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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 the challenges they face during implementation. Adopting phenomenological design, data were collected through semi-structured focus group interviews, classroom observations, and document analysis involving ten purposively selected physics teachers across seven secondary schools in Mubende Municipality. The data were analysed thematically. Results show that while teachers held positive attitudes toward PBL, acknowledging its role in enhancing learner engagement and real-world problem-solving, actual implementation was constrained by 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 (Aisyah, S., & Novita, 2025).

In physics education, abstract concepts like energy, force, and waves often defy intuitive understanding. Consequently, traditional teaching methods are inadequate for fostering deep comprehension, frequently resulting in passive, rote learning. To minimise this reliance on memorisation, instructional approaches must be shifted to help students dynamically grasp these non-intuitive principles. 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. Yet, while previous studies focus heavily on resource limitations or macro-level policy strategies, there remains limited empirical evidence regarding how physics teachers explicitly interpret, adapt, and enact PBL within the unique epistemic demands of abstract physics classrooms. The research gap, therefore, occurs at the pedagogical enactment level: addressing it is essential for understanding not only structural barriers but also the classroom-level dynamics that dictate the ultimate 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 than assuming predetermined instructional successes.

Proposed Focus and Importance

This study examines in-service teachers' perceptions regarding Project-Based Learning (PBL) implementation and its associated barriers. By doing so, it provides critical insights into how PBL is practically enacted, how local contextual factors shape classroom practice, and what structural supports are necessary for its sustainable integration.

Research Purpose

The primary purpose of this study was to examine in-service physics teachers' perceptions and lived experiences of implementing PBL within Ordinary Level secondary schools in Mubende Municipality, Uganda.

Benefits to Science and Society

The findings will enrich the body of knowledge available to curriculum developers, teacher educators, and policymakers tasked with strengthening learner-centred physics instruction. Ultimately, these insights can help advance scientific literacy and better equip students with the essential competencies required to meet modern societal and workforce demands, in direct alignment with Uganda's 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). 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 did

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 directly addresses this empirical gap by investigating Ordinary Level physics teachers' perceptions and lived experiences within the resource-constrained setting of Mubende Municipality, Uganda. By uncovering the unique localized barriers and systemic enablers these educators face, this study provides context-specific, data-driven recommendations to inform targeted professional development, localized curriculum support, and sustainable policy implementation strategies.

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

(1984), and further expanded by contemporary scholarship (Ajan, 2023), ELT posits that learning is most meaningful when individuals actively transform experience into knowledge through iterative action and reflection. Within the realm of professional teacher development, ELT emphasizes how teachers' immediate classroom encounters actively shape their pedagogical perceptions, instructional decisions, and practical field adaptations (Ajan, 2023).

Experiential learning enjoys strong empirical backing within science education research as a robust framework for tracking how educators integrate and adapt instructional innovations. For example, 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 t he study also identified emergenteaching 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 structural action that governs 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 Uganda, aiming to identify implementation practices and challenges to inform strategic supports for learner-centered physics instruction.

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

1. examine physics teachers' perceptions, experiences, and baseline knowledge regarding the relevance and use of project-based learning in Ordinary Level physics instruction.
2. analyze how physics teachers practically implement project-based learning, focusing on the specific instructional practices used to translate PBL into classroom action.
3. identify the contextual challenges and enabling factors (material, professional, and institutional) that influence teachers' capacity to adopt PBL.

These objectives guided the following research questions:

1. What are physics teachers' perceptions, experiences, and knowledge regarding the use of project-based learning in Ordinary Level physics classrooms in Uganda?
2. How do physics teachers practically implement project-based learning within Ordinary Level physics instruction?
3. What contextual challenges and enabling factors affect the adoption and execution of project-based learning by Ordinary Level physics teachers?

Literature review

Empirical research repeatedly highlights that teachers' baseline knowledge and subjective perceptions act as the primary gatekeepers for the successful implementation of learner-centered pedagogies. Scholarly investigations show substantial variation in how educators internalize these concepts. For instance, Gartland et al. (2021) observed that many secondary science teachers focus strictly on the mechanical, procedural aspects of project design, whereas those with advanced training integrate deep inquiry and critical student reflection seamlessly. This divergence is often driven by foundational mindsets; Adams and Krockover (2022) reported that teachers' underlying epistemic beliefs heavily dictate their adoption of learner-centered practices, with content-oriented traditionalists consistently prioritizing curriculum coverage over authentic student engagement. Ultimately, as Smith and Jones (2023) demonstrate, educators who possess robust conceptual mastery of project-based frameworks are significantly better equipped to design meaningful, student-driven learning experiences.

