

# *Enhancing Learners' Practical Skills and Perceptions in House Electrical Installation Through Project-Based Learning*

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**Abstract - Household electrical installation is an important aspect of modern life. Physics education should equip learners with practical skills related to electrical installation for everyday challenges, fostering perceptions, and societal progress. Since electricity is essential in our homes, people at young ages, including ordinary level learners, need to have practical skills on how it is performed. This study investigated the impact of Project-Based Learning (PBL) on learners' practical skills and perceptions in electrical installation, with the guidance of the two questions. The research covered a purposive sample of 89 senior three learners from one selected secondary school in Kayonza District of Rwanda. The study employed a participatory Action Research (PAR) design was used in this study to address the challenge of senior three learners who had sufficient theoretical background to undertake electrical-related projects as were selected. The data were collected using a practical activity observation tool and a structured survey questionnaire. The collected data were analysed using Excel and SPSS. The findings indicated that PBL significantly impacts learners' practical skills and positively influences their perceptions of electricity installation. Consequently, all learners showed improvement in practical skills and perceptions. The recorded data from observation also showed that PBL helps learners in applying what is studied at home. Therefore, Educators and education policy makers are recommended to integrate PBL approaches in teaching and learning activities to improve learner perceptions and build practical skills necessary for real-world applications.**

**Keywords: Electrical Installation, Learners ,Practical skills, Perceptions, , Project-based Learning.**

## I. INTRODUCTION

The teaching and learning of electricity in secondary schools have evolved globally with various pedagogical approaches aimed at enhancing learners' practical skills. In many developed countries, hands-on, inquiry-based learning methods such as Project-Based Learning (PBL) and STEM integration are widely adopted to ensure learners acquire both theoretical knowledge and practical skills (Hmelo-Silver, 2004). However, in developing countries, including parts of Africa, these approaches have demonstrated success in fostering problem-solving abilities, creativity, and electricity concepts, but have limited learners' engagement and skill acquisition (Edwards et al., 2018). In electricity education, fostering practical skills is essential, as it is integral to daily life, from household installations to broader infrastructure needs. Many learners at the Ordinary Level struggle to apply theoretical knowledge to practical situations, often perceiving electricity as a complex or intimidating subject (Hofstein & Mamlok-Naaman, 2007).

At the continental level, the teaching of electricity in African high schools is often constrained by inadequate infrastructure, lack of trained teachers, and limited access to modern teaching aids. Many schools rely on theoretical instruction, leading to a big gap

between learners' conceptual understanding and practical application (Mulenga & Kabombwe, 2019). This deficiency negatively impacts learners' ability to pursue technical and engineering careers, thereby affecting the continent's progress in science and technology. The consequences of the gaps are significant. Learners completing their secondary education with minimal practical exposure to electrical installation and less prepared for technical and vocational careers. This perpetuates a workforce shortage in skilled electricians and electrical engineers, hindering local economic development and technological advancement (Gormus, 2019).

In the Rwandan context, particularly in Kayonza district, the teaching and learning of electricity and electrical installation in houses, face similar challenges. The traditional instructional methods, which emphasize rote learning and theoretical instruction, do not provide sufficient opportunities for learners to develop hands-on skills (REB, 2023). Many secondary school learners can describe electrical concepts and draw circuit diagrams, but lack the practical competencies to construct or repair even simple electrical systems. This disconnect between theory and practice fosters negative perceptions of electricity, making it appear intimidating rather than an essential and applicable skill.

Different approaches were used to address the problem of insufficient practical skills and perceptions in electricity including virtual laboratory, virtual trainings (Gunawan et al., 2017), and consensus models, but they were found to be unhelpful in assisting learners in understanding the basic ideas of electric circuits (Hart, 2008).

To address these challenges, Project-Based Learning (PBL) emerges as a suitable pedagogical approach. PBL engages students in real-world projects that require critical thinking, collaboration, and hands-on problem-solving (Bell, 2010). Dimmitt (2017) found that, PBL method can provide students with effective techniques for improving self-reliant and critical thinking skills and this creates an environment that fosters active learning and skill development, hence positive perceptions about electricity. By implementing PBL in electricity courses, students can work on authentic tasks, such as designing and wiring electrical circuits, under the guidance of their teachers. This approach enhances their confidence, motivation, and ability to apply theoretical concepts practically (Barron & Darling-hammond, 2008). While traditional methods have emphasized theoretical understanding, they often fail to adequately prepare students for practical tasks or to foster positive perceptions of technical subjects like electricity (Gunawan et al., 2017; Kolodner et al., 2009; Matzembacher et al., 2019). Despite PBL being advocated in Rwanda's competence-based curriculum, its implementation in Kayonza remains limited. Several reasons contribute to this situation. First, many teachers lack sufficient training in PBL methodologies, making it challenging for them to shift from traditional teaching approaches (REB, 2023). Second, the resource constraints in schools, including inadequate workshop spaces and materials, hinder effective PBL implementation. Third, the pressure to complete the syllabus within a tight academic calendar often discourages teachers from adopting time-intensive approaches like PBL.

Project-Based Learning (PBL) has been identified as a promising approach to address these challenges by providing students with hands-on opportunities to explore and solve real-world problems (Dimmitt, 2017). PBL encourages active learning, critical thinking, and skill development, making the learning experience more engaging and meaningful (Condliffe, 2017; Makkonen et al., 2021; Pitterson, 2015).

In Kayonza District of Rwanda, gaps in the curriculum and teaching methods have limited students' practical competencies and their ability to bridge theory and practice. The transition to a competence-based curriculum offers a framework for integrating PBL, emphasizing skill acquisition over rote learning. This research explores how PBL can enhance students' practical skills in household electrical installations and improve their perceptions of electricity, ultimately equipping them for real-world challenges and contributing to Rwanda's broader economic goals. Alternatively, this study aims to explore the potential of PBL to transform the teaching of electricity by investigating its impact on students' practical skills and perceptions. By addressing these critical gaps, the research seeks to inform innovative teaching practices and support the development of a skilled, motivated workforce in the region.

The general objective of this study is to explore the use of PBL to improve learners' practical skills and perceptions in electricity and was conducted under two objectives. The first one is, to *"investigate the ordinary level students' practical skills and perceptions toward learning the electrical installation course"*. The second is to *"explore the impact of PBL usage on the students' practical skills and perceptions in electrical installation course"*. This research was conducted to give responses to two research questions. The first question is *"what are the current learners' practical skills and perceptions in electrical installation course?"*. The second question is *"what is the impact of PBL on students' practical skills and perceptions in the electricity course?"*

### 1.1 Students' perceptions of learning electricity.

Perception is the awareness of the world through the five senses of sight, touch, smell, taste, and hearing (Crane, 2005). Students' perceptions are considered as judgments of students of the elements. Understanding students' perceptions of electricity is crucial because these perceptions can significantly influence their learning outcomes and overall understanding of the subject (Tongsakul et al., 2011). Students' conception of simple circuit is influenced by their perceptions, which are the basics for building knowledge, unreliable and prone to distorting the world around us (Merleau-Ponty, 2004; Setyani et al., 2017). Various studies have examined the students' perceptions, like how students perceive the concepts and principles of electricity (Li, 2012). The factors that affect these perceptions (Jankowiak et al., 2021), and their implications for teaching practices (Mboniryivuze et al., 2019). If the student's perception is negative, it can cause a misconception. For example, some students mention that a high-voltage wire can cause an electric shock. This creates fear for making practices where there exist high-voltage wires.

