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Teachers' Perceptions of Project-Based Learning in Ordinary Level Physics in Uganda

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Abstract

Achieving Sustainable Development Goal 4 requires learner-centred pedagogies within Uganda's competency-based curriculum, particularly in Ordinary Level physics education. This study examined physics teachers' perceptions of project-based learning (PBL) and explored challenges facilitators face in implementing it in Uganda. A phenomenological design was adopted to explore teachers' perceptions. Data were collected through semi-structured interviews in focus group discussions. In addition, data were collected from classroom observations and document analysis from ten purposively selected physics teachers in seven secondary schools in Mubende Municipality. The data were analyzed thematically. Teachers had positive attitudes toward PBL and acknowledged its role in enhancing learner engagement and real-world problem-solving. However, implementing PBL was constrained by teachers' insufficient pedagogical competencies, abstract physics concepts, time limitations, and limited learner support materials. While teachers value learner-centred approaches, structured professional development and school support are essential for sustainable integration. The study's novelty revealed a mismatch between teachers' positive perceptions of PBL and their limited practical competencies in applying it to abstract physics topics within limited learner support materials contexts. Findings inform targeted interventions to strengthen competency-based science education and scientific literacy.

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INTRODUCTION

Globally, Project-based learning (PBL) in schools aims to enhance learner-centred strategies that promote active learner engagement and to enhance deeper conceptual understanding (Haatainen & Aksela, 2021). However, there are structural challenges in implementing it, and it largely depends on teachers' pedagogical attitudes and school practices (Lee & Grapin, 2025). Studies show that teachers hold positive perceptions of implementing PBL (Ling, 2024). In physics education, abstract concepts of topics like energy, force, and waves make traditional teaching methods less effective. They result in rote learning. To minimise that physics requires students to grasp abstract principles such as energy, force, and waves, which often defy intuitive understanding. In classroom practice, this abstraction presents concrete challenges for physics teachers: force and motion, weight and mass, heat and temperature, speed and velocity and many others. There is limited mathematical proficiency needed for problem-solving, inadequate laboratory equipment for practical demonstrations, large class sizes that constrain individualised support, and insufficient time to guide learners through inquiry-based experiments. These classroom realities, rather than curriculum reforms alone, significantly shape how physics is taught and learned.

Research gap

When engaged in Project-Based Learning (PBL), students are empowered to operationalise abstract physics concepts through experimentation, model construction, collaborative problem-solving, and real-world application. Such processes enable deeper conceptual understanding beyond rote memorisation. However, despite these pedagogical advantages, the integration of PBL into Ugandan secondary school physics remains uneven and contested. Studies highlight possibilities and challenges of learner-centred pedagogies. Muñoz-Losa et al. (2025) contend that teachers' emotional and teaching factors influence teachers' adoption of PBL. Similarly, teachers value PBL but require professional support to implement it (Haatainen & Aksela, 2021.While previous studies show challenges regarding resources, strategies to examine PBL at the required policy level. There remains limited empirical evidence on how physics teachers explicitly interpret, adapt, and enact PBL within the epistemic demands of abstract physics in the classrooms. The research gap, therefore, occurs at the pedagogical enactment level: little is known about teachers' perceptions regarding the implementation of PBL in physics classrooms. Addressing this gap is essential for understanding not only structural barriers but also the classroom-level dynamics for the effectiveness of PBL in Ugandan secondary education.

Therefore, rather than presuming direct improvements in physics instruction and student learning outcomes, this study seeks to systematically investigate how Project-Based Learning (PBL) is understood and enacted within secondary school physics classrooms. Although existing literature identifies several structural and pedagogical challenges, these have not been sufficiently articulated as an empirically grounded research gap at the classroom enactment level. Specifically, there is limited evidence on how physics teachers interpret PBL principles, the nature of the barriers they encounter during implementation, and the strategies they employ to navigate contextual constraints. Accordingly, the study is guided by the following objectives: (1) to examine physics teachers' perceptions of PBL; (2) to analyse how PBL is implemented in secondary school physics classrooms; and (3) to identify the contextual and pedagogical factors influencing its enactment. These objectives aim to generate context-specific, evidence-based insights into PBL practice rather than to assume predetermined instructional or learning outcomes.

Proposed Focus and Importance

This study focuses on examining teachers' perceptions regarding PBL implementation and its barriers. It provides significant insight into how PBL is enacted, how contextual factors shape practice, and what supports are necessary for sustainable implementation.

