024). Nonetheless, there are several methods for overcoming these obstacles. For instance, collaborations with companies and sectors can be used to share resources, purchase equipment at a reduced cost, or loan it out (Kebede et al., 2024). Institutions should closely partner with industries to access facilities through these partnerships, and students will be exposed to industry-relevant skills (Singh & Tolessa, 2019).

7.4 TVET alignment with industry needs

Graduate attributes TVET Engineering students develop through active and meaningful engagement must align with industry and employer needs for quality TVET education. According to Liu (2019), work-oriented instruction is the most common type of TVET instruction. Therefore, active industry participation through Work Integrated Learning (WIL) or Work-based Learning (WBL) is essential for successfully implementing TVET programs (Affandi et al., 2024; Van der Bilj & Taylor, 2020). TVET should have a close relationship with related industries, as the input should inform the output of TVET institutions of industries to ensure the delivery of industry-relevant learning experiences (Singh & Tolessa, 2019; Teis & Els, 2021). Therefore, to promote lifelong learning and match education with market demands, industry participation in TVET is essential (Affandi et al., 2024; Kipli & Khairani, 2020; Siddiky & Uh, 2020). PBL in electrical engineering frequently requires collaborations with industries that present real-world problems to succeed. Starting and maintaining this kind of cooperation could be challenging, especially if businesses and industries are not actively involved with the educational sector. Thus, lecturers face difficulty implementing PBL when teaching practices and content do not fully align with industry needs. The lack of industry-relevant problems is one of the reasons why lecturers may find it challenging to embrace PBL. Thus, insufficient industry-relevant issues may reduce PBL's efficacy. TVET college curriculum planners should work closely with industry to address this gap by ensuring that the curriculum reflects industry standards and expectations (Molele et al., 2024; Nkambule & Ngubane, 2023; Wagino et al., 2023). Thus, to develop skills, TVET institutions should establish forums for industry viewpoints and select industry experts (Mustapha et al., 2023).

Proactively tackling the challenges mentioned above will enable TVET institutions to establish a more dynamic and productive learning environment that better equips students for the changing demands of the industry.

8. PROPOSED TRAINING FRAMEWORK FOR TVET ELECTRICAL ENGINEERING LECTURERS' PROFESSIONAL DEVELOPMENT AND EFFECTIVE IMPLEMENTATION OF PBL

The training framework described in this section aims to change the teacher-centred teaching methods used by TVET Electrical Engineering lecturers to student-centred ones. Heron's Modes of Facilitation, Lewin's Theory of Planned Change, and Problem-Based Learning (PBL) serve as the foundation for the framework. The structure adheres to Lewin's three phases of change: unfreeze, change, and refreeze. PBL and Heron's facilitation modes are incorporated to aid in the transition. The proposed training framework for TVET electrical engineering lecturers' professional development aims to effectively enhance their teaching practices and implement problem-based learning (PBL).

This framework is structured in three distinct phases, each designed to address specific aspects of lecturers' pedagogical skills and the integration of PBL into the curriculum. Table 2 outlines the first phase, focusing on foundational training that equips lecturers with essential knowledge and strategies.

Table 2: The First Phase of the Proposed Training Framework for TVET Electrical Engineering Lecturers' Professional Development and Effective Implementation of Problem-Based Learning

PHASE 1:	TEACHING STRATEGIES	LEARNING ACTIVITIES	OUTCOMES
Understanding PBL and its application.	▪ Interactive lectures: introduce PBL concepts, emphasizing active learning and problem-solving. ▪ Small group discussions: encourage participants to share their experiences and discuss PBL scenarios. ▪ Case studies: analyze real-world examples of PBL implementation in TVET settings.	▪ PBL basics: explore the principles of PBL, including problem formulation, group dynamics, and self-directed learning. Participants work in small groups to define a problem related to their subject area. In this case, Electrical Engineering. ▪ Designing PBL scenarios: participants collaboratively create PBL scenarios aligned with their curriculum. Focus on authentic, context-specific problems relevant to TVET students. ▪ Role-playing: simulate PBL facilitation scenarios. Discuss effective strategies for guiding student inquiry and critical thinking.	▪ Participants understand the core principles of PBL. ▪ They can design PBL scenarios suitable for their course. ▪ Increased confidence in facilitating PBL sessions.

Building on this, Table 3 presents the second phase, which emphasizes developing practical skills and applying PBL in real classroom scenarios.