### 1.2 Students' practical skills.

Basically, teaching science and related disciplines consists of two parts, namely, theory and practice. Theory develops students' theoretical knowledge, ideas, and memorization (Gunarathna et al., 2024). While practical *"skills"* mean the ability to apply knowledge and use know-how to complete tasks and solve problems (Ornellas et al., 2019). In contrast, practical application develops critical thinking, problem-solving skills, logic, and skills of implementation, and they are necessary for undertaking a non-written specific task, hence developing the students' understanding of the concepts and of the experimental process (Rahman et al., 2021; Reiss & Abrahams, 2015; Smith, 2012). Hébert & Hauf (2015) added that those practical skills can be learned in a classroom setting and can be applied in a huge variety of situations. Remember that both male and female students can perform practical skills, because gender has no significant effect on students' practical skills in electricity (Ogunleye & Babajide, 2011).

### 1.3 The impact of PBL on the students' practical skills and perceptions in electrical installation.

Implementing PBL in technical education significantly improved students' attitudes and perceptions towards learning, as they felt more in control of their learning process (Wilson-thomas, 2022). A study by Liu et al. (2023) investigating the role of PBL in electrical engineering classes observed that students who participated in real-world projects reported increased motivation and a better appreciation of electrical concepts.

The activities of PBL help in empowering learners to conduct the learning project successfully (Tongsakul et al., 2011). The application of PBL models can increase students' activity and engage learners in sustained, co-operative and investigative work that is based on a driving question (Haryudo et al., 2020; Jafta, 2006). Munje (2022), mentioned that PBL is used in both classroom and laboratory teaching, individually and in groups (cooperatively) PBL improves students' learning outcomes. As the learners gain high results, they gain good perceptions towards the subject to gain more outcomes. (Holubova, 2008) did not hesitate to conclude in the study that, PBL encourages students to work as researchers, fosters a sense of teamwork and gets them involved in using a variety of tools. According to Tongsakul et al. (2011), the present study of students' perceptions shows that they are empowered in PBL focused on teachers and students in a department in of Education and Technology.

Not only in Africa and Rwanda in particular, PBL is helpful in many countries. Based on research conducted in India, improved practical abilities positively affected the academic performance (Rahman et al., 2021). Another study conducted in Kenya, concluded that practical work is an influencing agent in the process of learning electricity in physics and make the students keener on the content (Musasia et al., 2012). Practical work also is an essential element of the curriculum, in Sub-Saharan Countries

(Babalola et al., 2020). Like in Ethiopia, Belay et al. (2022) recommended that doing practical work can enhance the learning of scientific knowledge, motivate and promote good perceptions to the learning of electricity and acquiring laboratory skills. Practical skills in electricity need the real-life context examples for more impact in teaching and learning physics subject and teachers must be consistent to support the growth of knowledge and improve both students' application of electricity in the real world (Lamanauskas et al., 2016; Nyirantambineza & Minani, 2022).

PBL learning play a great impact on practical skills. For example, it is impactful on psychomotor skills. According to Sumarni et al. (2016), working practices play an important role in creating links between the subject learnt with everyday life, enabling students to understand the lessons, embody the knowledge learned and develop cognitive, affective and psychomotor skills specifically. As practical skills are one of the psychomotor skills, this study contributes by exploring how the PBL technique might improve electrical installation skills.

As Rwanda need enough professionals in electricity by exploring its solar, wind, thermal and methane gas potential and decentralized implementation capacity for sustainable energy service delivery (PSF-Rwanda, 2022). To get that knowledge, Project Based Learning (PBL) which is a project-based approach that helps teachers develop students' critical thinking skills by exposing them to the process in classroom practice, can be used (Jatmiko et al., 2018; Leasa, 2020; Putri & Istiyono, 2017).

## II. THEORETICAL FRAMEWORK

The principal theory underpinning this study is constructivism. This theory is initiated by Jean Piaget (1950-1960s) and is a major learning theory which is particularly applicable to the teaching and learning of science. This theory best fits with this study to create the constructivist teacher who encourages students to discover principles and construct knowledge within a given framework or structure (Norman, H., 2017).

Constructivism theory emphasizes how each person actively creates his or her own worldviews. However, it is commonly known that learners are not as blank slate, as some people believe, but rather possess knowledge from their surroundings and when applied, the learning is distinguished by interaction, which promotes collaboration and allows for behavioural change (Piaget, 1955). This shows that practical skills relate to constructivism and while making projects in what is called Project-Based-Learning, where learners construct skills by using prior knowledge. The Project Based Learning has a long history such as far back as the early 1900s, as John Dewey supported "learning by doing" (Khatri, 2020).

## III. METHODOLOGY

### 3.1. Research Design

This study was conducted in one of the districts in Rwanda. The study focused on Kayonza District because it represents a rural context where learners face challenges in practical science education, making it suitable for evaluating PBL. With respect to complexity of practical skills towards electrical installation, made an in-depth study in one district more feasible than covering many districts. As a case study, the research aimed for detailed insights rather than broad generalization, serving as a foundation for future studies. This research was conducted at a selected school in Kayonza district as it has the necessary materials for implementing PBL, including a room equipped with various electrical components. It also accommodates ordinary-level learners, some of whom have limited prior knowledge of electricity, as previously observed by the researcher before intervention. Additionally, the school provides a reliable electricity source essential for data collection. Focusing on a single school allowed for a more in-depth study, resulting in higher-quality data compared to a broader survey across multiple schools.

The sampled population is census purposive where all 89 senior three students participated in the study, because this is the level where deep practical related topics in electricity are theoretically studied in the topics titled: "*arrangement of resistors in electric circuit*", as it already has prerequisite introduction in senior two, on "*house electric installation*", studied in senior three. Even though senior one is one of the classes of ordinary level, it is not selected as their competencies are not enough to clearly do basic practical skills in electricity, as referred to in the curriculum. As described in the research design, this study is action-oriented research. This calls for educators to involve teachers in research to study different concerns in their own schools or classrooms to

enhance research as an integral part of daily classes and education (Creswell, 2015). This study covered the whole population of both classes. The researcher participated in every activity done, and the selected class was the one being taught. The researcher consulted other teachers who teach physics to act as results assistants, especially during the observation of the project-related practical activities.