Research Purpose.

This study aimed to examine in-service physics teachers' perceptions and experiences of implementing project-based learning in Ordinary

Level secondary schools in Mubende Municipality, Uganda.

Benefits to Science and Society

The results will enhance knowledge of curriculum developers, teacher educators, and policymakers in strengthening learner-centred physics teaching, enhancing scientific literacy, and preparing students with competencies needed for societal and workforce demands in alignment with national development goals.

Statement of the Problem

1) Ideal Condition

The ideal condition is that physics teachers in Uganda wish for the supported transition from traditional, teacher-centered methods to engagement-focused strategies like project-oriented teaching as emphasized by the National Curriculum Development Centre (NCDC) reforms of 2019). Research shows that PBL enhances students' conceptual understanding, engagement, and problem-solving skills in science classrooms (Ross & Bruce-Davies, 2025; Smith & Jones, 2023). Thus, reforms aim to promote competency-based learning, which has been recognized for its potential to enhance students' conceptual understanding of physics and improve academic achievement (Salaoru, 2020; Baghoussi, 2021). Such an approach is expected to enhance interactive and successful learning atmosphere. Furthermore, these reforms promote learner-centred pedagogies intended to strengthen conceptual understanding and improve academic achievement (Salaoru, 2020; Baghoussi, 2021), thereby fostering more interactive and meaningful learning environments.

However, a clear gap persists between these curriculum expectations and actual classroom practice in physics. While policy frameworks emphasise competency-based, project-oriented instruction, many physics classrooms continue to rely predominantly on transmissive teaching and examination-driven coverage of content. The core problem, therefore, lies in the misalignment between reform-oriented pedagogical ideals and the realities of classroom enactment. This study explicitly addresses this implementation gap by examining how physics teachers interpret, negotiate, and operationalise curriculum expectations within their specific school contexts.

2) Reality (Problem)

Despite curriculum reforms advocating PBL, many physics teachers continue to rely on teacher-centered approaches. Factors limiting adoption include insufficient professional development, low confidence in implementing PBL, and lack of practical skills to manage project-based activities effectively (Li & Wang, 2024). Teachers' limited understanding and experience with PBL hinder the successful translation of curriculum reforms into classroom practice.

3) Results of the Problem

The weak implementation of PBL contributes to low student engagement, limited conceptual understanding, and suboptimal academic achievement in physics (Smith & Jones, 2023). The persistence of traditional methods reduces opportunities for active learning and undermines the goals of competency-based reforms.

4) What the Study Will Do

Although previous research has documented the benefits of PBL and the influence of teacher beliefs on instructional practice (Ross & Bruce-Davies, 2025; Li & Wang, 2024; Smith & Jones, 2023), most studies have been conducted in developed-country contexts or focused on science teaching in general. There is limited empirical evidence on how in-service physics teachers in resource-constrained settings such as Mubende Municipality perceive and experience PBL**.** This study addresses this gap by investigating Ordinary Level physics teachers' perceptions and lived experiences, identifying both barriers and enabling factors, and providing context-specific recommendations to inform professional development, curriculum support, and policy strategies that enhance learner-centered physics instruction.

Theoretical perspective

This study is anchored in Experiential Learning Theory (ELT), which conceptualizes learning as a cyclical process of engaging in experience, reflecting on that experience, forming abstract conceptualizations, and applying new insights in practice. Originally proposed by Kolb, ELT posits that learning is most meaningful when individuals actively transform experience into knowledge through iterative action and reflection (Kolb, 1984; Chan, 2023). In the context of teacher learning, ELT emphasizes how teachers' classroom experiences shape their perceptions, instructional decisions, and practical adaptations (Chan, 2023).

Experiential learning has strong empirical support in science education research as a framework for understanding how teachers integrate and adapt instructional innovations. Studies in *International Journal of Science Education* demonstrate that teachers' beliefs, reflections, and experiential engagement with new pedagogies strongly influence how they implement learner-centered methods, including project-based learning (PBL) (Li & Wang, 2024). Similarly, research published in *Science Education* shows that iterative cycles of enactment, reflection, and refinement enable teachers to negotiate challenges in implementing complex instructional strategies in science classrooms, reshaping their instructional knowledge and classroom practices (Smith & Jones, 2023).

