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Problem-based Intervention via Task-based Scenarios

Analysis of Practical Skills Acquisition Relations in Vocational Electrical Technology

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Abstract

The inability of vocational electrical technology (VET) students to transit from school-to-work after graduation shows that the practical skills needed for employability are far from being achieved. This has caused an increased unemployment rate among VET students. Hence, this study ascertained the relationships between problem-based intervention via tasks-based conduit wiring scenarios in VET students' practical skills acquisition (PSA). Specifically, this study determined the sequential mediation effects of intrinsic motivation and ability beliefs on problem-based and practical skills acquisition relationship. A cross-sectional study design was adopted for the study. Data was collected from 78 VTE students that gave their consent to participate. The outcome revealed that problem-based intervention is a positive and significant predictor of VET students' practical skills acquisition tasks. The result also revealed sequential mediating effects of intrinsic motivation and ability beliefs

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on problem-based and practical skills acquisition relations. This study is unique in that it examines how intrinsic motivation and ability beliefs sequentially mediate the link between problem-based interventions and the development of practical skills in vocational electrical technology (VET) students. By addressing the critical gap in employability skills through task-based conduit wiring scenarios, it provides novel insights into enhancing school-to-work transitions for VET graduates.

Keywords: Problem-based learning; Practical skills acquisition; Intrinsic motivation; Ability beliefs; Vocational and technical education; Electrical technology; Domestic conduit wiring.

Introduction

Globally, the place of Vocational and Technical Education (VTE) in fostering the needed and demand driven industrial/technological workforce cannot be overemphasized (Ernest & Ansah, 2013; Urama, & Ndidi, 2012). VTE is at the frontline of providing technical and vocational skills to prospective VTE graduates to either secure employment, or become self-employed in their various areas of studies such as vocational electrical technology (Bakare & Orji, 2019; Federal Republic of Nigeria, 2013). Hence, well-organized and quality practical skills acquisition among students is fundamental to achieving this goal. Nevertheless, the inability of vocational electrical technology students to transit from school-to-work after graduation shows that the practical skills needed for employability are far from being achieved. In addition, empirical evidence has shown that vocational electrical technology students have low-class participation in practical skills outcomes due to the type of teaching and learning method applied by lecturers (Atsumbe et al., 2018; Husain et al., 2012; Olelewe et al., 2021; Orji, 2015; Orji & Ogbuanya, 2018, 2020; Tugwell, 2020; Zhang et al., 2020). There is need for an appropriate learning method that can improve vocational electrical technology students' practical skills learning outcome in developing countries like Nigeria.

In recent time, practical skills acquisition (PSA) has become a popular demand in Nigeria higher education due to its perceived remarkable role in facilitating students skills development, school-to-work transition and self-reliant decisions (Okolie et al., 2021; Orji & Ogbuanya, 2020). Idoko, (2014) defined PSA as the process of developing new skills, practice, and ways of performing a task, gained through training or experiences. Similarly, (Okwelle & Ojutule, 2018), conceptualized PSA as a planned training process that ultimately leads to efficiency in a given trade. In the same vein, practical skills and competencies are essential for all individuals to live and contribute to their society's development (FRN, 2013). Unfortunately, the level of practical skills acquired by vocational electrical technology students through lecture methods is characterized by passiveness, thus not encouraging. Prior studies (Orji & Ogbuanya, 2020) have suggested that students PSA needs further investigation to understanding how active instructional approach like problem-based learning experience can impact on students' practical skills outcomes, and behaviour to address their skills needs. Previous studies on PSA (Idoko, 2014; Okwelle & Ojutule, 2018; Raimi & Adeoye 2002) notwithstanding, little is known about how problem-based learning might enhances students PSA. This indicates an important empirical and theoretical gap that requires further investigation.

Our study seeks to fill this literature gap by not only looking at the problem-based learning and PSA relationship but also the psychological mechanisms through which problem-based learning might influence such relationship. Orji & Ogbuanya, (2018) defined PBL as a learner-centred pedagogical approach in which a real problem scenario or task serves as a stimulus for applying problem-solving, collaborative and self-directed learning skills among learners. Likewise, Dolmans et al., (2005) defined PBL as a self-directed, constructivist, contextual and collaborative process that provides opportunities for students to improve their problem-solving, creative/critical thinking, reflective and teamwork skills using a problem scenario. PBL has the potentials of improving VET student's practical skills acquisition purposefully. (Orji & Ogbuanya, 2020) produced a vital contribution towards the establishment of a link between PBL and student's practical skills acquisition. Their study suggests that students exposed to new learning environment with an appropriate learning strategy tends to improve the time and effort committed to a given practical skills activity. Although (Orji & Ogbuanya, 2020) investigation provided a useful insight, it considered just the student's engagement in practical skills acquisition. The study did not obviously examine the actual practical skill involvement which shows the degree to which students are making active progress in the practical activities presented. Also, existing studies on PSA (Ogbuanya & Chukwuedo, 2017; Okolie et al., 2021; Okwelle & Ojutule, 2018) did not look at how PBL interventions and psychological mechanisms might influence VET student's practical skills acquisition. Therefore, an empirical enquiry is needed to fill this knowledge gap.

