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Hybrid problem-based learning in Technology teacher preparation: Giving students a voice in their learning process

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Abstract

Technology education instils technological literacy in South African learners, preparing them for life and employment. Yet, few high school-level Technology[1] teachers are being trained and ensuring that Technology student teachers are optimally prepared, is vital. Learning strategies such as problem-based learning need to be implemented to provide students with opportunities to have their voices heard as well as being actively involved in their education. Hybrid problem-based learning has been successfully implemented in geography and life sciences teacher education, but its use in Technology teacher preparation has not been reported. Therefore, we conducted a concurrent triangulation research study at a South African university offering Technology teacher preparation. In the study, we explored how teacher students experienced and perceived hPBL as a teaching-learning strategy and how this gave them a voice in their teacher training. The study, therefore, substantiated hPBL as a beneficial teaching-learning strategy that can give Technology student teachers a voice and actively involve them in their construction of learning.

Keywords: hybrid problem-based learning, active learning, South Africa, student voice, Technology education, Technology teacher preparation

[1] We use a capital letter here and throughout to avoid having readers confuse the subject area, Technology, with the use of technologies such as computers etc.

Introduction and problem statement

Technology education is vital if we are to instil technological literacy in South African learners to prepare them for their future and develop their knowledge and 21st-century skills (Department of Basic Education, 2011). Few teachers are adequately trained to teach Technology in the Senior and FET Phases of South African schooling, despite the valuable educational benefits of the subject (Ankiewicz, 2020; Gumbo, 2020). Since many teachers struggle to understand the subject content or have limited pedagogical knowledge, they adopt teaching-learning strategies that are misaligned with the preferred Technology education problem-based pedagogy (Ankiewicz, 2020; Gumbo, 2020). Therefore, teacher educators at universities must prepare student teachers for Technology education by using strategies that will be responsive to these contextual requirements and professional expectations while keeping in mind the learning needs and development of the students during the learning process. It is therefore suggested that teacher educators implement active teaching-learning strategies, such as problem-based learning (PBL), in teacher education programmes (Golightly & Muniz, 2013). Few other teaching-learning strategies can accomplish the quality of learning that can be attained by using PBL and, in so doing, contribute to attaining the general aim of the South African National school curriculum that is to prepare and produce learners for the 21st century who can "identify and solve problems, make decisions using critical and creative thinking, and communicate effectively" (Department of Basic Education, 2011, p. 8).

To attain these aims, South African student teachers must be trained to construct learner-centred learning environments. They must be involved in active teaching-learning strategies and given a voice in the planning and execution of their learning tasks (Flavian & Kass, 2015; Fouche & Andrews, 2022; Strydom & Loots, 2020). Students being encouraged to voice their feedback and perspectives on the learning process can "shape our analysis and . . . inform our practice" (Fouche & Andrews 2022, p. 137) as university lecturers. We concur with Flavian and Kass (2015), that "the absence of the students' voice is detrimental to their learning process" (p. 38) and that their input and participation contribute to developing better teacher training programs.

The first issue we aimed to address in this study was how students could be given a voice and play a more active role in their being prepared to become Technology teachers. The second problem had to do with our limited insight into how Technology student teachers perceived hybrid problem-based learning (hPBL) as a teaching-learning strategy as part of their preparation, since this strategy could be useful in increasing their participation and, therefore, their voice in their own learning process. The research questions guiding us were: "How can the use of hPBL contribute to students' voice in the process of preparing them to be Technology teachers?" and "How do students perceive the roles of the different role players in hPBL?" along with "How do students perceive hPBL as a teaching-learning strategy as they prepare to be Technology teachers?" Addressing the third question had to do with our wanting to see how this strategy could be refined in order to increase student participation and voice in their own learning process. Here, we report on a study in which teacher educators implemented PBL along with direct instructional strategies such as lecturing and demonstrations in first-year Technology student teachers' first encounter with the hPBL process.

Theoretical and conceptual framework

The theoretical framework underpinning this study is social constructivism; "the constructs are the social product of the actors involved" (Van der Walt, 2021, p. 65). Learners, as actively participating actors, construct their knowledge and understandings of the world individually and through collaborating with others (Van der Walt, 2021). In this social constructivist study, we viewed learning as a process of collaboration and knowledge sharing between and among individuals as students interacted with each other and with more knowledgeable others such as facilitators, peers, parents, and community members. This led to the construction of many different subjective participant meanings contributed by these actors (see Creswell & Creswell, 2018). Core to the study were the notions of active learning, PBL and hPBL, Technology education, and Technology student teacher preparation.