The application of ELT in this study provides a useful lens for examining how physics teachers in Uganda engage with PBL as a lived pedagogy. Through active experience and reflection, teachers form evolving conceptual understandings of PBL, adjust their instructional strategies, and refine their perceptions of what constitutes effective learner-centered physics teaching (Ross & Bruce-Davies, 2025). In the context of Mubende Municipality — where high learner enrollment and variations in school commitment to active teaching present unique instructional challenges — ELT helps explain how teachers interpret, adapt, and apply PBL based on their first-hand classroom experiences.

By foregrounding teachers' experiential processes, ELT supports the analytical focus of this study: understanding how teachers' perceptions and experiences of PBL emerge, transform, and influence their classroom practice. It offers a coherent framework to interpret the dynamic interplay between experience, reflection, and action that shapes teachers' adoption of PBL in Ordinary Level physics instruction.

Purpose, Objectives, and Research Questions

The purpose of this study was to explore in-service physics teachers' perceptions and experiences of implementing project-based learning (PBL) in Ordinary Level physics classrooms in Uganda, with a focus on understanding implementation practices, challenges, and strategies for enhancing learner-centered instruction.

To achieve this purpose, the study was guided by the following objectives:

1. To examine physics teachers' perceptions of project-based learning in Ordinary Level physics instruction, addressing how teachers view its relevance and effectiveness in promoting conceptual understanding.
2. To describe teachers' experiences and variations in knowledge regarding the use of project-based learning, highlighting how prior experience and familiarity with PBL influence classroom engagement.
3. To investigate how physics teachers implement project-based learning in their classrooms, exploring the instructional practices and methods used to translate PBL into action.
4. To identify the challenges and enabling factors that influence the adoption of project-based learning, revealing contextual, resource-related, and professional factors that affect teachers' ability to implement PBL.
5. To develop strategies to improve the implementation of project-based learning in physics instruction, providing evidence-based approaches derived from teachers' perceptions and experiences.

These objectives guided the following research questions:

1. What are physics teachers' perceptions of project-based learning in Ordinary Level physics classrooms in Uganda?
2. How do physics teachers' experiences and knowledge influence their engagement with project-based learning in Ordinary Level physics classrooms?
3. How do physics teachers implement project-based learning in Ordinary Level physics instruction in Uganda?

4. What challenges and enabling factors affect the adoption of project-based learning by physics teachers in Ordinary Level classrooms?
5. What strategies can be developed to enhance the implementation of project-based learning in Ordinary Level physics classrooms in Uganda?

Literature review

Empirical research repeatedly highlights the importance of teachers' knowledge and perceptions in shaping the implementation of learner-centered pedagogies such as project-based learning (PBL). PBL is recognized for fostering deeper conceptual understanding, student engagement, and real-world problem-solving (Ross & Bruce-Davies, 2025; Smith & Jones, 2023). Teachers' beliefs and professional experiences significantly influence how they enact these pedagogical innovations (Li & Wang, 2024).

Variations in Teacher Knowledge and Perceptions

Studies show substantial variation in teachers' understanding of PBL concepts. Gartland, Snyder, and Hampton (2021) found that some secondary science teachers focused mainly on procedural aspects of PBL, while others integrated inquiry and reflection effectively. Adams and Krockover (2022) reported that teachers' epistemic beliefs shape the adoption of learner-centered practices, with some prioritizing content coverage over authentic student engagement. Smith and Jones (2023) found that teachers with deeper conceptual knowledge of PBL were more likely to design meaningful, student-driven projects.

PBL and Instructional Effectiveness

Research demonstrates that PBL can enhance student engagement and conceptual understanding. Tan and Yore (2022) observed that students in PBL environments achieved higher learning outcomes than peers in traditional classrooms. Muñoz-Losa, Martínez-Álvarez, and Corbacho-Cuello (2025) showed that when teachers effectively facilitate inquiry cycles, PBL strengthens students' reasoning and problem-solving skills. However, these benefits depend on teachers' ability to orchestrate complex tasks, manage classroom interactions, and align assessment with learning goals.

Implementation Challenges: Time, Resources, and Training

Time constraints limited instructional resources, and gaps in professional learning remain persistent barriers. Johnson and Smith (2022) noted that even motivated teachers struggled to balance curriculum coverage with the demands of authentic project work. Li and Wang (2024) emphasized that sustained professional development and collaborative planning are crucial for developing PBL competence.