During PBL instructional delivery, some psychological mechanisms might intervene in the association between PBL experience and student's practical skills acquisition. Self-determination (Deci & Ryan, 1985) and implicit theory of ability (Dweck, 1986) emphasized intrinsic motivation and ability beliefs as the two important psychological components that can influence students interest to acquire practical skills. This mechanisms according to LaForce et al., (2017) influences students view of their present capability at a given practical task and the self-confidence and belief to execute behaviours necessary to produce specific performance attainments. Despite that previous studies have found that PBL improved students' intrinsic motivation and self-efficacy (Massa et al., 2009), empirical research examining its serial mediating roles in the association between PBL experience and student's PSA is unexpectedly lacking. Theoretically, this study hinges on Self-determination theory (Deci & Ryan, 1985) which helps understand students become self-determined when their needs for autonomy, competence, and relatedness are fulfilled and implicit theory of ability (Dweck, 1986) which helps to clarify students interest to pursue and value different achievement goals, that leads to practical skills achievement.

Overall, this empirical research contributes to the increasing practical skills acquisition and problem-based learning experience literature by postulating and testing an indirect effect model that integrates intrinsic motivation and ability beliefs as intervening variables. The result of the study provides further empirical evidence that extends current conceptualization in this study area.

We hypothesized a model as shown in figure 2 to guide the authors to properly develop the following hypotheses that were afterward tested:

1. Problem-based learning experiences (PBLE) will significantly predict (a) practical skills acquisition (PSA) outcomes, (b) intrinsic motivation and (c) ability beliefs.
2. Intrinsic motivation will significantly predict practical skills acquisition (PSA) outcomes.
3. Ability beliefs will significantly predict practical skills acquisition (PSA) outcomes.
4. The effect of PBLE on practical skills acquisition from task 1-5 will be mediated by increased intrinsic motivation and ability beliefs as a result of the intervention.

Method

Procedures and participants

Eighty-eight (88) vocational electrical technology students in southeast universities in Nigerian consented to participate in the study. But only 78 students who meet the inclusion criteria were recruited. The sample size was determined to be statistically adequate for the study with the aid of Gpower software (Faul et al., 2007). The Gpower analysis revealed that a total sample of

88 would be adequate based on a *priori* statistical power of 0.95 at 0.05 alpha level to conduct multiple regression. Written permission was granted by the lecturers, and informed consent was obtained from the students. This study received ethical approval from the Faculty of Vocational and Technical Education Research Ethics Committee at the University of Nigeria, Nsukka. The demographic data in figure 1, showed that 24 (30.8%) participants were 16–18 years, 33 (42.3%) were 19–21 years, while 21 (26.1%) were between 22 years and above. Based on study hours among the treatment group, 19 (24.4%) study for less than an hour, 26 (33.3%) study between 1 and 3 hours, 16 (20.5%) study between 3 and 5 hours while 17 (21.8%) study for above 5 hours every week. Also, 30 (38.5%) of the participants were from University of Nigeria, Nsukka (UNN), 37 (47.4%) were form Nnamdi Azikiwe University (NAU) Awka, and 11 (14.1%) were Chukwuemeka Odimegwu Ojukwu University Uli. The vocational electrical technology programme in the institutions used were male-dominated. However, gender was not included in the demographic data because the few female participants did not meet the study inclusion criteria.

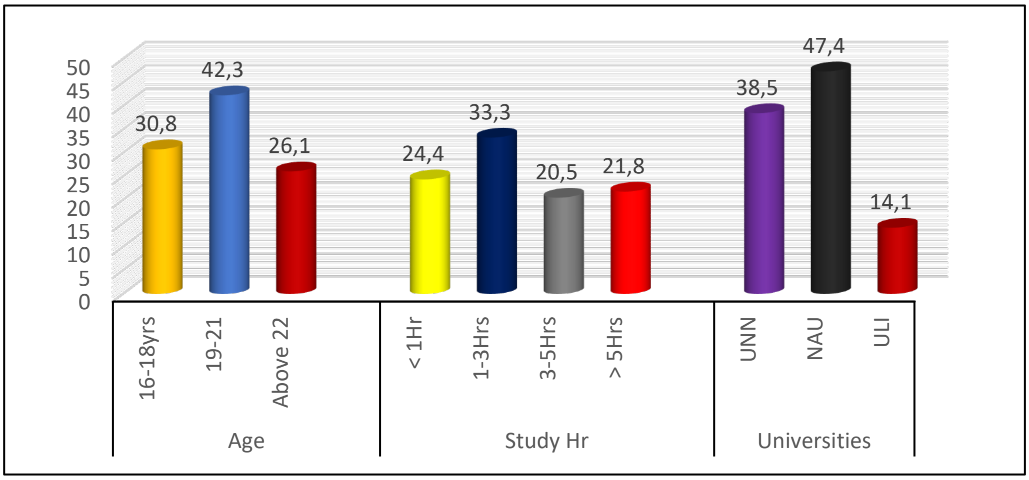

Figure 1. Demographic chart.