### 3.2. Research Instrument and Validation

The instruments used in this study are structured questionnaire and participatory activities observation. Both questionnaire and observation checklist were given to the experts before conducting research for cleared validity to critically analyse the language, suitability, readability and unambiguity. Some questions were removed from the question after experts, check-up then run a pilot study where the calculated Cronbach's alpha found to be 0.74 confirming internal validity of research instruments.

### 3.3. Data Collection and Analysis

After obtaining the permit to conduct data collection from the University of Rwanda, the letter was submitted to Kayonza District for official permission of conduction data collection in the district. The permission letter from the district was submitted to the Head-teacher of the school where the data were collected. During the observation, the researcher collected the preliminary data about the number of students, their ages and in which class they attend the physics subject.

The questionnaire and the observation were the data collection tools used in both the pre-intervention and post-intervention phases of the study. The researcher participated when teaching traditionally, then questionnaires related to the learners' perceptions were given during cycle one, and for the second time, the researcher observed by using a PBL approach, then gave questionnaires for the second time during cycle two. After collecting the data, they were first organized using Microsoft Excel for initial cleaning and arrangement. The dataset was then imported into SPSS (Statistical Package for the Social Sciences) to facilitate detailed statistical analysis. The Quantitative data were analysed using descriptive statistics including the mean and standard deviation. Particularly, SPSS was used to perform the Wilcoxon Signed Rank Test for comparing the responses to paired pre- and post-intervention questions, as well as Cronbach's Alpha for a reliability test. This test allowed the researcher to determine whether there were statistically significant changes in learners' practical skills and perceptions after the intervention. The reliability of the observation tool was also checked using Inter-Rater Reliability. Qualitatively, observations were focused on capturing learner behaviours and group dynamics during project work. These qualitative insights were then thematically analysed to complement the quantitative findings and to provide a more comprehensive understanding of the learners' practical skill development throughout the PBL intervention.

Below is the table showing the Wilcoxon signed Rank test.

Table 1: Wilcoxon Signed Ranks Test

Ranks		N	Mean Rank	Sum of Ranks
Post_Mean - Pre_Mean	Negative Ranks	0 <sup>a</sup>	0.00	0.00
	Positive Ranks	89 <sup>b</sup>	45.00	4005.00
	Ties	0 <sup>c</sup>		
	Total	89		
a. Post_Mean < Pre_Mean		b. Post_Mean > Pre_Mean		c. Post_Mean = Pre_Mean

Source: Primary data

Based on table above, all the respondents (89) experienced an improvement in performance or perception after the intervention, and these improvements were strongly ranked. The table below shows the p-value for the data.

Table 2: p-value for the data

Test Statistics <sup>a</sup>	
	Post_test_Mean - Pre_Obs_Mean
Z	-8.204 <sup>b</sup>
Asymp. Sig. (2-tailed)	.000 (2.3267E-16)

a. Wilcoxon Signed Ranks Test.

b. Based on negative ranks.

Source: Primary data

The Wilcoxon Signed-Rank Test showed a significant improvement in learners' practical skills and perceptions after applying in house electrical installation. The test produced a Z-value of -8.204<sup>b</sup> with a p-value of 0.000 ( $p < 0.05$ ), demonstrating that the PBL approach had a positive and meaningful effect on learners' practical skills and perceptions in house electrical installation.

### 3.4. Personal identification of respondents

A sample is a subset of the population (Acharya et al., 2013). The senior three classes were chosen because they provided the appropriate content alignment for implementing the PBL intervention and allowed the researcher to assess its impact on learners' practical skills development, as they have completed the units of "arrangement of resistors in electric circuit" and "House Electric Installation". The participants by age and sex for both classes are shown in the table below.

Table 3: Population by age and sex

CLASS	MALE		FEMALE		TOTAL
	Under 16 years old	16 years old and over	Under 16 years old	16 years old and over	
S3A	6	19	8	12	45
S3B	2	16	12	14	44
<b>BOTH CLASSES</b>	8	35	20	26	89
	43		46		

Source: Primary data

Where S3A: Senior three Class A and S3B: Senior three Class B. The table above presents the distribution of students from two classes (S3A and S3B) based on gender and age group (under 16 years old vs. 16 years old and over). It shows that the overall gender distribution is balanced (43 male students and 46 female students), with slightly more females than males. Most students (around 69%) are aged 16 and over, indicating that the sample is largely composed of older learners at the S3 level.

## IV. RESULTS AND DISCUSSION

The findings were grouped into findings from questionnaires before and after the intervention and those from observations before and after the PBL intervention. The results were presented, discussed and grouped into two parts: perceptions and practical skills, both before and after intervention.

### 4.1. Learners' Perceptions

After collecting and analysing the data from the participants, the learners' perceptions before and after the intervention were grouped in the table below. The table presents a comparison of learners' perceptions, abilities, confidence levels, and practical

engagement in electricity before and after the implementation of the Problem-Based Learning (PBL) approach. It highlights changes in attitudes toward the applicability of electricity in daily life, motivation, practical skills, confidence, classroom participation, and preparedness to apply electrical skills in real-world contexts.

Table 4: The learners' perceptions before and after PBL intervention.

Level	AGREE		NEUTRAL		DISAGREE	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Learners agree that studying electricity is mostly applicable to daily life.	83%	97%	6%	3%	11%	0%
Learners agree that not engaging in practical activities related to electricity negatively impacts the understanding and retention of the subject matter.	63%	79%	6%	8%	31%	13%
Learners agree that understanding electrical concepts is essential for safety in everyday life.	83%	97%	3%	2%	13%	1%
How learners feel more motivated to participate in class activities when they involve electricity projects.	82%	94%	4%	1%	13%	4%
<b>Ability</b>	<b>Able</b>	<b>Able</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not able</b>	<b>Not able</b>
How learners feel able to fix a bulb in a socket when given a screwdriver.	27%	72%	42%	21%	31%	7%
How learners feel able to fix an electric wall socket at home when given a screwdriver.	27%	80%	35%	18%	38%	2%
<b>Confidence</b>	<b>Confident</b>	<b>Confident</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not confident</b>	<b>Not confident</b>
How confident learners were in completing a task involving basic electrical wiring safely and correctly.	12%	51%	26%	36%	62%	13%
How confident learners were to confirm that the practical skills learnt in electricity class will be useful in real-world applications.	73%	67%	20%	28%	7%	4%
<b>What happened</b>	<b>Happened</b>	<b>Happened</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not happened</b>	<b>Not happened</b>
How often learners discuss practical electrical skills with peers outside of the classroom.	4%	18%	35%	66%	61%	16%