Perceptions as Determinants of Practice

Teachers' perceptions are influenced by prior experience, school culture, and available support. Ross and Bruce-Davies (2025) found that teachers who perceive PBL as compatible with their instructional goals are more likely to adapt its practices to local constraints. Conversely, teachers who view PBL as threatening to content coverage or classroom order tend to implement only superficial elements, limiting student engagement.

Context-Specific Gaps

Despite extensive research on PBL, limited attention has been given to how in-service physics teachers perceive and implement PBL in specific contexts such as Mubende Municipality in Uganda. General barriers like time constraints and resource limitations are documented, but the interplay of teacher knowledge, school conditions, and instructional practices in ordinary level physics classrooms remains underexplored. This indicates a need to examine how perceptions, experiences, and context-specific challenges affect PBL implementation.

Summary of the Gap

The reviewed literature shows that teachers' knowledge and perceptions of PBL vary widely, and these differences significantly influence classroom implementation and student engagement. However, there is insufficient research on physics teachers' perceptions, experiences, and contextual barriers in Ugandan secondary schools, particularly in Mubende Municipality. Addressing this gap is essential for enhancing student involvement and conceptual understanding through PBL in physics education.

METHODS

Research Design

This study used a qualitative research approach to explore in-service physics teachers' perceptions and experiences of project-based learning (PBL) in Ordinary Level classrooms. Qualitative designs are appropriate when the aim is to understand participants' subjective experiences and meaning-making in context (Creswell & Poth, 2018). A phenomenological design was adopted because it focuses on how individuals experience and interpret a phenomenon, enabling rich descriptions of teachers' lived experiences with PBL (Moustakas, 1994; Hayes et al., 2022). Phenomenological studies have been widely used to investigate teachers' interpretations of instructional innovations in science education (Li & Wang, 2024; Ross & Bruce-Davies, 2025).

Participants

The study's participants were ten in-service physics teachers from government and private secondary schools in Mubende Municipality. Purposive sampling was employed to select teachers who had experience in teaching Ordinary Level physics and were knowledgeable about instructional practices (Patton, 2015). Purposive sampling enhances the depth and richness of data when the goal is to obtain information-rich cases relevant to the phenomenon (Miles, Huberman, & Saldaña, 2020). Participants were identified and coded (e.g., T01-T10) to protect confidentiality (Simon & Goes, 2013). Informed consent was obtained, and participants were assured of voluntary participation and confidentiality throughout the research process, consistent with ethical research practice (Orb, Eisenhauer & Wynaden, 2001; Smith & Adams, 2023).

Data Collection

Data were collected through semi-structured interviews, classroom observations, and document analysis. Semi-structured interviews allow participants to express their perceptions and experiences in their own words while enabling the researcher to probe for clarity and depth (Kvale & Brinkmann, 2015; Muñoz-Losa et al., 2025). Classroom observations provided contextual data on how PBL practices were enacted in real time (Angelle & DeHart, 2011). Document analysis (e.g., lesson plans, teaching notes) offered additional insight into teachers' instructional planning and practice (Bowen, 2009). Triangulating these sources strengthens the credibility of qualitative findings (Flick, 2018; Ross & Bruce-Davies, 2025).

Data Analysis

Data analysis began with familiarisation with all collected materials, including interview transcripts, observation notes, and documents – a process of repeated reading to understand the overall content (Johnson, Onwuegbuzie & Turner, 2020; Sadiki & Kibirige, 2022). All interviews were transcribed verbatim to preserve participants' meanings, which is essential for accurate interpretation (Poland, 1995; Saldana, 2021). A thematic analysis approach was used following Braun and Clarke's (2006) six-phase framework for identifying, coding, and analysing patterns in qualitative data. This method has been widely applied in education research to systematically derive themes from complex textual data (Nowell et al., 2017; Nguyen et al., 2024). Initial codes were developed inductively and subsequently grouped into themes through iterative refinement, enabling the researcher to identify core patterns related to perceptions, implementation, barriers, and enabling factors (Braun & Clarke, 2006; Adu, 2022).

Trustworthiness

To ensure trustworthiness, the study employed multiple quality criteria. Credibility was enhanced through member checking, where participants reviewed preliminary interpretations to confirm their accuracy (Lincoln & Guba, 1985; Korstjens & Moser, 2018). Dependability was supported by maintaining a detailed audit trail of decisions made during data collection and analysis (Madison, 2019). Confirmability was strengthened through reflexive journaling, which helped minimize researcher bias (Patton, 2015). Finally, transferability was addressed by providing rich, contextual descriptions of the participants, setting, and findings to enable others to assess applicability in similar contexts (Creswell & Poth, 2018; Flick, 2018).