Following participant recruitment, the study focused on the implementation of a structured problem-based learning (PBL) intervention developed by the researcher. The intervention spanned eight weeks, with two 2-hour sessions conducted weekly. Students were divided into small collaborative groups and exposed to five sequenced performance tasks based on authentic problem scenarios in domestic conduit wiring (see Table 1). These tasks were carefully sequenced and included identifying the correct circuit positions; preparing the conduit for marking out and laying the appropriate boxes; demonstrating how to draw lighting cables; terminating and mounting components such as the ceiling rose, wall brackets, sockets, switches, and the cooker control unit (CCU); and inspecting the installation for straightness of fittings, loose cables, unterminated circuits or boxes, and the effectiveness of the earthing system. The

PBL process followed a consistent cycle: during the first session of each week, students analysed the problem scenarios, identified learning gaps, and developed hypotheses. In the second session, they engaged in peer teaching, group presentation of findings, and participated in structured reflection. Research assistants guided the sessions using the performance task and problem scenarios to ensure fidelity and consistency in delivery. At the end of the intervention, validated instruments were administered to collect cross-sectional data on students' PBL experiences, intrinsic motivation, ability beliefs, and practical skills acquisition through both questionnaires and performance assessments.

Task	Performance Task	Problem Scenarios
1	Identify circuit positions for: lightning points, sockets, water heater, cooker control unit, A/C and consumer unit.	Mr. Usman noticed that a lighting switch and an air conditioning socket were installed inside the toilet, while the consumer unit was located inside the bathroom. As a skilled craftsman, explain to your apprentice why these installations are unsafe and outline the correct procedure for positioning electrical fittings in wet or damp environments, referencing standard safety codes and best practices.
2	Preparing the conduit: for marking out, laying of appropriate boxes, laying of pipes, proper application of PVC gum and making a good bend.	Jude was assigned to complete a cable run and finalise the installation process. However, he encountered an obstruction that prevented the fishing tape from passing through the expected conduit path. As a professional, guide your apprentice on how to resolve this issue on-site and suggest preventive measures that should be taken during the initial planning and conduit installation stages to avoid such blockages.
3	Demonstrate how to draw light cable from distribution Board (DB) to the box, drop the lamp feed cable at the box, draw switch feed cable from the box 2 switch and back to box, draw life, neutral and earth cables from DB to the sockets, draw cable from DB to the CCU	Mr. Amadi neglected to accurately measure the distance between the distribution board and the designated points for the air conditioner and water heater. Consequently, the fishing tape could not reach either terminal point. Advise your apprentice on the importance of precise measurement before conduit installation and explain the correct procedures for determining cable lengths in residential wiring systems.
4	Terminate and mount the ceiling rose, the wall brackets, the sockets, the switches and the CCU.	After completing the termination and installation of lighting points, Mr. Johnson observed that the lighting in the sitting room was not functional. Upon testing the switch, it showed a weak current flow, insufficient to power any appliance. Additionally, slight electrical shocks were experienced when touching household appliances and even bathroom tiles. Instruct your apprentice on the likely causes of this anomaly, the appropriate diagnostic approach, and safety protocols to follow in identifying and resolving such faults.
5	Inspect for straightness of fittings, inspect for loose cables, inspect for unterminated circuits/boxes and inspect the effectives of the earth.	During inspection of his newly constructed home, Mr. Jacob discovered that the wall switch intended for lighting was instead controlling the ceiling fan, while the fan regulator controlled the lighting fixtures. Further, activating the lighting switch caused all lighting points to trip the circuit breaker. Educate your apprentice on the probable wiring errors that led to this situation and demonstrate how to correctly map, label, and connect control switches and regulators to their designated loads.

Table 1. Specific examples of performance task and problem scenarios used during the intervention

Measures

The instrument has two sections A and B. Section A comprises demographic information about the students while section B measured PBL experiences, intrinsic motivation, ability belief, and practical skills acquisition outcomes.

The student's problem-based learning satisfaction scale (SPBLSS) is a 12-items questionnaire developed by the researcher to measure electrical/electronic students' satisfaction of their problem-based learning experience based on previous literature reviewed (Munshi et al., 2008, Savery, 2015; Dolmans et al., 2005; Jacobs 2003, Patria 2015). Items of the SPBLSS were rated on a five-point scale ranging from (0 - Strongly Disagree to 4 - Strongly Agree). The SPBLSS total score can range from 0 to 48. Higher scores reflect the high level of PBL satisfaction and are based on a purposively set cut-off score of 20 – 48. Thus, a respondent with a score > 20 was considered to have a high level of PBL satisfaction. The Cronbach α is 931.