How often do learners use electrical skills outside of the classroom (e.g., hobbies, personal projects).	7%	21%	38%	56%	55%	22%
<b>Level of applicability</b>	<b>Good</b>	<b>Good</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Poor</b>	<b>Poor</b>
How learners rated their prior knowledge in electricity before using the PBL approach.	26%	84%	63%	15%	11%	1%
How learners rated their ability to correctly set up a basic electrical circuit (series and parallel).	54%	71%	35%	25%	11%	4%
How learners rated their ability to follow a schematic diagram to build an electrical circuit.	62%	88%	29%	10%	9%	2%
<b>Comfortability</b>	<b>Comfortable</b>	<b>Comfortable</b>	<b>Neutral</b>	<b>Neutral</b>	<b>No comfortable</b>	<b>No comfortable</b>
How comfortable learners feel when performing basic electrical tasks, such as wiring a plug or replacing a fuse.	20%	67%	26%	30%	54%	2%
<b>Being likely</b>	<b>Likely</b>	<b>Likely</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not likely</b>	<b>Not likely</b>
How likely were learners to pursue further education or a career in an electrical-related field?	33%	51%	31%	44%	36%	6%
<b>Applicability level</b>	<b>Easy</b>	<b>Easy</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Difficult</b>	<b>Difficult</b>
How learners perceive the level of difficulty in learning practical activities compared to theoretical concepts in an electricity course.	93%	99%	3%	1%	3%	0%
<b>Satisfaction</b>	<b>Satisfied</b>	<b>Satisfied</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not satisfied</b>	<b>Not satisfied</b>
How learners rated their overall satisfaction with their current level of practical electrical skills.	18%	70%	47%	26%	35%	4%
<b>Preparedness</b>	<b>Prepared</b>	<b>Prepared</b>	<b>Neutral</b>	<b>Neutral</b>	<b>Not prepared</b>	<b>Not prepared</b>
How learners were prepared to apply their electrical skills at home (e.g., home wiring, repairing electric circuits at home, ....).	18%	72%	30%	25%	52%	3%

Source: Primary data (November 2024)

The data indicate a substantial positive shift in learners' perceptions and practical competencies after the introduction of PBL. This solved the problem that was found, that Perception is unreliable and prone to distorting the world around the students at all (Maurice & Merleau-Ponty, 2004). Similarly, the proportion of learners who believed that a lack of practical engagement negatively affects understanding rose from 63% to 79%, with disagreement decreasing from 31% to 13%. The study conducted from a review of literature supports this by finding that PBL indicates that students appreciate the real-world relevance and hands-on experience that PBL provides, which often results in a deeper understanding of the subject matter (Song et al., 2024). Agreement that studying electricity is applicable to daily life increased from 83% to 97% (a 14% improvement), while disagreement dropped from 11% to 0%. Motivation also improved, as those feeling motivated by electricity projects increased from 82% to 94%. This is in line with (Zhang & Ma, 2023), who found that project-based learning can improve students' learning motivation, problem-solving skills, and teamwork. Shana & Abulibdeh (2020) supported this by mentioning that PBL incorporates practical skills in the classroom, prompts learners' favourable perceptions toward physics, and enhances learner motivation for successful learning.

Practical ability showed remarkable growth: Learners feeling able to fix a bulb increased from 27% to 72%, and those able to fix a wall socket rose from 27% to 80%, while the "not able" category reduced from 31% to 7% and from 38% to 2%, respectively. This had shown that the perceptions of learners positively increased from thinking of being not able to being able. As lack of self-confidence can harm students' learning achievement at school (Safitri et al., 2024). Confidence in completing basic wiring tasks increased from 12% to 51%, with "not confident" responses falling from 62% to 13%. This promotes self-directed learning among students (Song et al., 2024). Comfort in performing electrical tasks improved significantly from 20% to 67%, and learners' feeling prepared to apply skills at home increased from 18% to 72%, while those "not prepared" dropped from 52% to 3%. Overall satisfaction with practical skills rose dramatically from 18% to 70%. Although confidence in the real-world usefulness of skills slightly decreased from 73% to 67%, and neutral responses increased in some categories, the general trend demonstrates that PBL significantly enhanced learners' understanding, skill acquisition, engagement, and readiness to apply electricity concepts practically. This is in line with, (Sudarsono et al., 2022) stated that, project-based learning with an industrial partnership strategy succeeded in increasing the job readiness of students.

By grouping the agreement (agree and strongly agree) and disagreement (disagree and strongly disagree), the histogram below summarises the results.