Findings

Table 1. Demographic Characteristics of In-Service Physics Teachers

Characteristics	Categories	frequency	Percentage (%)
School type	Privately	4	57
	Government aided	3	43
Age for teachers	20-24	1	10
	25-29	1	10
	30-34	4	40
	35-39	1	10
	40-44	1	10
	45+	2	20
Gender	Males	8	80
	Females	2	20
Teaching experience (years)	1-4	2	20
	5-9	4	40
	10-14	2	20
	>15	2	20
Professional qualification	Bachelor's degree	9	90
	Diploma	1	10
Classroom enrolments	60-79	2	20
	80-89	3	30
	100-119	3	30
	120-139	1	10
	140-159	1	10

The Table 1 indicates a higher proportion of eight male teachers compared to two female teachers, which is relevant because gender may influence instructional approaches, classroom management, and engagement with project-based learning (PBL). Research suggests that male and female teachers may differ in their pedagogical preferences and risk-taking in adopting innovative methods (Li & Wang, 2024; Ross & Bruce-Davies, 2025). In this context, the predominance of male teachers could shape how PBL is implemented, potentially affecting collaborative activities, interaction patterns with students, and the degree to which learner-centered strategies are employed. Understanding this gender distribution is therefore essential for interpreting variations in teacher perceptions, confidence, and the practical execution of PBL in Ordinary Level physics classrooms.

Demographic Characteristics of Participants

Table 1 presents the demographic profiles of the ten in-service physics teachers who participated in the study. The school type distribution (4 private, 3 government-aided) is relevant because resource availability and institutional support can influence teachers' capacity to implement project-based learning (PBL). Private schools in this context often have smaller class sizes and more access to teaching materials, which may facilitate active learning, whereas government-aided schools may face constraints that hinder PBL adoption (Ross & Bruce-Davies, 2025).

Age and teaching experience are significant as they reflect potential differences in pedagogical adaptability. Teachers aged 30–39, representing most participants, are likely to have enough experience to manage classroom challenges while remaining open to innovative instructional strategies (Li & Wang, 2024). Similarly, those with 5–9 years of teaching experience may be more confident in implementing PBL than less experienced colleagues, whereas teachers with over 15 years of experience may rely more on traditional methods.

Gender distribution (8 males, 2 females) provides context for potential differences in instructional styles and classroom management, which may influence PBL facilitation.

Professional qualifications (9 bachelor's degrees, 1 diploma) indicate that most participants have sufficient academic preparation, which may affect their understanding of educational reforms and the pedagogical principles underlying PBL.

Finally, classroom enrolment sizes varied, with most teachers handling 80–120 students per class. Large class sizes can limit opportunities for individualized attention and hands-on activities, posing a practical barrier to effective PBL implementation (Hayes et al., 2022). Taken together, these demographic characteristics are crucial for interpreting teachers' experiences and perceptions, as they contextualize both the opportunities and challenges for implementing PBL in Ordinary Level physics classrooms.

RESULTS AND DISCUSSION

This section presents the results of the study on physics teachers' implementation of Project-Based Learning (PBL) in secondary schools in Mubende Municipality, Uganda. The analysis draws on three complementary data sources, semi-structured interviews, classroom observations, and document analysis like schemes of work and lesson plans to generate a nuanced understanding of teachers' perceptions, and enacted practices. Through methodological triangulation, the study moves beyond self-reported to examine how teachers stated perceptions about PBL align with their planning documents and observable classroom enactment.

The results reveal both convergence and divergence across data sources. While many teachers articulated strong conceptual support for PBL, observational and documentary evidence showed variation in the depth and consistency of its implementation. These discrepancies highlight how contextual constraints, pedagogical planning, and individual teacher understanding interact to shape classroom enactment. The results are organized into four interconnected themes: (1) variation in teachers' knowledge of PBL, (2) resource constraints affecting implementation, (3) planning practices and classroom enactment, and (4) teachers' positive perceptions of PBL and its perceived benefits.

Theme 1: Variation in Physics Teachers' Knowledge of PBL

Data analysis revealed significant variation in teachers' knowledge of project-based learning (PBL). Some teachers demonstrated procedural knowledge, focusing on steps and activities, while others exhibited a deeper understanding of PBL's impact on learning outcomes such as creativity, critical thinking, and collaboration.