Students intrinsic motivation scale (SIMS) is a 9-items instrument adapted from the academic motivated scale (AMS) by (Pintrich et al., 1993). The SIMS was scored based on a 5-point scale of strongly disagree (0) to agree (4). The SIMS total score can range from 0 to 36. Higher scores on the SIMS shows a high level of intrinsic motivation associated with the learning environment used. The cut-off score was purposively set between 15 – 36. Thus, a respondent with a score of > 15 was considered to have a high intrinsic motivation level. The Cronbach α is .863.

Students' ability beliefs scale (SABS) is a 9-items questionnaire describing students' confidence in their electrical/electronic practical skills and abilities. The ability belief items were adapted from the Motivated Strategies for Learning self-efficacy subscale (Pintrich et al., 1993). Each item was measured on a 5-point Likert scale anchored by strongly disagree (0) and strongly agree (4). The SABS total score can range from 0 to 36. Higher scores on the SABS show a high level of ability beliefs associated with the learning environment used. The cut-off score was purposively set between 15 – 36. Thus, a respondent with a score > 15 was considered to have a high level of ability beliefs. The Cronbach α is .828.

Students practical skills rating scale (SPSRS) is a 34-items rating scale developed by the researcher after a due consultation with five electrical installation experts. The scale comprises five sets of tasks that were used to assess skills in domestic conduit wiring: task 1- identification of circuit positions (6 items), task 2 - conduit preparation (5 items), task 3 - drawing of cables (9 items), task 4 - termination and mounting of fittings (9 items), and task 5 - inspection and powering (5 items). The items were rated independently on a five-point rating options ranging from very good (4) – very poor (0). The facilitators used the items in the rating scale to rate the students' practical skills outcomes in carrying out domestic conduit wiring effectively. The total score for task 1 ranges from 0 to 24. A higher score on task 1 indicates a high level of dexterity in identifying circuit positions and is based on a purposively set cut-off score of 10–24. Therefore, a respondent with a score > 10 is considered to have a significant level of competence in identifying circuit positions; The total score for tasks 2 and 5 can range from 0 – 20. A higher score on task 2 and 5 indicates a high level of dexterity in conduit preparation, inspection and powering and is based on a purposively set cut-off score of 8–20. Therefore, a respondent with a score > 8 is considered to have a significant level of competence in those tasks. The total score for tasks 3 and 4 can range from 0 - 36. Higher scores on tasks 3 and 4 indicate a high level of practical skills in drawing cables, termination, and mounting of fittings and is based on a purposively set cut-off score of 15 –36. Therefore, a respondent with a score > 15 is considered to have a significant level of competence in those tasks. The Cronbach α is .863, .798, .810, .844, .901, .827 respectively.

Data Analysis

We used IBM Statistical Package for Social Sciences (SPSS) 25.0 and PROCESS macro 3.5 to analyses the data in this study. Specifically, the first three hypotheses were analysed using correlation and regression to ascertain association between the independent variable (PBL), dependent variable (practical skills acquisition tasks) and among the study intervening variables. The remaining hypothesis was tested using mediation analysis to investigate the mediating roles of intrinsic motivation and ability beliefs in the association between PBL and PSA.

Results

Variables	1	2	3	4	5	6	7	8	9
1. PBL	1								
2. Intrinsic Motivation	.610**	1							
3. Ability beliefs	.496**	.699**	1						
4. Task 1	.533**	.709**	.845**	1					
5. Task 2	.548**	.638**	.596**	.749**	1				
6. Task 3	.625**	.736**	.801**	.842**	.699**	1			
7. Task 4	.634**	.725**	.705**	.693**	.628**	.747**	1		
8. Task 5	.623**	.840**	.735**	.773**	.795**	.811**	.843**	1	
9. Overall PSA	.667**	.813**	.828**	.895**	.825**	.925**	.897**	.934**	1

Table 2. Bivariate Correlations of Problem-based Learning and the Practical Skills Acquisition Outcomes.

*PBL – problem-based learning, IM – intrinsic motivation, AB – ability beliefs, PSA – practical skills acquired (Task 1-5), Task 1- identification of circuit positions, Task 2 - conduit preparation, Task 3 - drawing of cables, Task 4 - termination and mounting of fittings, and Task 5 - inspection and powering. **. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).*

As revealed in Table 2, the bivariate analysis shows that PBL (r = 0.667, p < .01), intrinsic motivation (r = 0.813, p < .01) and ability beliefs (r = 0.828, p < .01), correlated significantly with the overall practical skills acquisition outcomes. Also, PBL (r = 0.610, p < .01), correlated positively and significantly with intrinsic motivation, and (r = 0.496, p < .01) ability beliefs. This indorses the necessity for the mediation analysis proposed in this research (Baron & Kenny, 1986).