Table 3: The Second Phase of the Proposed Training Framework for TVET Electrical Engineering Lecturers' Professional Development and Effective Implementation of Problem-Based Learning

PHASE 2:	TEACHING STRATEGIES	LEARNING ACTIVITIES	OUTCOMES
Implementing Lewin's Planned Change Model.	▪ Workshops: hands-on sessions to apply Lewin's model. ▪ Guest Speaker: invite an expert to share practical experiences with planned change,	▪ Unfreezing: create awareness of the need for change. Explore the need for change in TVET institutions. Discuss the need for change in teaching approaches. Identify barriers to change (e.g. resistance, outdated practices). ▪ Change intervention: participants analyze case studies where planned change was successful. ▪ Discuss strategies for overcoming resistance and promoting buy-in. ▪ Moving: implement the desired change by developing training modules on PBL techniques, curriculum design, and student engagement. Action research: encourage lecturers to experiment with PBL in their classrooms—peer coaching: pair lecturers to observe and provide constructive feedback. ▪ Refreezing: develop action plans for implementing changes in their teaching practices. Consider sustainability and continuous improvement. Stabilize the change through: ▪ Community of Practice: establish networks where lecturers can share experiences and best practices. ▪ Recognition and Rewards: Acknowledge successful PBL implementation. ▪ Continuous Evaluation: Regularly assess the impact of PBL on student learning outcomes.	▪ Participants grasp Lewin's three-stage model. ▪ They can apply it to initiate positive changes in their teaching methods. ▪ Increased awareness of change management challenges.

Finally, Table 4 illustrates the third phase, where advanced methods and continuous professional development are incorporated to ensure the long-term effectiveness of PBL implementation. Together, these phases provide a comprehensive approach to improving the quality of electrical engineering education in TVET institutions.

Table 4: The Third Phase of the Proposed Training Framework for TVET Electrical Engineering Lecturers' Professional Development and Effective Implementation of Problem-Based Learning

PHASE 3:	TEACHING STRATEGIES	LEARNING ACTIVITIES	OUTCOMES
Enhancing Facilitation Skills Using Heron's Modes of Facilitation	▪ Role-playing: practice different facilitation modes. ▪ Peer Feedback: encourage constructive critique.	▪ Heron's Modes Overview: introduce the three modes of facilitation. E.g. hierarchical, cooperative, and autonomous. Discuss when each mode is appropriate. ▪ Mode exploration: participants work in pairs to practice specific modes. Reflect on their experiences and receive feedback. ▪ Creating a Facilitation Plan: participants design a facilitation plan for an upcoming TVET workshop. Apply Heron's modes strategically.	▪ Participants understand Heron's modes and their applications. ▪ Improved facilitation skills for engaging diverse students. ▪ Confidence in adapting facilitation approaches based on context.
RESOURCES			
1. PBL Handbook 2. Sample PBL Scenarios	▪ Provide a comprehensive guide on PBL principles and implementation. ▪ Share exemplars from various disciplines. ▪ Virtual representation of the three stages.		

3. Lewin's Model Infographic 4. Change Management Toolkit 5. Heron's Modes Chart 6. Facilitation Toolkit	▪ Templates for creating action plans. ▪ Visual reference for each mode. ▪ Templates for planning and executing practical sessions
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To sum up, the suggested training framework for TVET Electrical Engineering lecturers provides a methodological, phased strategy for improving their professional growth and guaranteeing the practical application of PBL. Each phase covers key elements of teaching effectiveness and innovation, which begins with foundational knowledge in Table 2, moves on to practical applications in Table 3, and ends with advanced strategies for sustained PBL integration in Table 4. It is advised that lecturers use a range of resources, including PBL training workshops and seminars, pedagogical journals and articles, online educational platforms, collaborative networks, and communities of practice, to facilitate the practical application of this framework. TVET Electrical Engineering lecturers can enhance their knowledge, improve their methods of instruction, and successfully integrate PBL into their classes by using these resources.

9. CONCLUSIONS AND RECOMMENDATIONS

This study explored how well South African TVET Electrical Engineering lecturers understood the NC: (V) Electrical Engineering program's learning objectives and how well they matched the curriculum. The results showed that lecturers' viewpoints and the official learning outcomes were highly aligned, demonstrating their understanding of the demands of education in the twenty-first century. Nevertheless, none of the instructors emphasized the value of collaborative problem-solving, an essential component of contemporary education. The study also analysed the teaching techniques lecturers employ to develop technical skills. The research found that the participating Electrical Engineering lectures applied a combination of cutting-edge teaching techniques like PBL and inquiry-based with more conventional methods like demonstration and observation. Interestingly, lecturer B, who has worked in the industry, showed a more profound comprehension of innovative teaching approaches. This observation demonstrated how exposing lecturers to the sector can improve the efficacy of instruction. The study further found that the main structural obstacles to PBL adoption are the embedded institutional curriculum delivery requirements, emphasis on standardized tests, and regulations that make it challenging to adopt innovative teaching strategies.

To support the successful implementation of PBL, the study proposes a professional development framework for lecturers that incorporates Heron's modes of facilitation and Lewin's theory of planned change, as illustrated/argued in this research. The study highlights the necessity of cooperation between academic institutions, industry professionals, and lecturers to bring about synergy within the electrical engineering industry and enhance technical literacy through TVET. Strong partnerships should be fostered to incorporate innovative teaching methods like PBL. To support the broader adoption of PBL across TVET colleges, the study also suggests creating learning communities of practice to mitigate the effect of the rapid technological advancement of teacher knowledge frameworks.