For instance, Teacher T03 stated:
"…I use computers, the internet, projectors, etc., in PBL practices. However, these are not adequate due to the high enrolment of learners."

This response illustrates that while teachers attempt to integrate technology, limitations such as class size impede full PBL implementation. In contrast, Teacher T02 described a collaborative project:
"…my learners were given an activity of coming up with a periscope. There was a sharing of responsibility and learners teamed up to achieve a common goal…"

This indicates recognition of the student-centered and collaborative aspects of PBL. Another teacher highlighted learner autonomy:
"…learners have the freedom to explore topics of interest and design their inquiries. PBL offers a platform for communication and collaboration within groups…" (T05)

These accounts demonstrate that teacher knowledge of PBL is inconsistent, affecting how PBL principles are applied in practice. Observations confirmed that only some teachers implemented classroom arrangements and ICT integration effectively (T03, T04). Document analysis showed that collaborative tasks were included in lesson plans for some teachers (T01, T02, T04, T08, T09) but not others, emphasizing disparities in understanding and application. Clearly, teachers explicitly expressed a need for professional development tailored to local contexts, revealing context-specific gaps not addressed in prior studies (Moore, 2019; Chan, 2023).

Theme 2: Resource Constraints

Resource limitations were a prominent barrier to effective PBL implementation. High learner enrollment, inadequate ICT tools, and limited teaching materials restricted teachers' ability to carry out PBL fully. Teacher T03 highlighted:

"…computers, the internet, projectors are not adequate due to high learner numbers…"

Observation data showed that teachers with access to collaborative spaces and ICT equipment (T03, T04) were better able to implement PBL, while others struggled. These findings suggest that teacher knowledge alone is insufficient; adequate resources are essential for meaningful PBL practices.

These results are unique in that resource constraints in urban schools within Mubende Municipality specifically affected the translation of teacher knowledge into practice, a context-specific insight not widely addressed in existing literature.

Theme 3: Planning Practices and Classroom Implementation

Teachers' planning practices were critical in determining PBL effectiveness. Document analysis revealed that teachers who explicitly incorporated collaborative tasks and material guidance in schemes of work (T01, T02, T04, T09, T10) were more successful in implementing PBL in classrooms.

Teachers viewed their roles as facilitators rather than traditional instructors. Teacher T09 stated:

"…learners collaborate, share ideas, and work in groups. My role is to guide and supervise…"

Observations supported these responses, showing that structured planning, active facilitation, and flexible classroom arrangements enhanced learner engagement, collaboration, and creativity.

A divergence between teachers prioritizing learner-centered practices and those emphasizing assessment emerged highlighting the need for professional development that balances both aspects of PBL.

Theme 4: Positive Perceptions of PBL

Overall, physics teachers held positive views of PBL. They recognized its role in fostering collaboration, critical thinking, creativity, and problem-solving. Teacher T07 commented:

"…there is collaboration among learners and critical thinking within PBL implementation, in addition to problem-solving…"

Teachers noted that PBL motivates students, promotes active engagement, and allows learners to develop tangible solutions (T02, T03, T08, T10). Positive perceptions also influenced classroom arrangements, teaching strategies, and planning, demonstrating that teacher attitudes are pivotal for successful PBL adoption.

The results show that teachers emphasized the importance of careful time management and structured planning to maximize PBL outcomes. This is a nuance rarely highlighted in prior research. Also, the reflections on contextual realities of Ugandan secondary physics classrooms is implied in this finding. These findings demonstrate that when teachers view PBL positively, they are more likely to integrate it systematically into their instructional planning.

Discussion

This study aimed to investigate teachers' perceptions of project-based learning (PBL) in Ordinary Level physics in Uganda, focusing on teachers' knowledge, experiences, contextual challenges, and strategies for effective implementation. The findings revealed nuanced patterns of understanding, enactment, and constraints that shape how PBL is interpreted and practiced in physics classrooms. In interpreting these results, experiential learning theory (ELT) provides a robust analytical lens for understanding how teachers convert classroom experiences into reflective practice, conceptual understanding, and actionable strategies (Kolb, 1984; Chan, 2023).