Hypotheses	Variables	Adjusted R^2	F (1,77)	β	t	ρ
	PBLE → Task 1	.275	30.135	.533	5.489	0.000
	PBLE → Task 2	.291	32.600	.548	5.710	0.000
	PBLE → Task 3	.382	48.598	.625	6.971	0.000
H_1	PBLE → Task 4	.394	51.050	.634	7.145	0.000
	PBLE → Task 5	.380	48.198	.623	6.942	0.000
	PBLE → IM	.364	45.080	.610	6.715	0.000
	PBLE → AB	.236	24.779	.496	4.978	0.000
	IM → Task 1	.496	76.896	.709	8.769	0.000
	IM → Task 2	.399	52.120	.638	7.219	0.000
H_2	IM → Task 3	.536	90.013	.736	9.488	0.000
	IM → Task 4	.520	84.311	.725	9.182	0.000
	IM → Task 5	702	182.214	.840	13.499	0.000
	AB → Task 1	.711	190.183	.845	13.791	0.000
	AB → Task 2	.347	41.947	.596	6.477	0.000
H_3	AB → Task 3	.637	136.181	.801	11.670	0.000
	AB → Task 4	.490	75.017	.705	8.661	0.000
	AB → Task 5	.533	89.036	.735	9.436	0.000

Table 3: Summary of simple linear regression for practical skills acquisition (PSA), intrinsic motivation and ability beliefs.

β: Beta for standardized coefficient, Task 1: identification of circuit positions, Task 2: conduit preparation, Task 3: drawing of cables, Task 4: termination and mounting of fittings, Task 5: powering of circuits, IM: intrinsic motivation, AB: ability beliefs.

As revealed in Figure 2, we hypothesized that PBL experience would significantly predict PSA ranging from Task 1: identification of circuit positions, Task 2: conduit preparation, Task 3: drawing of cables, Task 4: termination and mounting of fittings, to Task 5: powering of circuits, ability beliefs, and intrinsic motivation. In Table 3 and Figure 2, the regression analysis shows that PBLE is a significant positive predictor of PSA at task 1 (F = 30.135, t =5.489, β = 0.533, ρ < 0.001). The Adjusted R-square (0.275) shows that 27.5% of variance in task 1 is determined by PBLE. The regression analysis also shows that PBLE is a significant positive predictor of PSA at task 2 (F = 32.600, t =5.710, β = 0.548, ρ < 0.001). The Adjusted R-square (0.291) shows that 29.1% of variance in task 2 is determined by PBLE. At task 3, the regression analysis shows that PBLE is also a significant positive predictor with (F = 48.598, t =6.971, β = 0.625, ρ < 0.001). The Adjusted R-square (0.382) shows that 38.2% of variance in task 3 is determined by PBLE. The regression analysis also shows that PBLE is a significant positive predictor of PSA at task 4 (F = 51.050, t =7.145, β = 0.634, ρ < 0.001). The Adjusted R-square (0.394) shows that 39.4% of variance in task 4 is determined by PBLE. At tasks 5, the analysis shows that PBLE is a significant positive predictor of PSA with (F = 48.198, t =6.942, β = 0.623, ρ < 0.001). The Adjusted R-square (0.380) shows that 38% of variance in task 5 is determined by PBLE. Thus, the hypothesis proposed for the study is supported, implying that PBLE will aid in the enhancement of vocational electrical students' ability to identify circuit positions, prepare conduits, draw cables, terminate and mount fittings and power the circuit during domestic conduit wiring practical. Similarly, the regression analysis shows that PBLE is a significant positive predictor of intrinsic motivation (IM) (F = 45.080, t =6.715, β = 0.610, ρ < 0.001). The Adjusted R-square (0.364) shows that 36.4% of variances in intrinsic motivation is determined by PBLE. In addition, the regression estimates revealed that PBLE is a significant positive predictor of ability beliefs (F = 24.779, t =4.978, β = 0.496, ρ < 0.001). The Adjusted R-square (0.236) shows that 23.6% of variances in ability belief is determined by PBLE. Therefore, the hypothesis proposed for the study is supported, implying that PBLE will help to enhance the intrinsic motivation and ability beliefs of vocational electrical students' intrinsic motivation and ability beliefs during practical activities.

We hypothesized that intrinsic motivation would significantly predict PSA from task 1 to task 5. As indicated in Table 2, intrinsic motivation is a significant positive predictor of PSA in task 1 (F = 76.896, t = 8.969, β = 0.709, p < 0.001). Adjusted R-square (0.496) indicated that 49.6% of variances in task 1 are determined by intrinsic motivation. Hence, the hypothesis is supported for task 1, inferring that intrinsic motivation will aid in improving vocational electrical students' practical skills in the identification of circuit positions. In addition, intrinsic motivation significantly and positively predicted PSA in task 2 (F = 52.120, t = 7.219, β = 0.638, p < 0.001). The adjusted R-square (0.399) revealed that 39.9% of variances in task 2 are determined by intrinsic motivation. Hence, the hypothesis is supported for task 2, inferring that intrinsic motivation will aid in improving vocational electrical students' practical skills in circuit preparation. Similarly, intrinsic motivation significantly predicted PSA in task 3 (F = 90.013,

$t = 9.488$, $\beta = 0.736$, $p < 0.001$). The adjusted R-square (0.536) revealed that 53.6% of variances in task 3 are determined by intrinsic motivation. Hence, the hypothesis is supported for task 3, inferring that intrinsic motivation will aid in improving vocational electrical students' practical skills in drawing of cables. As indicated in Table 2, intrinsic motivation is also a significant positive predictor of PSA in task 4 ($F = 84.311$, $t = 9.182$, $\beta = 0.725$, $p < 0.001$) and task 5 ($F = 182.214$, $t = 13.499$, $\beta = 0.840$, $p < 0.001$). The adjusted R-square for task 4 (0.520) and task 5 (0.702) revealed that 52% of variances in task 4 and 70.2% of variances in task 5 are determined by intrinsic motivation. Hence, the hypothesis is supported for task 4 and 5, inferring that intrinsic motivation will aid in improving vocational electrical students' practical skills in termination and mounting of fittings and powering of circuits.