Active learning

An active teaching-learning strategy is not a single specific method nor a uniform scientific one (Gleason et al., 2011); it combines diverse teaching-learning strategies to support students' learning. Active learning refers to "how students engage with instruction" (Chi, 2021, p. 451) and includes "anything else students do that is more than paying attention only, such as solving a problem" (p. 452). In other words, students are not observers in the learning process; they participate actively as part of their learning. Active teaching-learning strategies combine subject content with the application thereof in learning activities. Students actively construct and become deeply involved in their learning (Chi, 2021). Some prominent active teaching-learning strategies embedded in social constructivism include PBL (Golightly, 2018), hPBL (Ahmad et al., 2015) and project-based learning (Du Toit, 2015). Problem-based learning is an active, constructivist teaching-learning strategy and is the preferred one for Technology education in the South African curriculum (Department of Basic Education, 2011; Du Toit, 2022). This pedagogical approach to Technology education requires learner-centred strategies based on real-world problems (Du Toit & Gaotlhobogwe, 2018).

Problem-based learning and hybrid problem-based learning

For PBL to be effective, the teaching-learning process needs to be well-planned and implemented attentively. The roles of different contributors (or role players) in the process need to be differentiated, and the type of PBL needs to be considered.

Problem-based learning formats

Pure PBL is a format implemented in a fully problem-based methodology based on the McMaster School PBL format (Gleason et al., 2011), often used as the primary teaching-learning strategy throughout an entire curriculum (Al-Drees et al., 2015). The main difference between pure PBL and hPBL is that in the latter format, facilitators include direct teaching-learning strategies, such as mini-lectures and demonstrations as scaffolds during the PBL process (Baresh et al., 2019) to present and explain fundamental concepts and difficult topics. However, hPBL is less resource-intensive and more flexible than pure PBL (Kharay et al. 2018). We found no studies on the implementation of hPBL in the area of South African Technology teacher education in social environments.

The problem-based learning process

Problem-based learning uses real-life ill-structured problems as a context for students to construct knowledge and provide many solutions (Golightly, 2018), based on a more structured way of approaching problems (Malan & Ndlovu, 2014). Examples of ill-structured problems involve having school learners provide ways of using electricity more wisely in their schools or making recommendations about how their school can use recyclable materials to earn extra income to support needy learners. As can be seen in these two examples, there can be many correct answers or solutions to the given problems. Before initiating the PBL process, students are divided into small manageable groups (Ravindranath et al., 2016) and are given training about the process. In hPBL activities, the PBL groups have to attend scheduled face-to-face tutorial sessions. During the first hPBL tutorial session the students are presented with a problem, they analyse the problem in their groups and clarify the different concepts, whereafter they formulate learning issues for further research (Ravindranath et al., 2016). These learning issues are conceptualised into different learning tasks and team members have to do self-directed research in their own time (Golightly, 2018). In subsequent hPBL tutorial sessions, groups and the facilitator meet to discuss their research and the new knowledge. If necessary, students must do further research on some of the learning issues. In the last tutorial session, the group members apply their newly acquired knowledge and formulate possible solutions to the problem (Malan & Ndlovu, 2014).

Role-players in hPBL

During hPBL activities, the facilitator plays a role, and so do students as group leaders or as members of various other groups.

The facilitator plays many roles (as observer, guide, consultant, and assessor) and ensures that the hPBL activities are designed to align with the module outcomes (Mulaudzi, 2021). Facilitators guide and support students in formulating learning objectives and keep them focused on their tasks in hPBL activities (Du Toit, 2022) to sustain effective student involvement (Golightly, 2018). The facilitator sets out rules and boundaries, defines the terms of assessment (Raath & Golightly, 2017), and assists students in selecting learning content.

The group leader is responsible for leading the group, encouraging group members' participation, and ensuring effective time management (Ahmad et al., 2015). Group leaders must treat group members with respect and involve all members in meaningful discussions (Golightly & Muniz, 2013).

The roles of members in groups include being leader, recorder, timekeeper, problem reader, and general group member (Raath & Golightly, 2017). Group members define, demarcate, and discuss the problem together, then identify the learning gaps and formulate the learning issues (Mulaudzi, 2021) that will guide them all during self-study (Malan & Ndlovu, 2014) outside hPBL tutorial sessions. During self-study, group members gather information to assist them to resolve the problem. They reconvene, present their research findings to the group, compile suggestions, generate ideas, and propose, present, and evaluate solutions (Ahmad et al., 2015). Preparing and evaluating the learning experiences and presenting their solutions to other group members all contribute to social constructivist learning (Mulaudzi, 2021).