ETHICS STATEMENT

The research study presented in this article was conducted in complete alignment with the ethical standards set forth by the Faculty of Education at the University of the Free State, South Africa. The study received approval from the Research Ethics Committee, with ethical clearance granted under No [UFS-HSD2022/2018]. Informed consent was obtained from all participants, and all other principles prescribed by the IJRVT Review Board were adhered to.

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2.5 CONCLUSION

In conclusion, the three articles presented in this chapter highlight how important professional development is to effectively implement PBL in TVET Electrical Engineering programs in South Africa. The first step in laying the groundwork for further research is Article 1 (cf. pp.25-45), which emphasizes the necessity of focused professional development techniques to assist lecturers in implementing PBL. Further elaborating on this, Article 2 (cf. pp.46-68) highlights the need to modify pedagogical approaches by analysing how PBL changes teaching practices. Article 3 (cf. pp.69-103), which offers a structured framework for professional development adapted to the TVET context in South Africa, finally expands on these insights. These articles show how PBL can be successfully incorporated to improve teaching and learning outcomes when accompanied by reflective practice, aligned strategies, and institutional support. Lastly, Chapter 3 answers the six research questions mentioned in Chapter 1, Section 1.6: conclusions, recommendations, implications, and research limitations.

CHAPTER 3

ANSWERING THE RESEARCH QUESTIONS, CONCLUSIONS, RECOMMENDATIONS, IMPLICATIONS, AND LIMITATIONS

3.1 ANSWERING THE RESEARCH QUESTIONS

The primary purpose of this study was to explore the teaching practices enacted by TVET Electrical Engineering lecturers in their respective classrooms and the challenges they might encounter that could hinder the adoption and effective implementation of PBL as a teaching and learning strategy. To achieve this purpose, six research sub-questions (cf. p.14) guided the study, and this section presents the discussion of the findings to demonstrate how the purpose of the study was achieved by answering the research questions identified and listed in the first chapter of this research report under Section 1.6. Table 3.1 answers each of the six research sub-questions identified in Chapter 1 based on the overall findings of this thesis.

Table 3.1: Answering the Research Sub-Questions

Research Sub-Question 1.6.1: *What challenges do TVET lecturers face when adopting and implementing Problem-Based Learning (PBL) as a student-centred strategy in Electrical Engineering education?*

The current teaching state at the specific TVET campus is teacher-centred and examination-focused and, thus, might be a challenge if PBL is adopted as a teaching and learning strategy (Bhagat & Chang, 2015). Lecturers are aware of the needs of 21st-century education, but they are not applying them in their respective classrooms. One of the lecturers with a vast knowledge of different strategies that support student-centred approaches to teaching and learning mentioned that he cannot teach focusing on the learning outcomes because of how **the curriculum is organized**. In this study, it is regarded as a structural challenge **beyond the lecturers' control**. Therefore, this finding calls for policymakers to revamp the trimester system in collaboration with various stakeholders. The challenges include, but are not limited to, state-mandated curricula, standardised assessment mandates, and rigid separation of subjects within the colleges (Asghar, Ellington, Rice, Johnson & Prime, 2012). The mentioned challenges promote traditional teaching approaches.

Research Sub-Question 1.6.2: *What are the current teaching practices of lecturers within a purposely selected TVET Electrical Engineering programme?*

Based on classroom observation findings, this study revealed that TVET Electrical Engineering lecturers use traditional teaching approaches to teaching and learning. This finding is also supported by an open-ended qualitative questionnaire, where lecturers, when responding to a question concerning teaching approaches to practical activities, mentioned demonstration and observation as one of the most prevalent teaching strategies. It was observed in this study that students were seated in rows, facing the whiteboard, and the lecturer was the only one talking. Research indicates that such seating arrangements are referred to as traditional and do not encourage students' active participation during the learning process (Vimbelo & Bayaga, 2023). Thus, the seating arrangement in this study supports Vimbelo and Bayaga's (2023) finding, as it also encourages traditional teaching approaches. According to Nufus, Muhith, and Sutomo (2023), seating arrangements play a vital role in 21st-century education. Handayani, Amrullah, and Apgrianto (2023) add that seating arrangements promote effective pedagogical activities by providing conducive environments for interactive learning. In this study, the researcher can argue that the aim of the lesson dictated the seating arrangements observed during all four sessions as lecturers were teaching students who were going to write a test in two weeks. The findings of this study support what was reported by Nehyba, Juhaňák, and Cigán (2023), that the goal of the lesson regularly dictates seating arrangements. Therefore, changing and adopting an innovative seating arrangement can be one step towards shifting TVET lecturers' practice from teacher-centred to student-centred teaching approaches. Thus, innovative seating arrangements, such as U-shaped, semi-circle, etc., promote student-centred approaches that have the potential to foster higher engagement and active participation (Handayan et al., 2023; Nufus et al., 2023; Papaioannou, Volakaki, Kokolakis & Vouyioukas, 2023). It can be concluded from this study that changing the seating arrangement has the potential to shift TVET Electrical Engineering lecturers' teaching practices and perspectives about teaching and learning that promote 21st-century skills.

