JOVACET
Journal of Vocational, Adult and Continuing Education and Training

To cite: Mulaudzi, MA, Teis, NJP & Seleke, B. 2023. Problem-based learning for shifting TVET 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 and TVET Electrical Engineering lecturers' practices: A scoping review

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ABSTRACT

Problem-solving capacity is continuously gathering prominence in the Engineering education programmes of most institutions of higher learning. Embracing problem-based learning is necessary for Electrical Engineering lecturers in technical and vocational education and training (TVET) so as 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 TVET contexts by Electrical Engineering lecturers is limited. In this study, we conducted a scoping review to identify those key components which are necessary for the effective implementation of problem-based learning in a TVET Electrical Engineering programme. Our findings indicated that the problem, the facilitator and the students are the three components noted as essential constituents that are vital to the effective implementation of a problem-based learning strategy in TVET Electrical Engineering programmes. Our findings stress that, in addition to the three components, the type and nature of the problem, including the philosophy of the subject or the programme, need to be considered before inculcating problem-solving capabilities in TVET Electrical Engineering lecturers.

KEYWORDS

Problem-based learning; technical and vocational education and training (TVET); Electrical Engineering lecturer competence; student-centred; teacher-centred

Introduction

There has recently been an increase in interest in technical and vocational education and training (TVET) globally (Šuligoj & Jerman, 2020; Wattanasin, Chatwattana & Piriyasurawong, 2021) and in South Africa (Blom, 2016; Badenhorst & Radile, 2018; Makhubele & Simelane-Mnisi, 2020; Papier, 2021) due to ever-increasing technical and technological advancement. Since the development of technology is advancing rapidly, the delivery of an Engineering curriculum becomes more challenging for TVET Engineering lecturers (Teis & Els, 2021). The expansion of technology requires that TVET Electrical Engineering lecturers deploy innovative ways of engaging students (Kereluik et al., 2013). It is therefore crucial that TVET Electrical Engineering lecturers devise a pedagogical shift from teacher-centred approaches to a student-centred pedagogical approach in which technology is integrated and adopted as a tool with which to mediate the teaching of learning content that is discipline-specific and appropriate in the 21st century (Teis & Els, 2021). However, the literature indicates that the majority of TVET lecturers lack innovative pedagogy and that they do not possess ideas on how to shift from teacher-centred approaches to innovative student-centred approaches (Ngubane-Mokiwa & Khosa, 2013; DHET, 2013). Research conducted by Abiddin and Ismail (2014), Field, Musset and Alvarez-Galvan (2014), Badenhorst and Radile (2018), and Teis, Els and Tlali (2022) reveals that most South African TVET Engineering lecturers lack teaching qualifications, and that more than half of them have no industry experience that would enable them to design and implement effective teaching in a TVET context.

Moreover, the relevance of TVET Engineering lecturers' knowledge is questionable, as indicated by research conducted by Manyau (2015), whose study revealed that little or insufficient training is being provided to lecturers and that this may have an impact on the quality of teaching. Surprisingly, the study by Teis et al. (2022) also established the same trends, with the authors noting that TVET Engineering lecturers received in-service training which was not focused on the development of their pedagogic content knowledge and skillsets. This does not help the TVET sector to ensure that lecturers undergo in-service training and upskilling in pedagogy, in particular vocational pedagogy. Further evidence in support of Manyau (2015) and Teis et al. (2022) is provided in the relevant literature (Blom, 2016; Badenhorst & Radile, 2018; Van der Bijl & Oosthuizen, 2019).

The study of Teis et al. (2022) strongly recommends that the Department of Higher Education and Training (DHET) and TVET colleges provide lecturers – and particularly Engineering lecturers – with relevant teaching skills development programmes to keep them abreast of the current changes in their area of specialisation. Their study also proposes that there 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 that enhance the ability of lecturers to develop effective learner-centred teaching and learning spaces. It is necessary to have competent and properly skilled TVET lecturers if effective teaching and learning processes are to be introduced in TVET colleges, as the central focus is on equipping students with the technical knowledge and skills required by the job market (Ismail et al., 2018). The process of creating improvements in the TVET field requires professionally qualified, competent and efficient lecturers to be deployed to fulfil this responsibility (Abdullah et al., 2019).