Students' perceptions of PBL and hybrid PBL

Existing literature indicates that students hold positive perceptions of PBL as a teaching-learning strategy (Du Toit, 2022; Golightly & Muniz, 2013). Golightly and Muniz's (2013) study with geography student teachers revealed that hPBL contributed to their learning motivation, to their taking responsibility for their learning, and to doing problem-solving research. PBL further developed students' subject content knowledge and learning outcomes (Ahmad et al., 2015; Du Toit, 2022). However, studies also reported that some students viewed PBL negatively, based on the belief that PBL increased their workload (Golightly & Muniz, 2013). When students first encounter PBL, they require additional guidance and need to be given a clear scope of work (Du Toit, 2015). Therefore, proper planning of PBL to support the intended learning of both skills and the subject content knowledge is needed (Du Toit, 2022). The increased structured guidance provided in hPBL will address these recommendations. Tican and Deniz (2019) reported that hPBL activities improved students' 21st century skills such as problem-solving and critical thinking. To expand the constructivist nature of this learning, students' voices in relation to their perceptions and experiences of the approach must be included to better align the process to their learning needs (Du Toit, 2022).

The preferred pedagogy for Technology education in the South African curriculum is PBL (Department of Basic Education, 2011) as has already been mentioned, so we go on to explain why this is so.

Technology education

In our study, Technology education refers to the teaching and learning of a set of South African school subjects collectively referred to as Technology subjects. Comparable subjects elsewhere include Design and Technology in Botswana (Du Toit & Gaotlhobogwe, 2018) and the United Kingdom (Hardy, 2023, while New-Zealand's Technology education describes a subject "that enables students' engagement in creative and practical tasks, to problem solve and think in a critical manner about a range of global or local issues" (Reinsfield, 2020, p. 427).

In South Africa, Technology as a school subject is task-oriented and activity-based and this means that it has to be presented differently from other school subjects (Gumbo, 2020). Technology education is intended to be a creative, purposeful learning activity linking material, emotional, cognitive, and creative resources to meet needs and opportunities through the development of products to address practical problems within a particular social context (Department of Basic Education, 2011). Technology is problem-based and scaffolded around the design process, and this challenges teachers to implement constructivist learning approaches (Ankiewicz, 2020). The Technology curriculum requires that learners work individually and as teams and this implies that teachers must be prepared to facilitate such constructivist learning effectively. Secondary school education in South Africa encompasses the Senior Phase (Grades 8 and 9) and the Further Education and Training (FET) Phase (Grades 10, 11, and 12). In the Senior Phase, Technology is a compulsory subject that includes four core content areas: structures; processing; mechanical systems and control; and electrical systems and control (Department of Basic Education, 2011) that are expanded into four specialised subjects in the FET Phase. These are civil Technology, electrical Technology, mechanical Technology, and engineering graphics and design (Department of Basic Education, 2011). To enable Senior Phase Technology teaching, the teachers must know, apply, and facilitate active teaching-learning strategies across all four content areas (Gumbo, 2020) so student teachers must be prepared thoroughly if they are to meet these objectives.

Technology teacher preparation

Technology teacher education aims to equip student teachers with knowledge, skills, and values to teach Technology in South African schools competently (Gumbo, 2020). Student teachers must develop deep content knowledge and strong pedagogical skills to assist the learners in their classes to achieve a deep understanding of technological knowledge and develop the skills needed to function optimally in the 21st century (Mulaudzi, 2021). Student teachers should be adequately trained to develop these skills, including techno-pedagogical, communication, critical thinking, and problem-solving in their learners (Tican & Deniz, 2019).

Technology education is learner-centred and grounded in constructivism. The design process that forms the “backbone for the methodology” in Technology education (Department of Basic Education, 2011, p. 10) aligns well with the requirements of hPBL that emphasises giving learners ownership as co-constructors of knowledge in the learning process. Flavian and Kass (2015) have stressed that students want to be viewed as partners and want to have a more active role in their own learning; hPBL could provide Technology student teachers with a voice by having them actively construct knowledge as part of their learning process. To attain all these goals for the adequate preparation in all respects of Technology student teachers while still giving them a voice in their learning will require careful construction of the teacher preparation programme.

Research methodology

Research design

We used a concurrent triangulation research design, as described by Warfa (2016). This design is referred to by several terms, including mixed methods research and convergent parallel mixed methods research design (Creswell & Creswell, 2018). It is used when the object of the study is to collect both qualitative and quantitative data concurrently in the same phase, after which it is analysed (Warfa, 2016). The design allows for the triangulation of findings and results about a single issue, thus contributing to a more complete or comprehensive understanding of the topic or phenomenon (Creswell & Creswell, 2018). Against this background, we followed a pragmatic research paradigm. According to Ivankova et al. (2022), the pragmatist combines quantitative and qualitative research methods in a study. This study relied mainly on quantitative data (QUAN) and the qualitative data findings (qual) were used to support and help explain the quantitative results. The main objective of this research design is to corroborate or cross-validate findings and/or results by using both quantitative and qualitative means for data collection and analyses (Warfa, 2016). In our study, the quantitative and qualitative data were collected in the same phase of a larger research study, but each data set was analysed separately, after which findings and results about the phenomenon (hPBL and students' experiences thereof) were triangulated to seek convergence from the different methods.