Research Sub-Question 1.6.3: *What are the key components of Problem-Based Learning (PBL), and how do TVET lecturers understand their application in shifting pedagogical approaches within the Electrical Engineering program?*

The findings of this study revealed that three key components (cf. Article 2, p.57) need to be considered and well-planned for the effective implementation of PBL as a teaching and learning strategy, namely, an ill-defined problem, a collaborative small group (students), and the facilitator. The problem is regarded as the prominent component that initiates the interactions between the other two components. The focus of the problem is to develop students' problem-solving skills through the application of acquired content, but not the teaching of the content (Adamuthe & Mane, 2020; Okolie et al., 2020). Thus, during the PBL process, students learn the subject by

experiencing the solution to an open-ended problem found in the trigger material, whereby students are encouraged to develop problem-solving skills and understand the concepts rather than absorbing facts (Dorimana, Uworwabayebo & Nizayimana, 2022). The critical and most important role is the facilitators' role during the PBL process (Ananzifa & Djukri, 2017; McQuade et al., 2020; Trullàs et al., 2022), particularly during the PBL tutorial sessions. Facilitators during the PBL process play multiple roles, depending on their students' situations (Adamuthe & Mane, 2020; Ananzifa & Djukri, 2017; Beagon, Niall & Ní Fhloinn, 2019; McQuade et al., 2020). For example, during the first PBL tutorial session, the facilitator guides and supports students in formulating the learning issues. Depending on the classroom situation, facilitators could adopt any of the three facilitation modes: hierarchical, cooperative, and autonomous.

Research Sub-Question 1.6.4: *How do these lecturers perceive and prioritize professional development strategies to enhance teaching effectiveness and support the transition to student-centred learning in Electrical Engineering?*

The study's findings derived from the qualitative open-ended questionnaire (cf. Appendix D, pp.131-135) revealed that the participants (n=4) specialising in TVET Electrical Engineering did not have or did not receive industry work-integrated learning during their respective training as students and during their professional development training. These lecturers positively perceived the impact that industry work-integrated learning could have on their teaching practice and on improving the quality of TVET education. This finding was also highlighted by one of the lecturers, who has industry experience, and this is an interesting and valuable comment. This core finding is considered one of the key elements in developing the quality of TVET education. It is also supported by Guthrie, Harris, Simons, and Karmel (2009) when they mentioned that vocational teaching and learning are associated with the world of work and the practical application of knowledge and skills. In this study, TVET Electrical Engineering, in their responses to the open-ended question (cf. Appendix D, p.135), mentioned that they are not members of any community of practice, be it at the college level or in any industry involvement currently. This finding is regarded in this study as a missed opportunity for lecturers to learn with or from each other.

Research Sub-Question 1.6.5: *How do TVET lecturers evaluate the alignment between their perceptions of learning outcomes in the Electrical Engineering program and the actual program outcomes?*

Concerning TVET lecturers' perceptions of the nature and learning outcomes of an Electrical Engineering program (cf. Appendix D, p.132), the findings revealed that lecturers are knowledgeable and have a clear understanding of what is required from 21st-century students, as well as the needs of potential employers, through their articulation of the learning outcomes of the program. One lecturer mentioned that the main aim is *"to know and understand how electrical equipment functions to benefit society"*. This finding also aligns with the role of engineering, as

Mitchell et al. (2021) mentioned, i.e., engineering is the art and practice of changing the physical world for the benefit of all. The findings also revealed that lecturers in their responses did not mention working in groups or collaboratively as one of the program's learning outcomes. This finding puts a rubber stamp on the teaching approaches that they are currently using, which do not support PBL.

Research Sub-Question 1.6.6: *How can TVET lecturers facilitate effective PBL pedagogical practice integration to ensure a student-centred TVET Electrical Engineering learning experience?*

Since PBL practice is a departure from traditional teaching approaches around which the college structure is designed, programs should, therefore, attend to the challenges that the college structure and policy requirements pose to lecturers. To overcome these structural barriers and promote the adoption of PBL teaching and learning strategy, demands that syllabi need to be reorganized to align with the 21st-century needs and curriculum mandates that support PBL policy in the classroom (Guerra, Ulseth & Kolmos, 2017). Research highlights some of the strategies that have the potential to promote the adoption and effective implementation of PBL by the lecturers for the sustainable application of PBL in their respective classrooms. For example, involve key stakeholders in the industry, particularly experts in Electrical Engineering, to assist lecturers in designing, restructuring, and implementing the learning program that responds to the needs of the local economy (Nkambule & Ngubane, 2023). Collaboration between TVET colleges and industries is crucial to share knowledge on how the activities should be organized for efficient and quality teaching in vocational education (Badawi & Drăgoicea, 2023; Wagino, Maksum, Purwanto, Krismadinata, Suhendar & Koto, 2023). The above strategies can potentially encourage TVET lecturers to adopt and effectively implement PBL as a teaching and learning strategy.