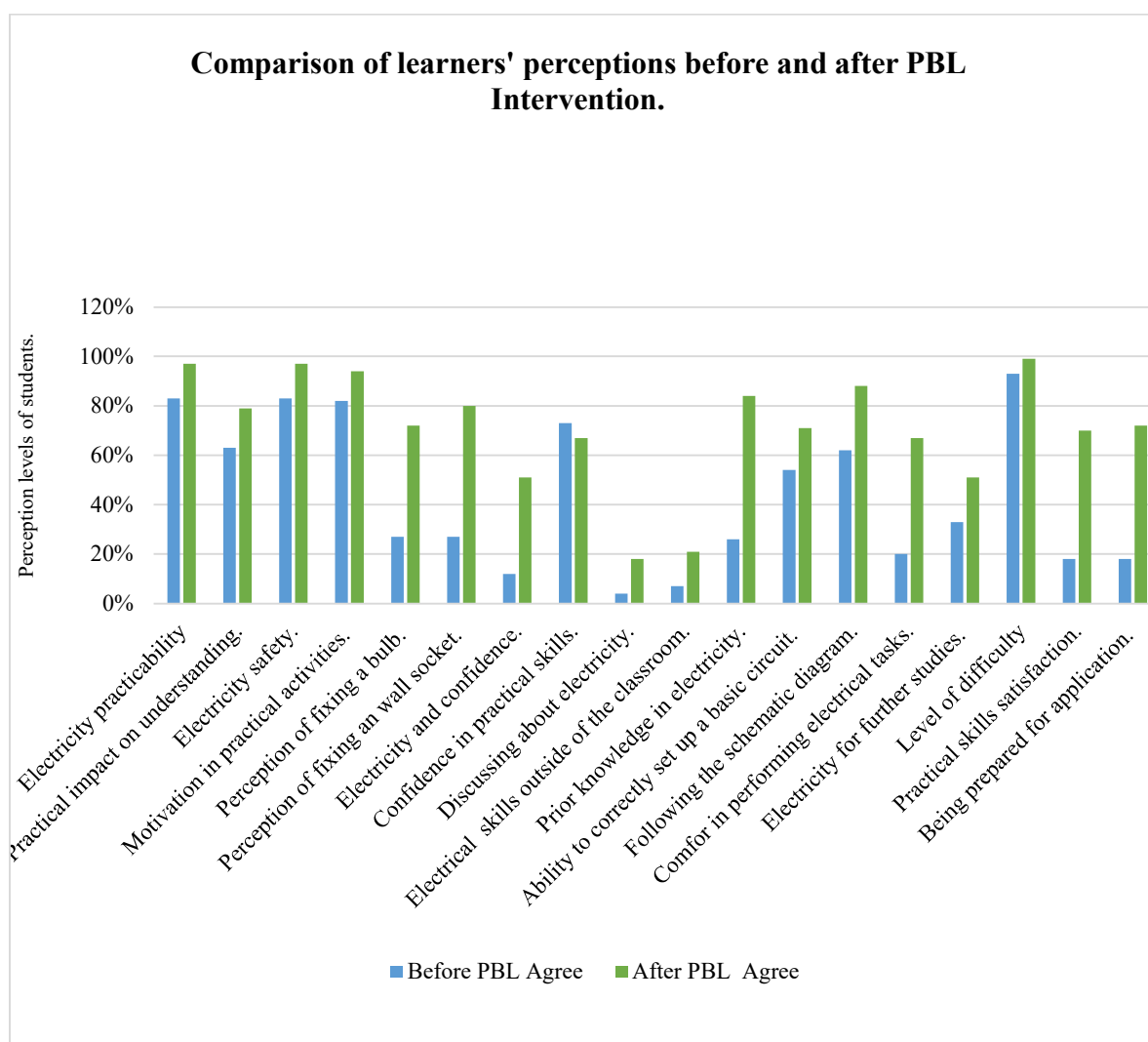


Figure 1: Comparison of learners' perceptions

The histogram above shows how learners perceive their self-efficacy in performing practical skills in electrical installation, and how these perceptions changed after the PBL intervention.

#### 4.2. Learners' practical skills

To assess the learners' practical skills in electricity, the researcher conducted a participatory observation after teaching using the already existing methods and after using PBL in teaching and learning activities. Using five levels from excellent to poor, the observer grouped the participants' skills, and then the numbers were analysed using SPSS. The scales of performance of the activity were: 5 for Excellent, meaning that the learner demonstrates complete understanding and proficiency in the skill; 4 for Good, meaning that the learner demonstrates solid understanding with minor errors. 3 for Satisfactory, meaning that the learner shows basic understanding but needs little guidance, 2 for Needs improvement stands for the learner who shows partial understanding and requires significant help. Lastly, 1 for Poor, which means that the learner does not demonstrate understanding and cannot complete the task without assistance. The table below presents the number and percentages of students demonstrating different levels of practical skills performance before and after the implementation of the Problem-Based Learning (PBL)

intervention. It compares learners' proficiency in wiring, fixing wall sockets, fixing bulbs, fixing switches, fixing junction boxes, and collaboration and teamwork, categorizing their performance into complete understanding, basic understanding, and partial understanding.

Table 5: Practical skills before and after intervention

Skills	Level of Performing a Practical Skill.	BEFORE PBL		AFTER PBL	
		Count	Percentage	Count	Percentage
Wiring (W)	Learner demonstrates complete understanding and proficiency but with minor errors.	1	1%	<b>68</b>	<b>76%</b>
	Learner shows basic understanding but needs few guidance.	5	6%	<b>16</b>	18%
	Learner shows partial understanding and requires significant help and assistance.	83	93%	<b>5</b>	6%
Fixing Wall Sockets (FWS)	Learner demonstrates complete understanding and proficiency but with minor errors.	5	6%	<b>65</b>	73%
	Learner shows basic understanding but needs a few guidance.	8	9%	<b>16</b>	18%
	Learner shows partial understanding and requires significant help and assistance.	76	85%	<b>8</b>	9%
Fixing a Bulb (FB)	Learner demonstrates complete understanding and proficiency but with minor errors.	2	2%	<b>71</b>	80%
	Learner shows basic understanding but needs few guidance.	13	15%	<b>11</b>	12%
	Learner shows partial understanding and requires significant help and assistance.	74	83%	<b>7</b>	8%
Fixing a Switch (FS)	Learner demonstrates complete understanding and proficiency but with minor errors.	7	8%	<b>71</b>	80%
	Learner shows basic understanding but needs few guidance.	13	15%	<b>13</b>	15%
	Learner shows partial understanding and requires significant help and assistance.	69	78%	<b>5</b>	6%
Fixing a Junction Box (FJB)	Learner demonstrates complete understanding and proficiency but with minor errors.	1	1%	<b>38</b>	43%
	Learner shows basic understanding but needs few guidance.	10	11%	<b>12</b>	13%
	Learner shows partial understanding and requires significant help and assistance.	78	88%	<b>39</b>	44%
Collaboration and Teamwork (CT)	Learner demonstrates complete understanding and proficiency but with minor errors.	55	62%	<b>52</b>	58%

Learner shows basic understanding but needs few guidance.	17	19%	<b>22</b>	25%
The learner shows partial understanding and requires significant help and assistance.	17	19%	<b>15</b>	17%

**Source: Primary data.**

The findings reveal a remarkable improvement in learners' technical practical skills after the PBL intervention. In Wiring (W), students demonstrating complete understanding increased from 1% (1 learner) before PBL to 76% (68 learners) after PBL, while those requiring significant help dropped from 93% (83 learners) to 6% (5 learners). A similar enhancement is observed in Fixing Wall Sockets (FWS), where proficiency rose from 6% (5 learners) to 73% (65 learners), and those with partial understanding decreased from 85% (76 learners) to 9% (8 learners). In Fixing a Bulb (FB), learners showing complete proficiency increased from 2% (2 learners) to 80% (71 learners), while those needing significant assistance reduced from 83% (74 learners) to 8% (7 learners). Likewise, in Fixing a Switch (FS), complete proficiency rose from 8% (7 learners) to 80% (71 learners), with partial understanding decreasing from 78% (69 learners) to 6% (5 learners). Although Fixing a Junction Box (FJB) showed improvement—from 1% (1 learner) to 43% (38 learners) in complete proficiency—the proportion of learners with partial understanding remained relatively high at 44% (39 learners), suggesting this skill may require more time and practice to master fully. All of these demonstrate a remarkable impact of PBL on the enhancement of practical skills of learners in electrical installation. This is in line with Fernandes (2014) who found that, PBL fosters deep-level learning and important skills for professional practice, which links theory to practice. This means that, the more the learners study using PGL approaches, the more practical skills' enhancement.

PBL improves collaboration, develops interpersonal skills and teach the value of teamwork (Krajcik & Czerniak, 2018) and also, PBL improves learners' teamwork (Holubova, 2008). This study also that there is a slight variation in Collaboration and Teamwork (CT) after PBL. This is also in line with Bell (2010) who found that practical skills need collaboration and problem solving skills. Learners demonstrating complete proficiency slightly decreased from 62% (55 learners) to 58% (52 learners), while those with basic understanding increased from 19% (17 learners) to 25% (22 learners). This is in line of Jollands & Parthasarathy (2013), who found that multiple projects are needed to develop student understanding. This study also found an enhancement in the learners' understanding by an increase of 5% of the respondents.