Study context

We selected a first-year B.Ed. Technology education module from a South African university. This module (coded FETE 121) prepares Technology student teachers to teach one of the four content areas in Senior Phase Technology, namely electrical systems and control. The primary module outcome is to develop student teachers' knowledge and understanding of electricity as a content component of Technology education. The module was previously presented using only lectures that were not student-centred but, for this study, hPBL was implemented as the teaching-learning strategy in two of the five study units of the module, amounting to 40% of the entire module.

Participants and scaffolding of the hPBL process

All student teachers registered for the module FETE 121 in 2019 (n=29) were invited to participate in this study that replaced the normal programme. Participation (in other words, contributing information that could be used as data for the study) was voluntary, and they all consented. The Electrical Technology FETE 121 module is compulsory in B.Ed. Technology education. All the stipulations of the ethics committee for conducting this research were carefully adhered to, including obtaining informed consent, and respecting confidentiality, anonymity, and the ethical handling of data. Before implementing hPBL as the teaching-learning strategy, the Technology student teachers were thoroughly prepared by a PBL and hPBL expert to ensure that they understood what would be expected of them. The hPBL expert has been using the strategy for several years and has published extensively on the topic. This preparation included a 90-minute orientation workshop during which the roles of students and the facilitator were discussed. Printed information and websites with additional information on the PBL process were distributed. The student teachers spontaneously formed groups of four or five members resulting in six groups overall. Subsequently, these six groups were presented with three hPBL activities. Activities were based on problems related to electrical Technology content, such as types of energy, and connecting various components in circuits for particular outcomes. The three hPBL activities were developed in consultation with the module facilitator to ensure alignment with the prescribed FETE 121 module outcomes. A lecturer guided and assisted students and acted as a facilitator during the PBL activities. The researcher (the first author) was a detached observer during the process and was helped by a research assistant (the second observer) to collect and organise data sets. The second and third authors supervised the study.

Data collection

Quantitative data (using an adapted hPBL questionnaire) and qualitative data (using semi-structured individual interviews, students' self-reflective journals, and observations) were collected. The hPBL questionnaire was adapted from Golightly and Muniz's (2013) PBL questionnaire (43 items) in geography education, from which 18 items were selected based on their alignment with the purpose of our study. The discarded items dealt with assessment that fell outside the scope of the current research. The acronym PBL was changed to hPBL (to include the hybrid approach), and references to geography were changed to Technology in all the questionnaire items used. The adapted hPBL questionnaire was divided into two parts to measure the Technology student teachers' perceptions and experiences of the hPBL process (11 items) and students' perceptions and experiences of the conduct of the different role players (facilitator (2 items); group members (3 items); and group leader (2 items)). Items were answered on a 5-point Likert scale. Researchers' field notes detailing their observations and Technology student teachers' reflective journals provided qualitative data, together with semi-structured individual interviews (lasting about 30 minutes each, audio-digitally recorded, and transcribed) were conducted with eight voluntary participants regarding their experiences of hPBL.

Table 1
Overview of methods and types of data collected

Methods	Types of data collected
hPBL activities 1 to 3	Qualitative data Researcher observation and field notes (during the activities) Student reflective journals (at the end of each activity)
Questionnaire	Quantitative data Students completed the adapted hPBL questionnaire
Interviews	Qualitative data Semi-structured individual interviews with volunteers

These methods (see Table 1) were designed to give students a voice in their learning development, thus forming an integrated qualitative data set of detailed descriptions of students' experiences and perceptions of hPBL to provide deeper insights into the quantitative results. To ameliorate potential participant bias regarding the questions in the questionnaire, the researcher, as well as the assistant researcher (the second observer), observed and took field notes during the PBL tutorial sessions.

Data analysis

Descriptive statistics such as the mean, standard deviation, and percentages were used to report the results. An independent statistical consultation service processed quantitative data using statistical software SPSS (Version 25). Concept-driven codes and categories (based on existing literature) were used for qualitative data analysis by systematically dividing up raw qualitative data (researchers' field notes, transcribed interviews, and student teachers' self-reflective journals). The reliability of the adapted hPBL questionnaire was calculated using Cronbach's alpha coefficient, delineating that if the questionnaire is used at different times or with different respondents of the same population, similar results should be obtained (Creswell & Creswell, 2018). The Cronbach's alpha coefficient values for the two components of the adapted hPBL questionnaire, namely Technology student teachers' perceptions of the hPBL process and their perception of the conduct of the different role-players in hPBL, were 0.781 and 0.821, respectively, contributing to the reliability of the quantitative data.

The procedures proposed by Thomas and Magilvy (2011) for dependability of the qualitative findings, were used. The procedures used to ensure the credibility of the findings were that the researcher explicitly defined the purpose of the study and discussed in detail:

- the sampling framework and criteria to explain how and why the Technology student teachers were selected;
- the data collection methods and the time period needed to collect the data for the study;
- the data analysis process used in the study; and
- the presentation and interpretation of the study findings.