By successfully answering the six research sub-questions (cf. p.14), the research objectives presented in Chapter 1, Section 1.7 were also successfully attained, thereby contributing towards addressing the research problem identified in Chapter 1, Section 1.4.

3.2 REFLECTION ON MY RESEARCH JOURNEY

My research journey to explore the teaching practices of TVET Electrical Engineering lecturers and the potential challenges they might face in adopting PBL was a rich and enlightening experience. It involved a multifaceted journey, encompassing a scoping literature review, data collection, analysis, and interpretation.

One of the most enlightening aspects of this process was engaging directly with TVET Electrical Engineering lecturers through open-ended qualitative questionnaires and classroom observations. Engaging with these lecturers was a pivotal aspect of the study. These interactions offered first-hand insights into their current teaching practices, pedagogical philosophies, and perceptions towards adopting PBL.

Navigating the realm of educational theory and pedagogical frameworks was equally enlightening. Delving into the literature allowed for a deeper understanding of the theoretical underpinnings of both traditional teaching methods and innovative approaches like PBL. This theoretical foundation provided a solid framework for analysing the empirical findings and identifying key trends and patterns.

Ultimately, the research process catalysed reflection and dialogue. It prompted critical conversations about the nature of effective teaching and learning in technical education and sparked ideas for future directions and interventions. The journey was intellectually demanding but also immensely rewarding, offering valuable insights into education dynamics and the potential for transformative change.

The research journey underscored the nuanced interplay between pedagogy, institutional dynamics, and individual beliefs. While adopting PBL in TVET Electrical Engineering education may present formidable challenges, it also signifies a profound opportunity for innovation and improvement. By acknowledging and addressing these challenges head-on, lecturers can pave the way for a more dynamic and impactful learning experience for students, preparing them effectively for the demands of the modern, unpredictable workforce.

3.3 CONCLUSION

The current study's primary purpose was to explore the current state of TVET college teaching practices and the challenges that might hinder the adoption and effective implementation of PBL as a teaching and learning strategy in South Africa. The study's findings reveal that TVET Electrical Engineering lecturers primarily use traditional teaching approaches. The challenges that might hinder the adoption and effective implementation of PBL are structural, influencing lecturers' decision-making when planning the learning activities that can best assist their students in achieving the learning based on the curriculum mandates. The study further explored various

strategies that can be used to overcome these challenges. One strategy that emerged as a key was the issue of reviewing the current policy to ensure that PBL principles and PBL policies are accommodated. Finally, the study ends by proposing a TVET Electrical Engineering lecturers' professional development training program framework for adopting and effectively implementing PBL in South African TVET classrooms.

3.4 IMPLICATIONS FOR THEORY AND PRACTICE

Since traditional practices and innovative practices used different theories and beliefs about teaching and learning, shifting TVET Electrical lecturers from teacher-centred to student-centred approaches impacts theory and practice. As Walan (2016) postulated, theory and practice are linked as two sides of the same coin. Therefore, changing one leads to changing the other. Adopting PBL as a teaching and learning approach requires lecturers to change their beliefs, attitudes, and teaching practices to align with 21st-century education. The shifting of the teaching practices demands that the current policy, curriculum, and assessment mandates be reviewed and aligned with innovative student-centred learning and supporting the PBL policy. As a result, policymakers must be brought to task.

3.5 RECOMMENDATION FOR FUTURE RESEARCH

Longitudinal studies should be conducted nationwide to explore the effective implementation of the proposed professional development training and how lecturers perceived and experienced the implementation of PBL as an intervention strategy. Such longitudinal research could be a collaborative action of various research studies, whereby different stakeholders come together to plan the PBL activities and teach them to their respective classes. The other direction that needs to be explored is the impact of collaboration between stakeholders, namely the Government, policymakers, TVET lecturers, and industry experts, on the quality of TVET education. The most critical area of research, which is highly ignored and undermined, is the voice of TVET lecturers in policy decision-making. This area must be explored since we cannot decide about them without hearing their views. It is further recommended that the

proposed professional development training framework could be adapted or adopted and used by other engineering disciplines besides the Electrical Engineering program.

3.6 LIMITATIONS OF THE STUDY

A limitation of the current study is that only TVET Electrical Engineering lecturers teaching in one TVET College campus that offers an Electrical Engineering program were sampled. The sample was only drawn from the Motheo Campus in the Motheo District of the Free State Province of South Africa. Since this study deployed a context-specific case study research design, the findings of this study cannot be generalised to the larger South African TVET context. However, the findings reported in this thesis seem to illustrate the current situation observed at most TVET Colleges (Gustafsson, 2017). Nonetheless, the findings reported in this thesis should be considered specific (context-sensitive) to the TVET College where this study was conducted.