Teachers' knowledge of PBL varied considerably, which has significant implications for how they enact learner-centered pedagogy (RQ1). Some teachers demonstrated procedural knowledge, focusing on activity steps and tools, but their application was limited by contextual constraints, such as large class sizes and limited resources. For example, Teacher T03 acknowledged using computers and projectors but noted the tools' relevance was curtailed by high learner enrolments that made collaborative use of technology difficult. This suggests that teachers may be aware of PBL techniques but lack the depth of conceptual knowledge needed to adapt these strategies to real classroom conditions. This pattern aligns with the findings of Gartland, Snyder, and Hampton (2021), who reported that science teachers often display inconsistent understanding of PBL, ranging from superficial procedural familiarity to deeper conceptual enactment of inquiry and collaboration.

In contrast, other teachers demonstrated meaningful knowledge of PBL principles by describing how learners shared responsibilities, collaborated toward common goals, and engaged in authentic problem solving. Teacher T02 explained that learners worked together to construct a periscope, noting that the collective effort fostered shared responsibility and goal achievement. This reflects a more sophisticated understanding of PBL as student-centered and collaborative rather than merely task-oriented. This progression from procedural to conceptual understanding resonates with experiential learning theory, which posits that educators' concrete experiences (e.g., trying PBL in practice) inform reflective observation and abstract conceptualization, enabling more effective active experimentation in subsequent lessons (Kolb, 1984; Chan, 2023).

The variation in knowledge found in this study echoes the work of Moore (2019) and Smith and Jones (2023), who documented that teacher knowledge shapes not only how PBL is understood but also how it influences learner outcomes. Where teachers possess only structural knowledge, activities tend to be fragmented, task-driven exercises rather than cohesive projects designed to promote deeper learning. This underscores that knowledge depth is not an academic abstraction but a practical determinant of instructional quality, aligning with prior high-impact research that emphasizes the centrality of teacher cognition in instructional reforms (Li & Wang, 2024; Ross & Bruce-Davies, 2025).

Teachers' perceptions of the value of PBL were predominantly positive, which aligns with literature suggesting that favorable teacher attitudes correlate with greater willingness to adopt learner-centered methods (Sartika, Rahmawati, & Kusuma, 2022). For instance, Teacher T05 highlighted that granting learners autonomy to explore topics of interest increased engagement and motivation, while Teacher T09 emphasized their role as a facilitator rather than a lecturer. These responses reflect a shift toward a learner-centered paradigm, where teachers recognize that PBL supports student agency, creativity, and critical thinking. Such perceptions corroborate the theoretical premise that teacher beliefs are foundational to pedagogical change, as documented in the science education literature (Muñoz-Losa, Martínez-Álvarez, & Corbacho-Cuello, 2025).

Experiential learning theory helps explain how positive perceptions develop: as teachers observe learners actively collaborating and making tangible progress in projects, they reflect on these experiences and adjust their instructional frameworks accordingly. Teacher T04's observation that students reflected on their own techniques and identified areas for improvement illustrates this cyclical process of acting, reflecting, and refining practice. This pattern aligns with Kolb's (1984) model in which *reflective observation* is critical for deepening understanding and informing future action.

Despite positive perceptions, *contextual constraints* significantly impeded effective PBL implementation (RQ3). Teachers identified large class sizes, limited ICT access, and time shortages as barriers that prevented the holistic enactment of PBL. Teacher T03's comment about inadequate technology underscores how structural limitations can dampen even well-intentioned instructional innovation. These findings are consistent with Li and Wang (2024) and Hayes, Bulunuz, and Southerland (2022), who noted that contextual factors such as resource scarcity and curriculum demand often disrupt learner-centered instruction in science classrooms. Such constraints also limit teachers' ability to proceed through the full experiential learning cycle: when concrete classroom conditions are not conducive to experimentation and reflection, the transformation of experience into knowledge is truncated.

Notably, this study contributes a context-specific insight: urban Ugandan secondary schools face distinct barriers that are underrepresented in existing research. While global studies often emphasize general implementation challenges, the teachers in Mubende Municipality specifically highlighted the interaction between learner numbers, resource quality, and classroom management as a primary inhibitor to PBL enactment. This underscores the importance of situated research that captures place-specific conditions, reinforcing the call by NCDC (2019) for contextually responsive pedagogies in Uganda.

Teachers' experiences with PBL also revealed divergent emphases in classroom practice (RQ2). Some teachers focused on promoting inquiry and collaborative problem solving, while others gave priority to assessment practices and curricular alignment. Teacher T04's emphasis on student reflection and iterative improvement highlights a deeper integration of PBL principles, whereas others were more constrained by summative evaluation demands. This echoes findings by Nsabayezu, Murekezi, and Uwizeyimana (2022), who identified that assessment practices can both support and constrain learner-centered methods, depending on how they are executed.