In this article, we argue for the application of innovative and transformative-based teaching approaches in the technical educational learning context, as advocated by Balasubramanian, Wilson and Cios (2006). Balasubramanian et al. (2006) outlined the need to design interactive learning environments that increase student achievement and promote purposeful social collaboration, distributed cognition, and contextual learning. Hung (2009) posits that problem-based learning is conceivably the most innovative instruction method devised and implemented to enhance students' problem-solving skills and stimulate higher-order thinking and self-directed learning skills in educational contexts.

Problem-based learning (PBL) is defined as

> a student-centred pedagogical strategy that poses significant, contextualized, real-world, ill-structured situations while providing resources, guidance, instruction, and opportunity for reflection to learners as they develop content knowledge and problem-solving skills (Hung, 2009:119).

The literature in respect of PBL has shown that this approach may not have been effective and could therefore affect the extent to which students acquire sufficient domain knowledge, activate appropriate prior knowledge, and properly direct their learning. Against this background, the purpose of this study was to identify the key components needed for effective implementation of PBL in TVET Electrical Engineering teaching and learning practices. To this end, the study aimed to identify and analyse the key components of PBL and their respective roles during each phase of the PBL process. 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

PBL is a complete paradigm shift towards a student-centred approach in which students' learning is triggered by real-life problems 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 taking decisions after conducting research on their own (Purnamawati, Usman & Saliruddin, 2017; Higuera Martinez, Fernandez-Samaca & Serrano Cárdenas, 2021). Therefore, to resolve a 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 problems through a design process. Engineers often design and make artefacts and processes to solve problems based on incomplete knowledge to be applied in a particular environment (Boelt, Kolmos & Holgaard, 2022). This implies that engineers are solutions-oriented and are often faced with ill-defined problems (De Vries, 2005). For this reason, one of the learning outcomes of Engineering education, in particular TVET Electrical Engineering, is to produce graduates who can identify and solve problems in real life (DOE, 2005). Research indicates that the learning outcomes of a subject or programme can best 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 claims to provide (Deep, Salleh & 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 of non-technical aspects such as problem-solving, collaboration and interpersonal skills. The 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 in technical skills but 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 have not had any opportunities to be exposed to innovative student-centred approaches; yet they are still tasked with training Engineering graduates who are supposed to have gained both technical and non-technical skills upon graduation. Recent research conducted by Teis et al. (2022) shows no sign of lecturers receiving any training in applying PBL during their in-service training. Therefore, the purpose of this study is to conduct a scoping review to identify and analyse the key components of PBL, and the evidence gathered will be used to design a PBL intervention that could be used to shift the teaching practices of TVET Electrical Engineering lecturers.

Barriers that may hinder implementation

The literature has also highlighted the possible barriers that might impede effective implementation that designers of the PBL need to consider when designing and planning the PBL as a teaching and learning approach. Some of the barriers that can hamper the effective implementation of PBL include a lack of resources (Amoako-Sakyi & Amonoo-Kuofi, 2015; Mansor et al., 2015), a lack of facilitation skills, and a lack of knowledge of designing scenarios that can motivate students to learn (Sithole, 2011; Farid & Ali, 2012). Amoako-Sakyi and Amonoo-Kuofi (2015) claim that, for PBL to be implemented effectively, resources such as the availability of specially designed and equipped tutorial and meeting rooms and a well-resourced library or media centre with network connectivity should be provided.

According to Brush and Saye (2017), the main barrier that has the greater potential to impede successful implementation is to shift teaching and learning from teacher-centred to a PBL design, allowing teachers to become facilitators as students direct their learning. This is because the shift may be towards an entirely different type of teaching that would entail relinquishing control of the classroom in order that teaching may be more student-centred. This radical shift might pose a challenge to lecturers who are used to being at the centre of the learning process. Thus, before the PBL process is initiated, training must be conducted, particularly for those lecturers who have not formerly engaged in PBL, so as to ensure its successful implementation in the way the literature suggests (Katwa et al., 2018; Tighe, 2020). During this training, the expectations must be clearly stated and the lecturers must receive detailed notes relating to the PBL process (Malan & Ndlovu, 2014; Al-Drees et al., 2015; Ravindranath, De Abrew & Nadarajah, 2016).