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APPENDICES

APPENDIX A: ETHICS STATEMENT



GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

16-Aug-2023

Dear Mr Mbofheni Abbie Mulaudzi

Application Approved

Research Project Title:

Shifting Electrical Engineering Lecturers' Perspectives and Practices from teacher-centred to student-centred approach through Problem-based learning.

Ethical Clearance number:

UFS-HSD2022/2018

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis

Chairperson: General/Human Research Ethics Committee

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APPENDIX B: MOTHEO STUDY APPROVAL LETTER



higher education
& training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA



MOTHEO TVET COLLEGE
CENTRAL OFFICE

Ref: MA Mulaudzi

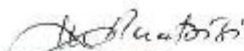
Shifting Electrical Engineering Lecturer's perspectives and practices from teacher – centred to student – centred through problem – based learning.

The College has evaluated your request and has decided to grant you permission to undertake the above research.

As part of your research it is noted that you will distribute questionnaires to 12 electrical engineering lecturers from different Campuses of the College and also request them to participate in individual interviews. You are advised to obtain further permission from the participants before commencing with your study.

The topic of your research is of great interest to the College and will therefore be appreciated if you could share the findings of your research with the College upon completion.

Yours faithfully


Prof MDM Phutsisi

Principal | Motheo TVET College

Date: 22/06/2023



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APPENDIX C: INFORMED CONSENT LEAFLET



Research study information leaflet and consent form

Date: The study will be executed in 2023

Title of the research project: Shifting Electrical Engineering Lecturers' Perspectives and Practices from teacher-centred to student-centred approach through Problem-based learning.

Principle investigator / researcher(s) name(s) and contact number(s):

Mbofheni Abbie Mulaudzi Std. no.2021968629

Cell. No 082 355 4674

Faculty and Department:

Name of Faculty: Education

Name of Department: Mathematics Natural Sciences and Technology Education

Study leader(s) name and contact number:

Dr NJP Teis

Email address: TeisNJP@ufs.ac.za

051 401 2693

What is the aim / purpose of the study?

This study aims to facilitate the implementation of PBL intervention design using a backward design model while taking into cognizance the identified key features of PBL to shift the perspectives and practices of TVET Electrical engineering lecturers and explore how they have perceived and experienced the shifting process as well as documenting the strengths and weaknesses of PBL intervention according to participating TVET Electrical engineering. I am conducting the study in order to learn more about how the implementation of PBL has shifted TVET Electrical engineering lecturers from teacher-centred to student-centred approach.

Who is doing the research?

I am a postgraduate student at the University of the Free State in the Faculty of Education. I am currently enrolled for the PhD in education specializing science and technology.

Has the study received ethical approval?

Yes.

Approval number: UFS-HSD2022/2018



Why are you invited to take part in this research project?

This study will use homogeneous purpose-driven sampling (Creswell, 2020; Efron & Ravid, 2020). With homogeneous sampling, individuals and sites are intentionally sampled based on membership of the subgroup that exhibits the defining characteristics (Creswell, 2020). In this study, the selected site is the Bloemfontein campus of Motheo TVET College, which offers Electrical Engineering. All electrical engineering lecturers will be invited to take part in the study. However, only 12 lecturers will be selected based on their teaching experience in the subject. Participants will provide the following valuable data: their perceptions and experiences and the strengths and weaknesses of the PBL intervention.

I choose this group of participants because they have the potentials that can help me to answer my research question better. I am intending to design an intervention, learn more about the PBL affordances in shifting (from teacher-centred to student-centred approach) the TVET Electrical engineering lecturers' perspectives and experiences in order to learn more about its effective use as a teaching and learning approach. The other reason why I choose this group is that I want to help them in shifting their perspectives and experiences thereof. In short, I want to gain a deeper understanding as to how they have experienced the shifting processes.

What is the nature of participation in this study?

The participants will actively take part in resolving issues presented to them via PBL scenarios. The participants will be required to keep an individual reflective journal after each activity. They will be required to complete an open-ended questionnaire as soon as they are done with the resolution of the problem. After a month has elapsed, participants will be interviewed through individual face to face interviews. The researcher will have a set of interview questions that will guide the study, however as the interviews will be semi structured the researcher will also be flexible in asking follow-up questions based on participants responses.

Can the participant withdraw from the study?

Yes. Participation in this study is voluntary and that there is no penalty or loss of benefit for non-participation. Being in this study is voluntary, and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

What are the potential benefits of taking part in this study?