The proportion requiring significant assistance slightly declined from 19% (17 learners) to 17% (15 learners). This indicates that while PBL significantly strengthened technical and hands-on electrical skills, collaboration skills were already relatively strong before the intervention; the more the students use PBL, the less they need assistance in practical skills, like in house electrical installation. Overall, the data clearly demonstrated that PBL had a substantial positive impact on learners' practical electrical competencies.

The number of learners according to the skills they became able to perform after PBL intervention were compared to the number of learners who were able to perform skills before the PBL intervention. This is presented using histograms where the symbols used with their meaning are: W: Wiring, FWS: Fixing Wall Socket, FB: Fixing a Bulb, FS: Fixing a Socket, FJB: Fixing a Junction Box, and CT: Collaboration and Teamwork.

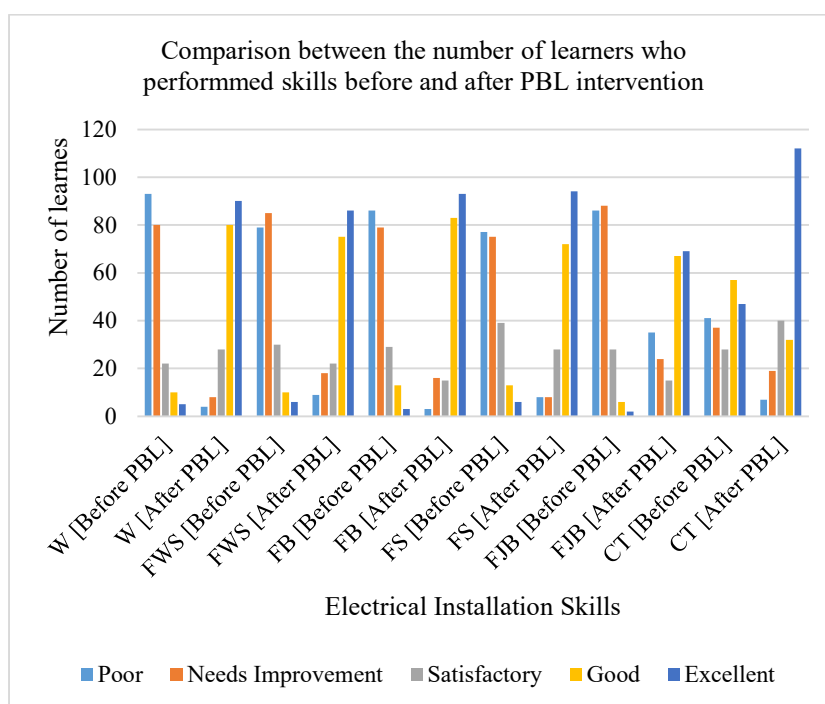


Figure 2: Number of skills and the number of learners who performed a skill.

The findings, as illustrated in the histogram, reveal a substantial improvement in learners' performance across all assessed competencies following the intervention. Firstly, the results indicate a marked decline in the number of learners categorized under Poor and Needs Improvement after the implementation of PBL. Before the intervention, a considerable proportion of learners demonstrated limited competence in skills such as wiring, fixing wall sockets, fixing switches, and handling safety procedures. However, after engaging in PBL activities, these lower performance categories significantly decreased. This suggests that PBL effectively supports struggling learners by providing hands-on experiences and opportunities for active engagement, which are often lacking in traditional teacher-centered approaches.

Secondly, there is a notable increase in the number of learners achieving Good and Excellent performance levels across all skills. This improvement reflects the effectiveness of PBL in promoting deeper understanding and mastery of practical tasks. Through collaborative projects, learners were able to apply theoretical knowledge in real-life contexts, thereby strengthening both their cognitive and psychomotor skills. This finding is consistent with constructivist learning theory, which emphasizes that knowledge is best acquired through active participation and experience.

Moreover, the observed improvement in specific skills, such as wiring (W), fixing wall sockets (FWS), fixing switches (FS), and fixing junction boxes (FJB), highlights the role of PBL in enhancing technical competencies. This is in line of a research conducted by Owens & Hite (2020), which suggested that global PBL is a meaningful strategy for teachers to develop students' communication competencies in STEM, and this study found that PBL enhances the technical competencies. These skills require precision, practice, and confidence, all of which are fostered through repeated hands-on activities embedded in project work. The increase in performance suggests that learners became more confident and competent in executing electrical installation tasks. In addition, the results show a moderate increase in the Satisfactory category, indicating a gradual progression of learners from lower to higher performance levels.

## V. CONCLUSION

The findings of the study conclude that implementing PBL in the physics curriculum, specifically in house electrical installation, significantly enhanced learners' practical skills and positively influenced their perceptions. Learners gained confidence, motivation, and a better understanding of the relevance of electricity in daily life. Skills such as wiring, fixing sockets, bulbs, switches, and circuit breakers improved notably, and learners became more open to engaging with tools and performing electrical tasks both in class and at home. Observation data and questionnaires confirmed a marked shift in learners' attitudes and abilities, showing that PBL increased their interest and perceived competence in electricity-related activities. The study showed that learners became more confident, motivated, and interested in physics-related tasks after participating in PBL activities. Practical abilities such as wiring, fixing sockets, switches, bulbs, and circuit breakers improved significantly. Learners also demonstrated an increased willingness to use tools and apply their skills at home, showing the real-life applicability of what they had learned. Despite challenges such as limited resources and delayed permissions, collaborative efforts and group-based approaches ensured active student participation and the achievement of research objectives.

## VI. RECOMMENDATIONS

Based on the research findings, it is recommended that PBL needs to be adopted in teaching electricity, particularly house electrical installation, due to its effectiveness in enhancing learners' practical skills and perceptions. Teachers consistently are recommended to integrate Project-Based Learning (PBL) into practical subjects to strengthen learners' technical competencies, particularly in electrical installation. Schools should ensure adequate provision of tools, materials, safety equipment, and sufficient time allocation to support effective project implementation, alongside continuous professional development for teachers on PBL design for simplified application in teaching and learning activities. Curriculum developers and policymakers should formally include PBL within competency-based frameworks and align assessments with practical performance outcomes.

For future studies, it is suggested that researchers explore the broader application of PBL across various science and technical subjects to examine its overall impact on learners' academic growth and skill development. Further research could also investigate how learners transfer practical skills gained through PBL into real-life situations, such as during school breaks or in home settings. Additionally, future studies should consider addressing challenges encountered in this research, including equipment shortages, language barriers, and parental consent, to improve the effectiveness and reliability of similar studies.