We hypothesized also that ability beliefs would significantly predict PSA from task 1 to task 5. As indicated also in Table 2, ability beliefs significantly predicted vocational electrical technology students PSA in task 1 ($F = 190.183$, $t = 13.791$, $\beta = 0.845$, $p < 0.001$) and task 2 ($F = 41.947$, $t = 6.477$, $\beta = 0.596$, $p < 0.001$). Adjusted R-square (.711) and (.347) indicated that 71.1% and 34.7% variances in tasks 1 and 2 are determined by ability beliefs. Hence, the hypothesis is supported for task 1 and 2, inferring that ability beliefs will aid in improving vocational electrical students' practical skills in the identification of circuit positions and preparation of conduit. In addition, ability beliefs significantly and positively predicted PSA in task 3 ($F = 136.181$, $t = 11.670$, $\beta = 0.801$, $p < 0.001$), task 4 ($F = 75.017$, $t = 8.661$, $\beta = 0.705$, $p < 0.001$) and task 5 ($F = 89.036$, $t = 9.436$, $\beta = 0.735$, $p < 0.001$) respectively. The adjusted R-square (.637), (.490) and (.533) indicated that 63.7%, 49.7% and 53.3% of variances in tasks 3, 4 and 5 are determined by ability beliefs. Hence, the hypothesis is supported for task 3,4 and 5, inferring that ability beliefs will aid in improving vocational electrical students' practical skills in drawing of cables, termination and mounting of fittings, as well as powering of circuits.

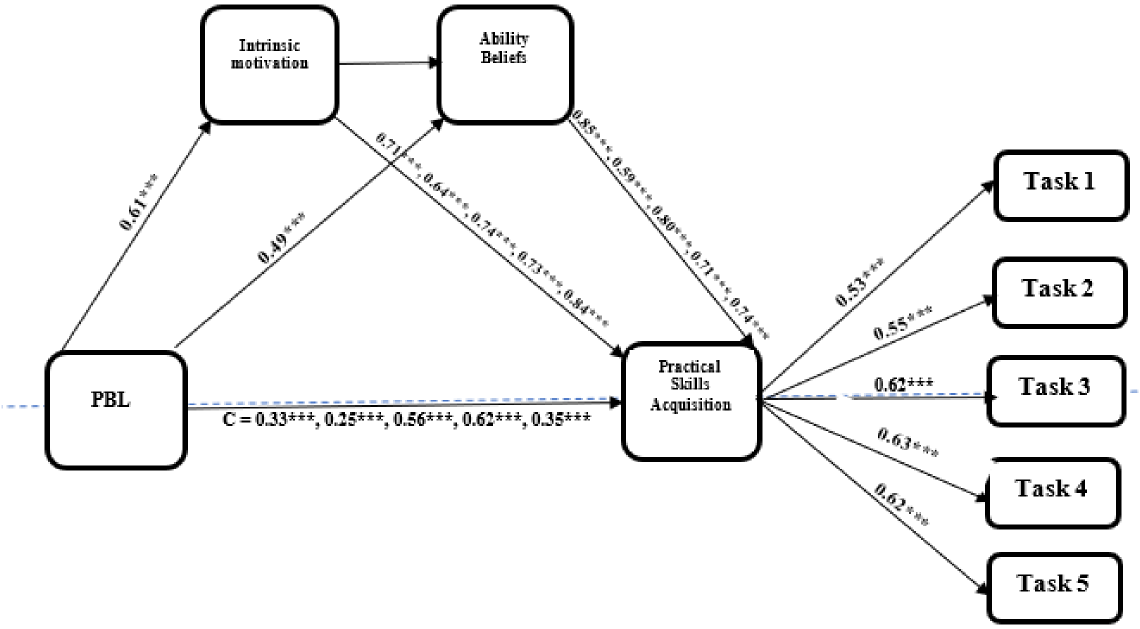

Figure 2. A sequential mediation model on practical skills acquisition.