The effective group process must also be explained and information regarding relevant websites that could serve as learning resources must be provided in order to promote the effective implementation of PBL (Golightly & Raath, 2015). Thus, for PBL to be implemented the most effectively in the classroom, lecturers must be prepared to facilitate and guide students' learning rather than control it.

Theory underpinning problem-based learning

Significant evidence in the literature has demonstrated that PBL as a teaching and learning approach works best in a constructivist environment, in particular in a social constructivist environment (Sekarwinahyu et al., 2019; Dupri et al., 2020; McQuade et al., 2020; Sousa & Costa, 2020). Social constructivism is based on Vygotsky's view of learning, which places 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. For 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 learning and develops independent thinking skills (Sekarwinahyu et al., 2019).

In PBL, students work collaboratively in small groups to solve problems presented to them 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 'soft' skills such as cooperation, negotiation and communication, which can be useful for students in future and in practical life within a teamwork environment (Ali, 2019; Tsalapatas et al., 2021; Dupri et al., 2020). In following this approach, students construct knowledge for themselves, make comparisons with their peers' knowledge, debate about the information they have found and learnt, and refine their understanding as a result (Alharbi, 2017; Wosinski et al., 2018; Deep et al., 2019), all of which supports 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 at 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, 2022). Sekarwinahyu et al. (2019) hold 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 the constructivist theory of learning, especially 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. A scoping review is a valuable tool used to identify the key components in the literature related to a concept under scrutiny that researchers may adopt in order 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 responds to 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 the key components of problem-based learning with the intention of informing 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 respond to a specific research question or 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 the data (Boelt et al., 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 made for pragmatic reasons and it is worth noting 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 aimed at identifying and accumulating national and international peer-reviewed journal articles published from 2011 to 2022. The search was undertaken on EBSCO as the database, resulting in a total of 56 studies being gleaned, of which 38 were included for thorough qualitative analysis (see 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, which introduced another limitation to this study. In this study, to minimise such limitation, the researcher enlisted the services of a librarian to access these articles. The librarian was not only helpful with accessing articles that required payment, but also assisted 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 were adopted for this study. Thus, during the scoping review, the abstract of each peer-reviewed journal article was reviewed to make a judgement about the significance of the journal article to the study – particularly regarding 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 a 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 using the last name of the first author if more authors were involved in writing the journal article. Finally, saved data were exported to a Refworks account.

In this study, several methods of managing the data were adopted. They 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 a decision whether the journal article was relevant, the following steps were taken: (1) the researcher glanced rapidly at each paragraph's opening sentence without attempting to comprehend every word; and (2) 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.

Identification of studies

Records identified from EBSCO: n = 56
Records screened: n = 56
Reports sought for retrieval: n = 56
Reports assessed for eligibility: n = 56
Studies included in review: n = 38
Reports of included studies: n = 38

Figure 1: Data-collection procedure

Data synthesis and theme generation

Thematic analysis is an approach to qualitative data analysis which involves organising collected data into themes and categorising these so as to better understand the collected dataset (Norton, 2019; Kiger & Varpio, 2020). Thematic analysis is one of the qualitative data analyses used by researchers in qualitative research: the researcher commences by familiarising themselves with the dataset, which entails repeatedly and actively reading through the articles included. This process provided a valuable orientation to the dataset. 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 and 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 consideration the core words in the research question and going through whole datasets accordingly, three main themes emerged: the problem, the facilitator or tutor, and the students. Subsequently, subthemes also emerged, as shown in Table 1.

Findings

Through qualitative data analysis, a plethora of components of PBL were highlighted in 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 Table 1.