Study limitations

The small sample size may have limited this study's eligibility as a determinant of the full potential that the hPBL-intervention had (or could have) on Technology student teachers. The current investigation was implemented over a short period (5 weeks) and might have yielded different results had it been implemented over a more extended time period.

Research results and findings

The quantitative data obtained from the adapted hPBL questionnaire informed the results reported on in this section. The findings are based on qualitative data (Table 1) that contributed complementary and deeper insights into the results through triangulation. Statements from individual students that reflect the views of most of the students were included to illustrate some of the findings.

Technology student teachers' perceptions and experiences of the hybrid problem-based learning process during the hPBL activities

Table 2 displays data concerning students' perceptions of the hPBL process. Students' mean scores of the hPBL process scale items ranged from 3.07 to 4.41 (all items above-average $\bar{x}$ = 2.5) on the 5-point Likert scale. Overall, students held positive perceptions of all the items associated with the hPBL process, therefore most students perceived their involvement in the hPBL activities as a positive learning experience. The highest scoring items in Table 2 indicated by students include "I find it to be effective when fellow students assist me with the mastering of skills and knowledge" (mean = 4.41), "I had the opportunity to share my knowledge with the other students in the hPBL activities" (mean = 4.17) and "hPBL encourages the integration of different study materials (resources) in order to solve the problems" (mean = 4.00). This is encouraging since the implementation of hPBL challenged students to take responsibility for their learning.

Numerous qualitative findings supported this quantitative result. For example, an interviewed student (Participant 3) mentioned that the hPBL process helped their group solve problems and learn about electrical concepts and said,

> The Technology problems we had to solve helped us to learn a lot about the electrical concepts found in the FETE module, in particular, the difference between parallel and series wiring.

A focus group student (Participant 1) commented that more hPBL should be applied in other Technology modules, thus echoing positive perceptions about this teaching-learning strategy when they said,

> In my opinion, the way we worked well within our groups, hPBL activities should be implemented on a more regular basis in all our Technology modules and other modules as well.

Other students pointed out that the hPBL activities developed their collaborative abilities, improved their communication and time-management, and had them take responsibility for their learning. For Participant 2,

> hPBL provides us with the opportunity to communicate in writing when one had to submit the self-study information and that had improved my writing skills as the

hPBL compiler effectively compiled our documents for submission without any difficulties.

For Participant 1,

hPBL is advantageous in the sense that it provides students with the opportunity to take responsibility for their own study by giving students the opportunity to set learning objectives and set certain times and to be able to meet them on their own.

These findings indicate that enabling communication and creating a conducive environment in which students can openly voice their views are vital elements during students' learning in hPBL environments.

Table 2
Technology student teachers' (n=29) perceptions of the hPBL process

hPBL Process Scale Items	**Totally Disagree**		**Disagree**		**Neutral**		**Agree**		**Totally Agree**		**Mea (x̄)**	**Std Dev**
	F	***freq %***	***F***	***freq %***	***F***	***freq %***	***F***	***Freq %***	***F***	***freq %***		
I find it to be effective when fellow students assist me with the mastering of skills and knowledge.	0	0	0	0	3	10.4	1	37.9	1	51.7	4.41	0.682
I had the opportunity to share my knowledge with the other students in the hPBL activities.	1	3.4	0	0	2	6.9	1	55.2	1	34.5	4.17	0.848
hPBL encourages the integration of different study materials (resources) in order to solve the problems.	1	3.4	1	3.5	2	6.9	1	62.1	7	24.1	4.00	0.886
I experienced quality interaction with fellow students in terms of learning.	0	0	1	3.5	5	17.2	1	62.1	5	17.2	3.93	0.704
The group easily identified learning issues.	0	0	1	3.5	7	24.1	1	62.1	3	10.3	3.79	0.675
The assessment rubrics for the hPBL reports effectively guided the group in the writing of the reports.	1	3.5	2	6.9	7	24.1	1	37.9	8	27.6	3.79	1.048
hPBL will definitely assist me in becoming an independent, self-directed learner.	0	0	2	6.9	1	34.5	1	34.5	7	24.1	3.76	0.912
The hPBL assessment rubrics were useful in enabling group members to monitor their progress.	4	13.8	3	10.4	7	24.1	9	31.0	6	20.7	3.34	1.317

hPBL Process Scale Items	Totally Disagree		Disagree		Neutral		Agree		Totally Agree		Mea ($\bar{x}$)	Std Dev
	F	***freq %***	***F***	***freq %***	***F***	***freq %***	***F***	***Freq %***	***F***	***freq %***		
The use of direct instructional strategies (lectures/demonstrations) during the hPBL process assisted students in solving the problems.	4	13.8	1	3.5	1	44.8	4	13.8	7	24.1	3.24	1.431
hPBL increases the workload of students.	2	6.9	7	24.1	9	31.0	5	17.3	6	20.7	3.21	1.236
The delimitation of the stated Technology problems is difficult.	0	0	6	20.7	1	55.2	6	20.7	1	3.4	3.07	0.753