The shift in participants' views and practices from a teacher-centred to a student-centred approach will benefit both participating Electrical engineering lecturers and their electrical engineering students. Thus, the teaching approaches of lecturers will be better than before. Students will receive a quality education. In turn, this would help in developing electrical engineering students or workers who are skilled, resourceful, craftsmanlike, literate, and numerate customer-oriented and highly capable individuals. The national aspiration of the SA Department of Higher Education and Training will be realised. TVET colleges where this study is conducted will confidently teach and produced quality

graduates who are problem solvers and who are employable. Thus, the reduction of much unemployed graduates will be reduced and the economy of the country will improve.

What is the anticipated inconvenience of taking part in this study?

For most of the TVET Electrical engineering lecturers, it will be a first encounter with PBL as a teaching and learning approach. It can also increase their workload as it will require them to conduct self-study after each group sessions. Therefore, these lecturers will be trained in PBL during a workshop before the implementation.

In terms of addressing the issue of the lecturers' workload the facilitator will guide them as to how the process of PBL is conducted and will provide some of the resources that lecturers can utilise. The lecturers will be required to schedule additional tutorial sessions, outside the set timetable, to accommodate the additional tasks associated with PBL. As this is the lecturers' first encounter with PBL, they will be allowed to ask questions and for assistance whenever they need it.

Will what I say be kept confidential?

Pseudonyms will be used, and all personal information will be stored in a password-protected file which can be only accessed by the principal researcher. If there any modifications to the study the participants will be informed. Your name will not be recorded, anywhere and no one will be able to connect you to the answers you give. Your answers will be given a fictitious code number or a pseudonym, and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. Your anonymous data may be used for other purposes, e.g. research report, journal articles, conference presentation, etc. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

How will the information be stored and ultimately destroyed?

The recorded interviews will be transferred from a recording device to a password protected computer [PC] that will only be accessible to the researcher. Ultimately the researcher will delete the files from the computer [PC] once the report has been evaluated.

Will I receive payment or any incentives for participating in this study?

There is no payment for participating in this study.

How will the participant be informed of the findings / results of the study?

If you would like to be informed of the final research findings, please contact **Mr Mulaudzi MA** on 0823554674 or **MulaudziMA@ufs.ac.za**. The findings are accessible for a year after the project has been evaluated. Should you require any further information or want to contact the researcher about any aspect of this study, please contact **Mr Mulaudzi MA**

on the above-mentioned contacts details. Should you have concerns about the way in which the research has been conducted, you may contact my supervisor Dr Dr NJP Teis on 051 401 2693 or TeisNJP@ufs.ac.za. There will be no potential harm to the participants involved in this study.

Thank you for taking the time to read this information sheet and for participating in this study.

Consent to participate in this study

I, the undersigned,

(participant's full names to be included), (the "Participant")

confirm that I voluntarily agree to participate in the research study referred to as the

_____ (the "Study") in relation to

_____ and which Study is being conducted by

_____ (insert the name of the researcher), (the "Researcher").

I, the undersigned Participant, further confirm that-

1. the Researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);
5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;
6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;
7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage;
8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

I, the Participant, agree to the recording of the observations and interviews.

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

APPENDIX D: QUALITATIVE QUESTIONNAIRE



QUALITATIVE QUESTIONNAIRE TO EXPLORE ELECTRICAL ENGINEERING LECTURERS' PERSPECTIVES TO UNDERSTAND THE CURRENT STATE AS FAR AS ELECTRICAL ENGINEERING EDUCATION IS CONCERNED.

INTRODUCTION

The spread of new forms of learning and education in the ever-changing modern world is an important issue. Implementing a new curriculum in the form of National Certificate: Vocational (NC(V) in TVET colleges mostly implies changing lecturers' practices, their beliefs and the materials used. Engineering, as with ALL creative arts, requires professionals with a range of skills, knowledge, and attributes.

A. ELECTRICAL ENGINEERING SUBJECT KNOWLEDGE AND PERCEPTIONS:

1. What is the difference between NC(V) and NATED program?

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2. What type of information do you think is important to be taught?

a) In NC(V) program.

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b) In NATED program

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3. Please give reasons for your answers question 2 (a) and (b).

- a)
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- b)
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-
-

4. Which type of teaching approach do you think will be most effective to teach the information that you have listed in question 1 above to Electrical Engineering students? Give reasons.

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B. ELECTRICAL ENGINEERING CONTENT KNOWLEDGE

5. What do you think are the main aims of Electrical engineering program, in particular the NC(V) program?

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6. Which of the practical options in the NC(V) program you can teach confidently?

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7. Which teaching approaches do you use to teach practical and why?

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8. What is the difference between NC(V) and NATED program?

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9. Do you offer both NC(V) and NATED program? If so do you approach this program the same way?

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10. Can you teach the NC(V) program with confidence? Give reason.

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11. Are the available textbook and study materials NC(V) compliance? Give reasons.

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C KNOWLEDGE ABOUT PROBLEM-BASED LEARNING AS A TEACHING AND LEARNING STRATEGY.

12. What is your understanding of problem-based learning?

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13. Do you have any prior experience in using problem-based learning? If so, please give details.