Table 1: Key components of PBL and their respective subthemes

PROBLEM	TUTORS/FACILITATORS	STUDENTS
Ill-structured Complex Ill-defined Contextual Not structured Appropriate scenarios Authentic Hypothetical scenarios Problematic situation Shared problems Open-ended Issues Student-driven Role of the problem	Scaffolding Guiding questions Prompts Guide Providing problems Asking questions Facilitating investigation and dialogues Giving advice Task-setter Project supervisor Providing resources Facilitator–student interaction Demonstration Managing behaviours Teacher–student dynamics Role of tutor	Small-group learning Team dynamics Team learning Collective student engagement Dialogue Teamwork Student-regulated learning Peer support Social interactions Collaborative learning Group work Small-group teaching Group discussions Self-regulation Small groups Role of students Active participation Reflection Evaluation

Discussion

The findings revealed that the problem is a prominent component of PBL: it initiates the interaction between the other two components, namely the tutor and the 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 process 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 by 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 a lack of opportunities to develop a particular graduate attribute (Beagon et al., 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 learnt content and the non-technical skills (Frey & Fisher, 2011). Therefore, the 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 accordingly. 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 as one of its learning outcomes the ability to identify and solve a 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 (Beagon et al., 2019; Naji et al., 2020).

The second key component of PBL is the critical role played by the lecturers who serve as facilitators of learning during the different stages of the PBL process (Anazifa & Djukri, 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 multiple roles during the PBL learning process (Anazifa & Djukri, 2017; Beagon et al., 2019; Adamuthe & Mane, 2020; McQuade et al., 2020). Some of the roles that PBL facilitators play include, but are not limited to, guiding and supporting students in formulating the learning issues (Al-Drees et al., 2015; Du Toit, 2015), laying down the rules, setting out boundaries, defining assessment (Raath & Golightly, 2017), and designing and planning the PBL activities (Du Toit, 2015; Gao et al., 2018). Therefore, 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. It is crucial that the stages of PBL be identified during the planning process of the learning activities, as doing so enables the facilitators to organise their roles appropriately and 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 the facilitators' roles during each stage of the PBL is also supported by Anazifa & Djukri (2017), Beagon et al. (2019) and Trullàs et al. (2022). Their research confirms that the efficient fulfilment of the facilitators' roles leads to the successful implementation of 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 facilitators' knowledge of the required pedagogical processes involved in PBL, and their ability to manage activities during each stage of PBL, is crucial to the successful implementation of the strategy.

The last but not least of the components of PBL is that designers of PBL learning activities should consider having students actively engage with the learning activities in the PBL environment through facilitated sessions. The role of students and what is expected of them should be made visible prior to creation of the actual PBL learning environment. One of the key roles of students in a 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 interactions, 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 are of critical importance to the success of PBL, supporting the collective and social construction of knowledge. The findings reveal that small-group learning modes encourage student–student and teacher–student communication during the learning process (Century et al., 2020; McQuade et al., 2020; Naji et al., 2020). Thus, the key ingredient of the successful implementation includes the learning and social environment and self-regulated learning coupled with active, engaged students working in small groups to construct and apply knowledge while exploring solutions to real-life problems (Wosinski et al., 2018; Du et al., 2021). However, the effective implementation of PBL, the role of groups, and the role of the student must be made explicit in all PBL tutorial sessions; hence it must be made clear what the role of the students and small groups is during the first PBL sessions, during self-study, during the second PBL sessions, and during group presentations.

If the roles of the students and small groups are explicitly established and followed without deviations, the practices of TVET Electrical Engineering lecturers can be shifted from teacher-centred to student-centred. Thus, TVET Electrical Engineering lecturers should be motivated to adopt PBL as their new teaching and learning strategy. Their adoption of PBL could make significant contributions to their classroom practices and help their students to acquire the desired non-technical abilities that are valued by contemporary industries.

Conclusion

The identification and understanding of the three key components of PBL and their roles in accordance with each stage of the PBL processes as discussed in this article are of the utmost importance to the successful implementation of the PBL strategy in the TVET Engineering classroom. In this study, the 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 a PBL strategy. The focus of PBL as a teaching and learning strategy, the type of PBL, the nature of the subject or programme and its underlying philosophy, and, finally, the competencies of the facilitators who will be supporting students' learning are essential considerations for the designers of PBL interventions. 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 the 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 strategy. According to this study, it is strongly advised that facilitators who work with PBL obtain the proper PBL training so that 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 to its success, it is of equal importance to consider the other factors that this study revealed. Therefore, the design of PBL interventions has to acknowledge the existence of other factors which are also crucial to the successful implementation of a PBL intervention.

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