The two items, "The delimitation of the stated Technology problems is difficult" and "hPBL has increased my workload" received the lowest mean scores of 3.07 and 3.21, respectively. Interestingly, 38% of the students believed hPBL increased their workload. Remarks by two students in their reflective reports echo this finding: "hPBL demand[s] that we carry [out] our own research . . . which is more work than when the lecturer gave us a powerpoint to prepare for test and exam" and "hPBL demanded a lot from us, it required us to get along with each other and search for information . . ."

Technology student teachers' perceptions and experiences of the conduct of role-players during the hPBL activities

Students' perceptions and experiences of the different role-players in hPBL were measured by seven items in the adapted hPBL questionnaire (see Table 3). The qualitative data from individual semi-structured interviews, observation field notes, and students' self-reflective journals were triangulated with quantitative data.

Table 3
Technology student teachers' perceptions and experiences (n=29) of the conduct of role-players

Role-players and Items		Totally Disagree		Disagree		Neutral		Agree		Totally Agree		Mean ($\bar{x}$)	Std Dev
		f	***freq %***	***f***	***freq %***	***F***	***freq %***	***f***	***freq %***	***f***	***freq %***		
Facilitator	The facilitator (lecturer) encouraged groups to make use of different resources to solve the problem.	0	0	0	0	7	24.1	10	34.5	1	41.4	4.17	0.80
	The facilitator gave constructive guidance to foster effective group work for the solving of the problems.	0	0	1	3.5	9	31.0	12	41.4	7	24.1	3.86	0.83
Group leader	The group leader involved group members in meaningful discussions and communications.	1	3.5	4	13.8	7	24.1	8	27.6	9	31.0	3.69	1.16
	The group leader encouraged group members to share their own opinions	1	3.5	3	10.3	9	31.0	8	27.6	8	27.6	3.66	1.11

Role-players and Items		Totally Disagree		Disagree		Neutral		Agree		Totally Agree		Mean (x̄)	Std Dev
		f	*freq %*	*f*	*freq %*	*F*	*freq %*	*f*	*freq %*	*f*	*freq %*		
Group members	Group members exhibited respect for one another's opinions and views.	0	0	0	0	5	17.3	7	24.1	1	58.6	4.41	0.78
	Group members helped me to understand the necessary concepts, ideas, and study content towards the problem solution.	1	3.4	1	3.4	5	17.3	8	27.6	1	48.3	4.14	1.06
	Group members worked together well to solve the problems.	0	0	2	6.9	7	24.2	9	31.0	1	37.9	4.00	0.96

The Technology student teachers' perceptions of the role played by the facilitator in hPBL

The mean scores of the two items that reported on the conduct of the facilitator were 3.86 and 4.17, respectively (Table 3). Students clearly agreed that the facilitator encouraged them to use different resources to solve the problem, as evidenced by the 75.9% (n = 22) of students who agreed or totally agreed on this. An interviewed student commented that the facilitator constantly encouraged her to consult different resources to gain different perspectives in understanding electrical concepts. Another student reported in their reflective journal that the lecturer gave them information on what to expect when solving the problem and which resources they should use to help them solve the problem. Interview Participant 1 said,

> Okay, firstly the lectures gave us the knowledge of what we should expect when solving the problem and which resources we should look at to find information in solving the problem.

For Interview Participant 4,

> Because of his [the facilitator's] guidance and encouragement to always listen to each other, nobody argued in our group. Our entire group ended up understanding the problem better after our group discussions.

And in the Self-reflective Journal No. 9, we read,

> The lecturer encouraged us to use different resources so that we gain different perspectives as some resources explain better than the other resulting in understanding the electrical concept in multiple ways. This assisted us in understanding the electrical concepts better by comparing the characteristic of parallel and series circuits using both text and diagrams.

These results and findings underscore the facilitator's critical role in hPBL in enabling students to solve the problem and master the intended learning content successfully. Students also commented that the facilitator provided them with constructive guidance that effectively fostered group work to solve the problems. They all affirmed that they believed that hPBL as a process would have been overwhelming and discouraging without this guidance.

Furthermore, 37.9% of students in the study believed that direct instructional strategies in the hPBL process assisted them in solving the hPBL problems ($\bar{x} = 3.24$), but 44.8% were neutral. Some students believed that they would have struggled to identify the problem and learn the content in the module without direct instructional strategies. For example, Interview Participant 2 said,

> It [direct instructional strategies by the facilitator] provided us with guidelines so you know more or less what is expected of you. For example, activity three was about designing the circuits for the trailer lamps, we thought we had to perform a practical activity like really making the trailer, but we were only expected to design the electrical circuits and we manage to finish the activity with the help of the direct instructional strategies provided to use by the lecturer.