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D COLLECTIVE PARTICIPATION (COMMUNITIES OF PRACTICE)

14. What is your current experience of being personally involved in an industry? Have you done this, and what value has it added to your professional work? If you have not had any workplace-based, what value could it add to your work?

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15. Are you part of any active communities of practice in your college or subject specialisation? What is the purpose behind this collaboration?

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16. Are you part of any communities of practice that involve employers? How were this started and who keeps them going?

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Thank you for taking the time to answer these questions.

APPENDIX E: CLASSROOM OBSERVATION SCHEDULE



TVET Electrical Engineering Lecturer Classroom Observation Schedule

Observer:

Date:

Time:

Subject/Class:

Lecturer observed:

Number of observed activities	Observed behaviour	Objective	Observation points
1	Classroom arrangement	To assess how the classroom environment supports learning and interaction.	Seating arrangement (individual desks, groups, etc.)
2	Teaching in General	To evaluate the overall effectiveness of teaching methods and classroom management.	• Clarity of instructions and explanations • Engagement strategies (questioning, discussions, group work). • Classroom management techniques (behavioural management, attention to individual students). • Use of instructional time effectively



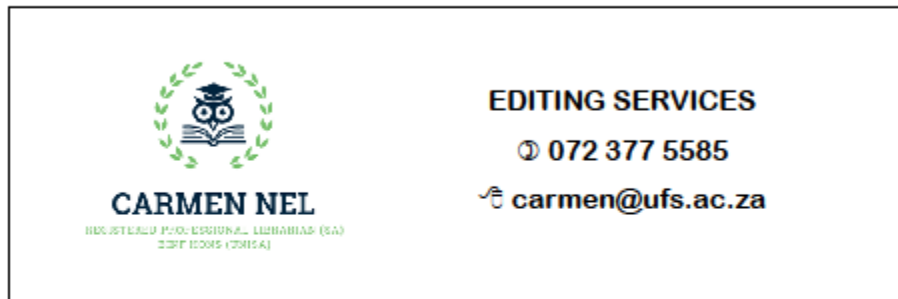
3	Lesson Planning and Delivery	To assess the structure and execution of lesson plans.	• Alignment of lesson objectives with curriculum goals. • Introduction and development of key concepts. • Differentiation strategies for diverse learners. • Integration of varied instructional methods (visual aids, hands-on activities) • Assessment of student understanding during the lesson
4	Key Elements of Educational Reform	To determine how teaching practices align with educational reform initiatives.	• Implementation of innovative teaching practices. • Integration of 21st-century skills (critical thinking, collaboration)
5	Teaching Strategy	To evaluate the effectiveness of teaching strategies employed	• Incorporation of student-centered approaches. • Adaptation of teaching strategies based on

			student responses.
6	National Curriculum Goals	To assess how the lesson content and objectives align with national curriculum standards.	• Clear connection of lesson content to curriculum standards. • Use of curriculum documents and guidelines.
7	Lecturer and Student Interactions	To evaluate the quality and frequency of interactions between teacher and students.	• Tone and rapport in teacher-student interactions. • Frequency of student participation. • Provision of feedback (individual and whole class). • Support for student questions and contributions
8	Resources Used and Use of ICT	To review the variety and effectiveness of instructional resources, including technology integration.	• Use of textbooks, worksheets, and supplementary materials. • Incorporation of digital resources (computers, tablets, interactive whiteboards). • Use of educational



			apps or software.
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APPENDIX F: LETTER FROM LANGUAGE EDITOR



CERTIFICATE OF LANGUAGE EDITING

This certifies that I have language-edited the research report with the exception of Article 2 (which has already been language-edited and published) detailed below.

Title:

"SHIFTING ELECTRICAL ENGINEERING LECTURERS' PERSPECTIVES AND PRACTICES FROM TEACHER-CENTRED TO STUDENT-CENTRED APPROACH THROUGH PROBLEM-BASED LEARNING"

by

MULAUDZI MBOFHENI ABBIE
STUDENT NO. 2021968629

Regards

Carmen Nel

Carmen Nel
22 June 2025

Professional editing of articles, thesis, dissertations and books

APPENDIX G: TURN IT IN REPORT

SHIFTING ELECTRICAL ENGINEERING LECTURERS' PERSPECTIVES AND PRACTICES

ORIGINALITY REPORT

14%	10%	10%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Can Qiu, Baoxin Long, Dengxiu Yu, Kang Hao Cheong. "Evolving the classroom: A mathematical and didactic exploration of teacher-guided peer learning", Chaos, Solitons & Fractals, 2023 Publication	<1%
2	doaj.org Internet Source	<1%
3	Theresa Adelman-Mullally, Sandy Nielsen, Seon Yoon Chung. "Planned change in modern hierarchical organizations: A three-step model", Journal of Professional Nursing, 2023 Publication	<1%
4	scholar.ufs.ac.za Publication	<1%