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## REFERENCES

- [1]. Acharya, A. S., Prakash, A., Saxena, P., & Nigam, A. (2013). Sampling: Why and how of it. *Indian Journal of Medical Specialities*, 4(2), 330–333. <https://doi.org/10.7713/ijms.2013.0032>
- [2]. Babalola, F. E., Lambourne, R. J., & Swithenby, S. J. (2020). The Real Aims that Shape the Teaching of Practical Physics in Sub-Saharan Africa. *International Journal of Science and Mathematics Education*, 18(2), 259–278. <https://doi.org/10.1007/s10763-019-09962-7>
- [3]. Barron, B., & Darling-hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. *Powerful Learning: What We Know About Teaching for Understanding*, 11–70.
- [4]. Belay, E. B., Alemu, M., & Tadesse, M. (2022). The Effect of Dialogic Practical Work on Secondary School Students' Attitudes toward Physics. *Science Education International*, 33(2), 232–241. <https://doi.org/10.33828/sei.v33.i2.11>

- [5]. Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House*, 83(2), 39–43. <https://doi.org/10.1080/00098650903505415>
- [6]. Condliffe, B. (2017). Project-Based Learning: A Literature Review. Working Paper. MDRC.
- [7]. Crane, T. (2005). What is the problem of perception? *Synthesis Philosophica*, 20(2), 237–264.
- [8]. Creswell, J. W. (2015). *Educational Research Methodology: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*.
- [9]. Dimmitt, N. (2017). The power of project based learning: Experiential education to develop critical thinking skills for university students. In *CBU International Conference Proceedings* (Vol. 5, pp. 575–579). <https://doi.org/10.12955/cbup.v5.988>
- [10]. Edwards, D. B., Okitsu, T., Da Costa, R., & Kitamura, Y. (2018). Organizational legitimacy in the global education policy field: Learning from UNESCO and the Global Monitoring Report. *Comparative Education Review*, 62(1), 31–63.
- [11]. Fernandes, S. R. G. (2014). Preparing graduates for professional practice : findings from a case study of Project-based Learning ( PBL). *Procedia-Social and Behavioral Sciences*, 139, 219–226. <https://doi.org/10.1016/j.sbspro.2014.08.064>
- [12]. Gormus, A. (2019). Future of Work with the Industry 4.0. *International Congress on Social Sciences (Incos 2019) Proceeding Book, October*, 317–323. <https://www.researchgate.net/publication/336846985>
- [13]. Gunarathna, C., Yang, R., Wijeratne Mudiyansele, P., Amarasinghe, G., Samarasinghalage, T., Weerasinghe, R. P. N., Zhao, H., Zhang, C., Liu, C., Wang, K., & Dev Sureshkumar Jayakumari, S. (2024). Project-based learning for proactive skills development of postgraduate students in solar energy building design digitalisation. *Smart and Sustainable Built Environment*, 13(4), 828–855.
- [14]. Gunawan, G., Harjono, A., Sahidu, H., & Herayanti, L. (2017). Virtual laboratory to improve students' problem-solving skills on electricity concept. *Jurnal Pendidikan IPA Indonesia*, 6(2), 257–264. <https://doi.org/10.15294/jpii.v6i1.8750>
- [15]. Hart, C. (2008). Models in physics, models for physics learning, and why the distinction may matter in the case of electric circuits. *Research in Science Education*, 38, 529–544. <https://doi.org/10.1007/s11165-007-9060-y>
- [16]. Haryudo, S. I., Agung, A. I., Firmansyah, R., Wibowo, W. A., Ekohariadi, & Munoto. (2020). The effect of the implementation of project based learning on learning activities of electrical engineering students. In *Journal of Physics: Conference Series* (Vol. 1569, Issue 3). <https://doi.org/10.1088/1742-6596/1569/3/032099>
- [17]. Hébert, A., & Hauf, P. (2015). Student learning through service learning: Effects on academic development, civic responsibility, interpersonal skills and practical skills. *Active Learning in Higher Education*, 16(1), 37–49.
- [18]. Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3), 235–266.
- [19]. Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice*, 8(2), 105–107. <https://doi.org/10.1039/b7rp90003a>
- [20]. Holubova, R. (2008). Effective Teaching Methods--Project-based Learning in Physics. *Online Submission*, 5(12), 27–36.
- [21]. Jafta, T. D. (2006). *A participatory study of project based learning as mediated in a teaching unit of electricity for Grade 8 learners (Doctoral dissertation, University of KwaZulu-Natal)*.
- [22]. Jankowiak, K., Driessen, S., Kaifie, A., Kimpeler, S., Krampert, T., Kraus, T., Stunder, D., & Kursawe, M. (2021). Identification of Environmental and Experimental Factors Influencing Human Perception of DC and AC Electric Fields. *Bioelectromagnetics*, 42(5), 341–356.