Students reported that mini-lectures and demonstrations enabled them to identify the problem independently and learn the required electrical Technology content.

Technology student teachers' perceptions and experiences of the conduct of the group leader

The mean scores of the two items that report on the conduct of group leaders were 3.69 and 3.66, respectively (Table 3). 58.6% (n=17) of the students agreed or totally agreed that group leaders had involved group members in meaningful discussions and communication, thus indicating that most participants believed that the conduct of the group leader contributed to their meaningful learning during the hPBL activities. The two observers' field notes reflected that the group leaders had effectively encouraged and involved group members in meaningful discussions on the identified learning issues during the hPBL tutorial sessions, as was also evident in students' own experiences. For Interview Participant 2,

> The group leader encouraged every member to come prepared for the tutorial sessions and actively contribute to the discussion that helped our group to come out with multiple ways to solve the problem. He encouraged us to explain electrical concepts using our own words and asked us clarity-seeking questions so that every one of us gains a common understanding of the electrical concepts being discussed.

Interview Participant 4 said,

> The group leader encouraged us to freely communicate and wanted us at all times to treat each other with respect and dignity, as a result, we gained confidence in expressing ourselves during group discussions.

Technology student teachers' perceptions and experiences of the conduct of the group members

The mean scores of the three items that reported on the conduct of group members in the hPBL process were 4.41, 4.14, and 4.00, respectively (Table 3). Most of the students (82.7%) agreed or totally agreed that group members exhibited respect for one another's opinions and views. Most interviewed students added that their involvement in group activities helped them to socialise and that it fostered effective communication. Several students also mentioned that their presentation and self-expression skills developed during the hPBL activities. Their involvement in group work activities and the respect from fellow students when they were presenting and discussing the Technology problems boosted their confidence and contributed greatly to their learning. Group members also helped each other understand the concepts, ideas, and learning content necessary to solve the stated problems. Most students (n = 22; 75.9%) agreed or totally agreed that fellow group members helped them gain a better understanding of electrical concepts (Table 3). Several students expressed their enjoyment of the learning process in solving real-world problems. For example, we read in the Self-reflective Journal No. 22,

> The way we worked well together was very much encouraging, the way we freely contributed ideas and brainstormed them helped us to find the solution without any difficulties. We proudly presented as a group a respectable and quality report at the end of each activity.

And, according to the Self-reflective Journal No. 26,

> It was fun when we [had] to design electric circuits (brake light, hazard, indicators, and tail lamps) of the trailer. Everybody. . . played the part due to them and we ended [up] submitting a highly respectable hPBL activity report.

Discussion of the findings and results

We discuss first the results and findings concerning the Technology students' perceptions of the hPBL process and then those regarding the different role players. In support of the view that students' feedback and perspectives on the learning process can "shape our analysis and . . . inform our practice" (Fouche & Andrews, 2022, p. 137), we also indicate how the socially constructed hPBL process provided opportunities for students to use their voices and be actively involved in their education. These discussions also link back to the theoretical framework and the study's pragmatic research paradigm.

Technology student teachers' perceptions and experiences of the hPBL process

Students held positive perceptions of the hPBL process. They highlighted, in particular, the support and assistance of fellow students in their mastering of knowledge and skills, as well as their sharing of this knowledge with other students during the hPBL activities.

Most students agreed (in their self-reflective journals and interview responses) that the collaboration between and among group members during the hPBL process contributed to and enabled them to control the learning process, in line with the findings of Golightly (2018). In this study, only 37.9% of the students agreed or totally agreed that the use of direct instructional strategies in the PBL process assisted them in solving the stated problem. This finding differs from that of Chilkoti et al. (2016) in which most of the medical students highlighted the importance of using lecture-based methods and group discussions during the hPBL process in solving the problem.

According to the module facilitator, the student teachers solved all the technological problems with the support of the scaffolding in the hPBL, as was evident from their assessment marks for the three hPBL activities. The Technology problems used to guide the learning process were regarded as neither easy nor difficult. This result echoes the recommendations of Wass and Golding (2014) that the problems used for PBL activities should be designed so that students complete the task with some assistance from the facilitator and group members. In our study, students held positive perceptions about the hPBL process, confirming the findings of Al-Drees et al. (2015). Technology student teachers reported that hPBL was interesting and a good learning approach and this finding was similar to those of Golightly and Muniz (2013). The guidance students received from the facilitator and the discussions during group tutorial sessions contributed to the construction of their social learning. Expressly inviting students' feedback and comments on the process gave them a voice in how the hPBL was presented and explained in their electrical Technology module since it helped shape the insights of the module developer and the facilitator on this praxis. Students' feedback will also serve to inform future adaptations to improve the implementation of similar hPBL strategies in the Technology education teacher preparation programme.