Variables		Effects	Mediator	β	SE	CI	
						LL	UL
Task 1	Identification of circuit positions	Total		.334***	.061	.213	.456
		Direct		.053	.047	-.040	.146
		Indirect 1	AB	.333	.059	.224	.456
		Indirect 2	IM	.065	.037	.009	.137
		Indirect 3	AB →IM	.049	.029	.008	.106
Task 2	Conduit preparation	Total		.248***	.043	.161	.334
		Direct		.101	.048	.005	.197
		Indirect 1	AB	.131	.061	.203	.452
		Indirect 2	IM	.111	.047	.019	.203
		Indirect 3	AB →IM	.083	.037	.013	.161
Task 3	Drawing of cables	Total		.557***	.079	.398	.716
		Direct		.197	.068	.061	.332
		Indirect 1	AB	.263	.052	.171	.376
		Indirect 2	IM	.081	.037	.003	.151
		Indirect 3	AB →IM	.060	.029	.002	.116
Task 4	Termination and mounting of fittings	Total		.615***	.086	.444	.787
		Direct		.258	.085	.088	.428
		Indirect 1	AB	.174	.063	.053	.303
		Indirect 2	IM	.111	.042	.039	.201
		Indirect 3	AB →IM	.083	.034	.029	.160
Task 5	Inspection and powering circuits	Total		.346***	.049	.247	.445
		Direct		.081	.040	.001	.161
		Indirect 1	AB	.133	.038	.066	.216
		Indirect 2	IM	.197	.047	.106	.292
		Indirect 3	AB →IM	.147	.035	.085	.221

Table 4. Summary of Sequential Mediation Tests of direct and Indirect Effects on Practical Skills acquisition.

***$p < 0.001$; β – Beta for standardized estimate; *SE* – standard error; *CI* – confidence interval (*LL* – lower limit; *UL* – upper limit); Ind – indirect effect; AB – ability beliefs; IM – intrinsic motivation.

Table 4 revealed no significant direct effects of problem-based learning on task 1 (β = .053, *SE* = .047, *LL* = .040, *UL* = .146), and significant direct effects of problem-based learning on task 2 (β = .101, *SE* = .048, *LL* = .005, *UL* = .197), task 3 (β = .197, *SE* = .068, *LL* = .061, *UL* = .332), task 4 (β = .258, *SE* = .085, *LL* = .088, *UL* = .428) and task 5 (β = .081, *SE* = .040, *LL* = .001, *UL* = .161) of the practical skills learning outcomes via ability beliefs and intrinsic motivation. The data reveals significant specific indirect effects of ability beliefs on task 1 to task 5. The specific indirect effects of intrinsic motivation on task 1 to task 5 are also significant. The result shows that the sequential multiple mediation effects on task 1 (β = .049, *SE* = .029, *LL* = .008, *UL* = .106), task 2 (β = .083, *SE* = .037, *LL* = .013, *UL* = .161), task 3 (β = .060, *SE* = .029, *LL* = .002, *UL* = .116), task 4 (β = .083, *SE* = .034, *LL* = .029, *UL* = .160) and task 5 (β = .147, *SE* = .035, *LL* = .085, *UL* = .221) are significant. This suggests partial multiple mediation effects of intrinsic motivation and ability beliefs on PSA from task 1 to task 5 of the practical skills learning outcomes. The hypothesis is, therefore, supported.

Discussion and implications

The study employed task-based domestic conduit wiring scenarios to determine the association between PBL experience and PSA and the indirect sequential mediating effects of intrinsic motivation and ability beliefs. Our study made useful contributions to the study of PBLE, intrinsic motivation, ability beliefs, and Practical skills acquisition with respect to domestic conduit wiring as well as contributed to the assumptions that support the sequential mediating roles of intrinsic motivation and ability beliefs in the association between problem-based learning experience and practical skills acquisition. The study outcome revealed that PBLE is a positive and significant predictor of VET students PSA from task 1 to task 5. In other words, VET students PSA increase can be accredited to the problem-based intervention. Hence the more students get involved in finding solutions to practical problem scenarios in a PBL environment the more their practical skills experience increases. These results are in alliance with the study of Orji & Ogbuanya (2020) which established that a positive and significant association exists between PBL and engagement in practical skills acquisition among electrical/electronic technology students. Our study is also in agreement with the findings of Bedard et al. (2010), who determined that PBL curriculum is a significant predictor of electrical students' engagement. Our findings are congruent with the study Meti et al. (2024) and Bhosale, (2020) which found that PBL methodologies, such as designing electrical substations, significantly improve student engagement by involving them in real-world projects that require collaboration, problem-solving, and critical thinking. Similarly, our findings revealed that PBLE also predicted intrinsic motivation and ability beliefs significantly. This outcome shows that VET students' active participation in PBL environments helped to activate those psychological behaviours that made practical skills tasks exciting, engaging and enjoyable. This outcome validates the perspective that PBL experience helps to develop in students the confidence and belief to execute behaviours necessary to produce a specific performance, thus, increasing their practical skills outcome. These findings are congruent with the study of LaForce et al. (2017), which found that higher student ratings of PBL predict science intrinsic motivation and ability beliefs and predict higher student interest in STEM.