- [23]. Jatmiko, B., Prahani, B. K., Supardi, Z. A. I., Wicaksono, I., Erlina, N., Pandiangan, P., & Althaf, R. (2018). The comparison of OR-IPA teaching model and problem based learning model effectiveness to improve critical thinking skills of pre-service physics teachers. *Journal of Baltic Science Education*, 17(2), 300–319.
- [24]. Jollands, M., & Parthasarathy, R. (2013). Developing engineering students' understanding of sustainability using project based learning. *Sustainability*, 5(12), 5052–5066. <https://doi.org/10.3390/su5125052>
- [25]. Khatri, K. K. (2020). Research Paradigm: A Philosophy of Educational Research. *International Journal of English Literature and Social Sciences*, 5(5), 1435–1440. <https://doi.org/10.22161/ijels>
- [26]. Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., Ryan, M., Janet, L., & Paul, J. (2009). Problem-Based Learning Meets Case-Based Reasoning in the Middle-School Science Classroom : Putting Learning by Design ( tm ) Into Practice Problem-Based Learning Meets Case-Based Reasoning in the Middle-School Science Classroom : Putting Learning by Desi. *Learning*, 12(4), 495–547.
- [27]. Krajcik, J. S., & Czerniak, C. M. (2018). Teaching Science in Elementary and Middle School: A Project-Based Approach. *Routledge*.
- [28]. Lamanaukas, V., Makarskaitė-Petkevičienė, R., & Lukavičienė, V. (2016). THE DEVELOPMENT OF PEDAGOGICAL INTERNSHIP: MENTOR AND STUDENT ACTIVITY AND EXPERIENCE ASPECTS. *Bulgarian Journal of Science and Education Policy*, 10(2).
- [29]. Leasa, M. (2020). *The effect of learning styles on the critical thinking skills in natural science learning of elementary school students*. 19(4), 2086–2097. <https://doi.org/10.17051/ilkonline.2020.763449>
- [30]. Li, J. (2012). *Improving students' understanding of electricity and magnetism (Doctoral dissertation, University of Pittsburgh)*.
- [31]. Liu, M., Cai, Y., Han, S., & Shao, P. (2023). Understanding Middle School Students' Self-Efficacy and Performance in a Technology-Enriched Problem-Based Learning Program: A Learning Analytics Approach. *Journal of Educational Technology Systems*, 51(4), 513–543.
- [32]. Makkonen, T., Tirri, K., & Lavonen, J. (2021). Engagement in Learning Physics Through Project-Based Learning: A Case Study of Gifted Finnish Upper-Secondary-Level Students. *Journal of Advanced Academics*, 32(4), 501–532.
- [33]. Matzembacher, D. E., Gonzales, R. L., & do Nascimento, L. F. M. (2019). From informing to practicing: Students' engagement through practice-based learning methodology and community services. *International Journal of Management Education*, 17(2), 191–200.
- [34]. Maurice, & Merleau-Ponty. (2004). *The World of perception*. Routledge.
- [35]. Mboniyiriyuze, A., Yadav, L. L., & Amadalo, M. M. (2019). Students' conceptual understanding of electricity and magnetism and its implications: A review. *African Journal of Educational Studies in Mathematics and Sciences*, 15(2), 55–67.
- [36]. Merleau-Ponty, M. (2004). *The World of Perception*. Routledge.
- [37]. Mulenga, I. M., & Kabombwe, Y. M. (2019). Learning from theory and some countries around the world. *International Journal of Education and Research*, 7(2), 117–130.
- [38]. Munje, R. K. (2022). Project-Based Learning: Teaching Methodology to Impart Knowledge and Skills. *Journal of Engineering Education Transformations*, 35(Special Issue 1), 326–333.
- [39]. Musasia, A. M., Abacha, O. A., & Biyoyo, M. E. (2012). Effect of Practical Work in Physics on Girls' Performance, Attitude change and Skills acquisition in the form two-form three Secondary Schools' transition in Kenya. *International*

*Journal of Humanities and Social Science*, 2(23), 151–166.

- [40]. Nyirantambineza, T., & Minani, E. (2022). Experiences of Physics Teachers with integration of Real-life Contexts in their Teaching and Learning Processes. *Rwandan Journal of Education*, 6(1), 85–100.
- [41]. Ogunleye, B. O., & Babajide, V. F. T. (2011). Commitment to Science and gender as determinants of students achievement and practical skills in physics. *Journal of the Science Teachers Association of Nigeria*, 46(1), 125–135.
- [42]. Ornellas, A., Falkner, K., & Edman Stålbrandt, E. (2019). Enhancing graduates' employability skills through authentic learning approaches. *Higher Education, Skills and Work-Based Learning*, 9(1), 107–120.
- [43]. Owens, A. D., & Hite, R. L. (2020). Enhancing student communication competencies in STEM using virtual global collaboration project based learning. *Research in Science and Technological Education*. <https://doi.org/10.1080/02635143.2020.1778663>
- [44]. Pitterson, N. P. (2015). *A systematic review of undergraduate engineering students' perception of the types of activities used to teach electric circuits*.
- [45]. PSF-Rwanda. (2022). *SECTOR SPECIFIC SKILLS NEEDS ASSESSMENT ENERGY DRAFT REPORT*. [https://lmis.rdb.rw/media/resources/20220412\\_Energy\\_Specific\\_Sector\\_Final\\_Report\\_March\\_2022-SK.pdf](https://lmis.rdb.rw/media/resources/20220412_Energy_Specific_Sector_Final_Report_March_2022-SK.pdf)
- [46]. Putri, F. S., & Istiyono, E. (2017). The Development of Performance Assessment of Stem- Based Critical Thinking Skill in the High School Physics Lessons. *INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION*, 12(5), 1269–1281.
- [47]. Rahman, M. M., Watanobe, Y., Kiran, R. U., Thang, T. C., & Paik, I. (2021). Impact of Practical Skills on Academic Performance: A Data-Driven Analysis. *IEEE Access*, 9, 139975–139993.
- [48]. REB. (2023). Republic of rwanda ministry of education education sector strategic plan 2018/19 to 2023/24. *Sector Strategic Plan*.
- [49]. Reiss, M. J., & Abrahams, I. (2015). The assessment of practical skills. *School Science Review*, 357, 40–44.
- [50]. Safitri, R., Wahyuri, A. S., & Ockta, Y. (2024). The Impacts of the Project-Based Learning and Problem-Based Learning Models with Self-Confidence on Students' Learning Outcomes. *Indonesian Research Journal in Education*, 8(1), 269–283.
- [51]. Setyani, N. D., Suparmi, Sarwanto, & Handhika, J. (2017). Students conception and perception of simple electrical circuit. *Journal of Physics: Conference Series*, 909(1).
- [52]. Shana, Z., & Abulibdeh, E. S. (2020). Science Practical Work And Its Impact On Students' Science Achievement. *Journal of Technology and Science Education*, 10(2), 199–215.
- [53]. Smith, C. J. (2012). Improving the school-to-university transition: Using a problem-based approach to teach practical skills whilst simultaneously developing students' independent study skills. *Chemistry Education Research and Practice*, 13(4), 490–499.
- [54]. Song, X., Razali, A. B., Sulaiman, T., & Jeyaraj, J. J. (2024). Impact of Project-Based Learning on Critical Thinking Skills and Language Skills in EFL Context : A Review of Literature. *World Journal of English Language*, 14(5), 402–412. <https://doi.org/10.5430/wjel.v14n5p402>
- [55]. Sudarsono, B., Tentama, F., Mulasari, S. A., Sukesu, T. W., Sulistyawati, S., Ghozali, F. A., Yuliansyah, H., Nafiati, L., & Sofyan, H. (2022). Development of Integrated Project-based (PjBL-T) model to improve work readiness of vocational high school students. *Jurnal Pendidikan Vokasi*, 12(3), 222–235. <https://doi.org/10.21831/jpv.v12i3.53158>
- [56]. Sumarni, W., Wardani, S., Sudarmin, S., & Gupitasari, D. N. (2016). Project based learning (PBL) to improve psychomotoric skills: A classroom action research. *Jurnal Pendidikan IPA Indonesia*, 5(2), 157–163.

- [57]. Tongsakul, A., Jitgarun, K., & Chaokumnerd, W. (2011). Empowering Students Through Project-Based Learning: Perceptions Of Instructors And Students In Vocational Education Institutes In Thailand. *Journal of College Teaching & Learning (TLC)*, 8(12), 19.
- [58]. Wilson-thomas, J. (2022). *Swiftly Switching Project-Based Learning to an Online Short Course Format : Lessons Learnt from Covid Prompted Teaching Adaptations*. 4(2), 72–81.
- [59]. Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, 14, 1202728.