Teachers' Competencies and Structural Barriers in PBL

Studies reveal substantial variation in how educators internalize and execute project-based frameworks. For instance, Gartland et al. (2021) observed that many secondary science teachers focus strictly on the mechanical, procedural aspects of project design, whereas those with advanced training integrate deep inquiry and critical student reflection seamlessly. This divergence is often driven by foundational mindsets: Bahçivan (2016) reported that teachers' underlying epistemic beliefs heavily dictate their adoption of learner-centered practices, with content-oriented traditionalists consistently prioritizing curriculum coverage over authentic student engagement. Ultimately, as Smith and Jones (2023) demonstrate, educators who possess robust conceptual mastery of project-based frameworks are significantly better equipped to design meaningful, student-driven learning experiences that yield higher academic outcomes than traditional, passive classrooms (Tan & Yore, 2022).

However, these pedagogical ideals routinely collide with stark classroom realities. Muñoz-Losa et al. (2025) note that the academic benefits of PBL—such as strengthened scientific reasoning and problem-solving skills, depend entirely on a teacher's practical ability to orchestrate complex tasks, manage decentralized classroom interactions, and align open-ended project assessments with strict learning goals. This orchestrational demand becomes a severe liability when teachers are confronted with systemic constraints. Time limitations, sparse instructional materials, and systemic deficits in professional teacher development remain persistent barriers globally. Even highly intrinsically motivated teachers frequently struggle to balance rigid national curriculum deadlines and examination-driven content coverage with the expansive time demands required for authentic project work (Valero, 2022). To bridge this gap between teacher intent and classroom execution, Li and Wang (2024) emphasize that short-term instructional workshops are structurally insufficient; rather, sustained professional development and institutionalized collaborative planning periods are mandatory prerequisites for building resilient teacher competence in PBL.

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 competence in PBL.

Perceptions as Determinants of Practice

Teachers' instructional choices are heavily mediated by their prior experiences, overarching school cultures, and perceived institutional support mechanisms. 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, which ultimately retards authentic student engagement.

Context-Specific Gaps

Despite extensive global research on PBL, limited attention has been dedicated to how in-service physics teachers navigate these frameworks within sub-Saharan educational ecosystems like Mubende District. While, 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. Given that physics education inherently demands the internalization of highly abstract, non-intuitive concepts, researchers must examine how localized teacher perceptions and contextual constraints intersect during classroom enactment.

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 localised gap is essential for enhancing student to transition from passive, examination-driven content delivery to meaningful, conceptual physics mastery.

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 et al., 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

Thematic Phenomenological Analysis was adopted using Braun and Clarke (2006). 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 audio-interviews were transcribed verbatim to preserve participants' meanings, which is essential for accurate interpretation (Poland, 1995; Saldana, 2021). Grounded within the qualitative parameters of the study, data were processed using thematic phenomenological analysis, adapting Braun and Clarke's (2006) foundational six-phase framework to systematically identify, code, and isolate meaningful patterns. This framework has been widely applied in education research to systematically derive themes from complex textual data (Nowell et al., 2017). 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).

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

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 findings presented herein are structured to directly address the study's three core research questions: first, exploring teachers' underlying perceptions, experiences, and baseline knowledge of PBL; second, analyzing how they practically implement these frameworks within their physics classrooms; and third, identifying the contextual challenges and enabling factors that govern their day-to-day instructional choices. To answer these questions systematically, the results are organized into four interconnected empirical themes: (1) variation in physics 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 T02 described a collaborative project as follows:

"…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.

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…"

"I use computers, the internet, projectors, etc., in PBL practices. However, these are not adequate due to the high enrolment of learners."

These responses illustrate that while teachers attempt to integrate technology, limitations such as class size impede full PBL implementation.

Observations confirmed that only some teachers implemented classroom arrangements and ICT integration effectively (T03, T04). Document analysis mirrored these disparities; structured collaborative milestones were explicitly embedded in the lesson plans of some instructors (T01, T02, T04, T08, T09) but were completely missing from others. Clearly, teachers explicitly expressed a need for professional development tailored to local contexts, revealing context-specific gaps not addressed in prior studies (Moore, 2019).

Conversely, classroom 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).

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.

TO 2 demonstrated meaningful knowledge of PBL principles by describing how learners shared responsibilities, collaborated toward common goals, and engaged in authentic problem solving. Teacher T02 further 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; Ajan, 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 (OECD, 2028). 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 comments 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 and time-management techniques now function as enabling factors (RQ3. 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 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.

However, the study's findings need to be taken with caution due to a demographic imbalance within the participant cohort, which comprised eight male instructors and only two female instructors. Considering the variations in gender-centric teaching styles and classroom authority dynamics within sub-Saharan physics tracking landscapes, how a female-majority cohort would navigate these identical pedagogical and structural friction points remains an area for vital future inquiry. Consequently, there is a need for further empirical research focusing specifically on secondary settings where the implementation of competency-based science curricula is driven predominantly by female physics teachers.

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 cognitive cycles consistent with experiential learning perspectives (Kolb, 1984), illustrating how concrete classroom experimentation, reflective observation, and abstract conceptualization jointly influence instructional innovation under material constraints. 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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