Furthermore, our findings show that intrinsic motivation and ability beliefs significantly predict VET students practical skills acquisition outcomes from task 1 to task 5. This implies that VET students whose intrinsic motives and ability beliefs increased as a result of the PBLE, participate actively in practical tasks that interest them without the necessity of material rewards. The enthusiasm is self-determined because the VET student has positive feelings while performing the task. This finding is comparable to the study of Orji & Ogbuanya (2020), who found that ability beliefs and intrinsic motivation are positive predictors of electrical/electronic technology education students' engagement in practical skills acquisition. The study is also in line with (Mwangi, 2018, Sheldrake et al., 2015), who found that ability beliefs significantly predict achievement. Additionally, the study is also in agreement with Cooper and Kotys-Schwartz (2022) who found that the introduction of project clients and real-world problem contexts can enhance students' intrinsic interest and accountability.

Our results revealed that sequential mediating effects of intrinsic motivation and ability beliefs were significantly supported. Thus, VET students' intrinsic motives and ability beliefs mediated the relationship between PBLE and practical skills acquisition. This suggests that VET students' exposure to PBL may not absolutely be the motive for their improved practical skills outcomes, rather they believe in their ability to be effective in the practical tasks of interest. Our finding is comparable to the study of Orji & Ogbuanya (2020), who found that ability beliefs and intrinsic motivation are multiple mediators of the of relationship between PBL and engagement in practical skills acquisition. These findings are also comparable with LaForce et al. (2017) who found that science intrinsic motivation and ability beliefs mediate the relationship between perceived PBL and student interest in a future STEM career. To the best of our knowledge, our study is the first to investigate the sequential mediating effects of intrinsic motivation and ability beliefs in the existing literature of PBL and PSA relationships. These results are how our study contributes to the existing knowledge of PBL, ability beliefs, intrinsic motivation, and practical skills acquisition.

Generally, the findings of this study offer important practical implications for vocational and technical education trainers. Specifically, our study suggests that trainers should use structured problem-based learning (PBL) activities that reflect real challenges found in the working environments. In our intervention, students engaged in five highly practical tasks, such identifying the correct circuit positions; preparing the conduit for marking out and laying the appropriate boxes; demonstrating how to draw lighting cables from the distribution board (DB) to the cooker control unit (CCU); terminating and mounting components such as the ceiling rose, wall brackets, sockets, switches, and the CCU; and finally, inspecting the installation for straightness of fittings, loose cables, unterminated circuits or boxes, and the effectiveness of the earthing system. Each task was linked to a realistic problem that electricians might face on the job, making the tasks highly relevant and applicable (Table 1). These activities helped students not only improve their technical skills but also increase their motivation and confidence in solving practical problems. For trainers, this means creating learning experiences that are hands-on, task-based and focused on problem-solving. It is also important to give timely and helpful feedback during these tasks to support students' belief in their own abilities. When students face meaningful problems and are guided in solving them, they are more likely to stay engaged and develop the practical skills they need for success in vocational careers.

Limitations and future research study

The positive outcome notwithstanding, limitations a bound in this study. First, study used self-report measures which may have resulted in self-report bias possible. Thus, the actual association between the study variables might be weaker or even stronger than the relationship observed in the study. The authors recommend the adoption of a different measure in future studies. Secondly, the sample size is very small. The generalization of the result of this study beyond the scope of this study should be done with caution. Nonetheless, G*power confirmed the sample big enough to warrant its generalization. In addition, 5000 resample bootstrapping method was also used, to ensure that the outcome of this study can be generalized (Hayes, 2013).

While this study offers valuable insights into the sequential mediating roles of intrinsic motivation and ability beliefs in problem-based learning environments, it also opens up several important areas for further research. The potential for future research to examine how these psychological constructs function across different vocational fields, such as plumbing, carpentry, or automotive technology, is vast and inspiring. This could determine whether the observed patterns are generalizable beyond electrical installations. In addition, the recommendation for longitudinal studies to assess the sustainability of practical skills acquisition and motivational gains over time, especially after student's transition into workplace settings, is a call to action for all of us in the field. Another promising direction involves exploring how variations in trainers' instructional styles, feedback strategies, and emotional support influence the development of ability beliefs and intrinsic motivation. Finally, with the rise of educational technology, future studies could compare traditional hands-on PBL approaches with hybrid or digital PBL models, such as those incorporating virtual simulations or augmented reality, to evaluate their relative impact on student engagement and practical competence.

Conclusion

Summarily, this empirical study has demonstrated that problem-based learning experience (PBLE) significantly predicts vocational students' practical skills acquisition (PSA) across all five performance tasks. The findings further suggest that this relationship is not merely direct but is sequentially mediated by students' intrinsic motivation and ability beliefs. These results extend our understanding of how PBLE can effectively support the development of practical competence in vocational electrical training programmes. Importantly, this study contributes to the growing body of literature by providing empirical evidence that the influence of PBL on skill acquisition is partly explained by its capacity to enhance learners' motivation and confidence in their abilities. Given the significance of these findings, further research is encouraged to replicate and expand this work across other vocational trades and instructional contexts to better understand the broader applicability of the proposed model. The need for such research is crucial to validate and strengthen this study's findings and enrich the literature on PBLE in vocational education and training.

Declarations

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