Technology student teachers' perceptions of different role players in hPBL

The primary role players in hPBL were the facilitator, the group leaders, and the group members.

The Technology student teachers' perceptions of the role played by the facilitator

The facilitator used their Technology education expertise to facilitate and guide students in the hPBL tutorial sessions towards solving the stated Technology problems successfully. A number of interviewed students mentioned that the facilitator had guided them in implementing the hPBL and helped them to stay focused on the task at hand. This was in line with the recommendation of Yadav et al. (2018) that the facilitator should ensure that students fully understand the hPBL process before its implementation to gain their acceptance of this teaching-learning strategy. They also highlighted that facilitators need training to enable them to facilitate hPBL effectively. Interestingly, most of these Technology students appreciated to a great extent the conduct of the facilitator who contributed to their learning by encouraging them to use critical and creative thinking to solve Technology problems, and apply the knowledge gained. They believed that this contributed to fostering their 21st-century skills. The results and findings of our study support those of Yadav et al. (2018) regarding the critical role of the facilitator during the hPBL process. In their role as a listener the facilitator served as the main audience for what the students had to say, and they then used this feedback to reflect on their own praxis for future implementation or adaptation of the same strategies. All interviewed students mentioned that the facilitator motivated them to consult different resources. Several comments in students' self-reflective journal entries made the same point. The importance of students consulting different sources to solve the ill-structured problems was mentioned by Du Toit (2015). It can be seen, therefore, that the facilitator plays a vital role as a co-constructor of knowledge in the successful implementation of hPBL.

Technology student teachers' perceptions of the role played by the group leader

Students were very appreciative of the group leaders' contributions during the hPBL process. All interviewed students noted that group leaders treated them with respect, led the groups well, encouraged group members to participate in meaningful discussions, ensured that hPBL tutorial activities were started on time, and managed time effectively during tutorial sessions. The results and findings in this study indicate that group leaders' positive conduct in tutorial sessions contributed to Technology student teachers' positive perceptions of hPBL. These results and findings align with those of Ahmed et al. (2015) and Golightly and Muniz (2013), who reported that influential group leaders treat group members with respect, perform their duties effectively, encourage group members' active participation, and involve group members in meaningful discussion. It is clear that group leaders play a vital role in the implementation of hPBL by encouraging students to co-construct knowledge and, in this way, have a voice in the learning process.

Technology student teachers' perceptions of the roles played by the group members

Most group members exhibited respect for each other's opinions and views during the hPBL process, mirroring the recommendation of Baresh et al. (2019) that group members treat each other's opinions and views in this way. Our study also found that most group members worked well together to solve Technology problems. In their reflective journals, most students noted that their hPBL activity reports were completed because of good communication, collaboration, and the sharing of ideas between and among group members. Effective communication, collaboration, and problem-solving are valuable 21st-century skills for teachers to have (Tican & Deniz, 2019). The lecturer encouraged students to listen to each other and offered ample and explicit opportunities to comment on the construction, implementation, and effectiveness of the hPBL process. All these aspects provided opportunities for students to contribute to the co-construction of the learning process by having their say and, in this way, adding their voice. In summary, student teachers in this study were given a voice in their learning process, developed 21st-century skills, and gained more knowledge when they were respectfully exchanging ideas and resources. In this way, group members acted as scaffolding agents during the hPBL process and can be seen to have been vital for the effective implementation of hPBL, developing knowledge and skills, and giving voice to students in their construction of learning.

Conclusion and recommendations

This study highlighted the benefits that hPBL can contribute to Technology teacher preparation and how it supports teacher educators in their quest to prepare these student teachers optimally for the various contextual demands and particular professional expectations required in the implementation of Technology education. The socially constructed development of knowledge and meaning making in the hPBL process was perceived positively by students and the module facilitator, who were all co-constructors of this learning. Students reported positive perceptions and experiences with all components of hPBL, including the process and the different role-players involved. The students' feedback confirms that the hPBL approach motivated them to learn. Technology student teachers perceived and experienced hPBL sessions as an interactive teaching-learning strategy and reported on its contribution to improving their electrical Technology content knowledge and fostering their 21st-century skills development. The effective use of hPBL as a teaching-learning strategy in Technology education gave students a voice in planning and constructing their learning and in their preparation as future teachers. Subsequent longitudinal studies could explore the long-term influence of hPBL-interventions on the preparation of student teachers. We also recommend experimental studies dealing with the implementation of hPBL with students in experimental and control groups at different universities in South Africa. Investigating the suitability of hPBL as a teaching-learning strategy could be extended to other Technology subjects and year groups in future studies.

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