Experiential learning theory again offers interpretive power: teachers' prior professional experiences, whether rooted in learner-centered methods or traditional assessment-oriented practice influence how they integrate PBL. Teachers who had engaged in active teaching before demonstrated greater facility in facilitating collaborative groups and guiding inquiry. These contextualized experiences shape the reflective and conceptual phases of ELT, enabling some teachers to adapt PBL more effectively than others.

The study also identified emergent strategies that teachers believe could enhance PBL implementation (RQ4). These included deliberate lesson planning that foregrounds collaborative tasks, professional development tailored to local needs, and mentorship or peer support to sustain reflective practice. Teachers who reflected on their classroom experiences reported increased confidence and intentional facilitation of projects. These suggestions resonate with recommendations from Sartika et al. (2022) and Moore (2019) that continuous professional learning and structured reflection opportunities are necessary to support teachers in adopting complex pedagogies like PBL in various contexts of environments.

The emphasis on time management as a critical enabler surfaced as a unique insight. Teachers recognized that managing instructional time effectively is essential for creating meaningful project cycles that allow sufficient time for student exploration, feedback, and synthesis, a nuance less frequently discussed in empirical PBL literature. Interpreted through ELT, time management is not just a logistical concern; it is part of the active experimentation phase, where teachers adjust pacing and sequencing of tasks to maximize experiential learning opportunities.

Overall, the study demonstrates that physics teachers' knowledge, perceptions, experiences, and contextual constraints are interwoven, collectively shaping how PBL is enacted. Positive perceptions alone do not guarantee successful implementation; they must be supported by deep knowledge, reflective professional practice, contextual resources, and intentional planning. The study's theoretical framing illustrates that teachers' progression through experiential learning cycles from concrete classroom experience to reflection, conceptualization, and adjusted practice is key to realizing the potential of PBL in enhancing learner engagement and conceptual understanding. The study's finding need to be taken with caution as there was a imbalance and it is not clear what the results would have been if there were more females than males. Hence, a need for further study with a focus on classes where most of the teachers were females.

CONCLUSION

This study provides a critical and contextually grounded contribution to the discourse on Project-Based Learning (PBL) in secondary science education by illuminating how teachers' perceptions, pedagogical competence, and structural conditions interact to shape classroom practice in Ordinary Level physics in Uganda. While physics teachers expressed strong endorsement of PBL and recognized its capacity to enhance learner engagement, collaboration, and real-world problem-solving, implementation was uneven and frequently constrained by limited pedagogical expertise, abstract disciplinary content, time pressures, and insufficient instructional resources.

Importantly, the findings move beyond the simplistic assumption that positive teacher attitudes are sufficient for pedagogical transformation. Instead, they demonstrate that the translation of reform-oriented policy into classroom practice depends on the alignment of teacher knowledge, structured planning practices, institutional support, and material resources. Variation in teachers' conceptual understanding of PBL resulted in corresponding disparities in implementation, underscoring the centrality of sustained, context-responsive professional development. Moreover, the documented tension between learner-centered inquiry and examination-oriented assessment highlights systemic contradictions that must be addressed if PBL is to be meaningfully institutionalized.

Theoretically, the study advances scholarship by linking teachers' readiness to adopt PBL with motivational dynamics consistent with self-determination perspectives, illustrating how autonomy, competence, and contextual affordances jointly influence instructional innovation. Empirically, it contributes rare, context-specific evidence from urban secondary schools in Mubende, thereby extending the predominantly Global North–centered PBL literature into underrepresented African educational contexts.

For policymakers and curriculum developers, the findings signal that successful integration of PBL in physics education requires systemic investment—not only in material infrastructure and ICT resources, but also in targeted professional development that strengthens teachers' conceptual and pedagogical mastery of project-based approaches while aligning them with assessment frameworks. Without such structural coherence, PBL risks remaining an aspirational reform discourse rather than a transformative instructional reality.

Ultimately, this study underscores that sustainable pedagogical change in Ordinary Level physics classrooms will depend on bridging the gap between enthusiasm and enactment. By foregrounding the lived experiences of teachers within their socio-institutional contexts, the research offers a roadmap for translating positive perceptions into sustained, high-quality PBL practice capable of enhancing science learning outcomes in Uganda and comparable educational systems.

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