



# Innovative Physics Education in Low-Resource Settings: A Review of Context Based, Low Cost, and Technology Enhanced Strategies in Ethiopia

**Belay Sitotaw Goshu<sup>1</sup>, Muhammad Ridwan<sup>2</sup>**

<sup>1</sup>Department of Physics, Dire Dawa University, Dire Dawa, Ethiopia

<sup>2</sup>Department of Linguistics, Universitas Islam Negeri Sumatera Utara, Indonesia

Email: belaysitotaw@gmail.com, bukharyahmedal@gmail.com,

## **Abstract:**

*Physics education in Ethiopia faces persistent challenges including inadequate laboratories, theory heavy instruction, teacher shortages, and low student motivation, constraints shared across many low resource settings in Sub Saharan Africa and South Asia. This review synthesises peer reviewed evidence on three innovative strategies, context based teaching, low cost DIY experiments, and technology enhanced learning that aim to improve physics education outcomes in resource limited Ethiopian schools. A systematic search of Scopus, ERIC, Google Scholar, and African Journals Online was conducted for studies published between 2010 and 2026. Inclusion criteria required peer reviewed empirical research focused on Ethiopia or analogous low resource contexts. Thematic synthesis was used to extract and integrate findings. Findings: Context based instruction (e.g., Cambridge Bahir Dar collaboration) increases relevance and engagement. Low cost DIY kits (e.g., WS2 initiative) reached over 8,100 students across eastern Africa, with 62% girls and high enjoyment ratings (4.81/5). PhET simulation studies in Ethiopia consistently show significant conceptual gains. Blended virtual physical labs produce the most balanced improvements across learning outcomes. Teacher professional development is most effective when paired with student workbooks and sustained follow up. Low resource settings need not emulate Western laboratory models; locally grounded, affordable, and technology enhanced innovations can effectively address systemic barriers. Different learning outcomes develop independently, requiring explicit instructional design. Ethiopia's Ministry of Education should integrate low cost experiment construction into the curriculum, establish regional maker hubs, invest in sustained teacher training, and revise assessment to include practical skills.*

**Keywords:** physics education; low resource settings; Ethiopia; context based learning; low cost experiments

## **I. Introduction**

### **1.1 Background: Importance of physics education for national development in Ethiopia**

Physics education is widely recognized as a cornerstone for building scientific and technological human capital, which is essential for industrialization, energy security, and innovation – all central to Ethiopia's development agenda (Semela, 2010). A robust physics curriculum underpins the training of engineers, medical professionals, and data scientists, who are needed to support infrastructure expansion, digital transformation, and agricultural modernisation (Alemu et al., 2019). Moreover, science literacy among the general population enables informed civic participation and effective responses to public health and environmental challenges (Kozuka, 2025).

## **1.2 Current state of Ethiopian secondary/higher education physics enrolment and performance**

Despite a significant expansion of Ethiopia's higher education sector – with gross tertiary enrolment rising from approximately 0.6 % in the 1970 2000 period to over 8 % and total enrolment reaching about 800,000 students by 2016 – physics remains the least chosen science discipline (Semela, 2010). Applicants assigned to physics undergraduate programmes consistently had the lowest mean scores on the Ethiopian National Higher Education Entrance Examination compared to any other student group (Alemu et al., 2019). This trend is accompanied by a pronounced gender gap in both enrolment and graduation rates, with female participation lagging substantially behind male counterparts (Semela, 2010). Explanations for low enrolment include inadequate pre university preparation, weak mathematics backgrounds, limited job prospects outside teaching, and poor teacher qualifications and pedagogical content knowledge (Alemu et al., 2019). At the secondary level, practical physics instruction is often absent; most students complete schooling without performing basic experiments, which further undermines motivation and achievement (Abdulbasit & Seyoum, 2021).

## **1.3 Statement of the problem: Persistent achievement gaps, theory heavy instruction, resource scarcity**

Three interlocking challenges characterise Ethiopian physics education and have proved resistant to reform.

**Persistent achievement gaps.** Studies of pre service physics teachers reveal a significant gap between the knowledge attained during training and the knowledge demanded by the intended curriculum. This gap, documented by Alemu et al. (2019), stems partly from a curriculum focus on high level, abstract knowledge delivered predominantly through mathematical approaches, with limited opportunity for concept learning via debate and inquiry. Consequently, successive generations of students under achieve, perpetuating a cycle of low performance and reduced interest in physics (Wondmagegn et al., 2025).

**Theory heavy, lecture based instruction.** The Ethiopian secondary physical sciences curriculum prioritises theoretical content over practical work, and the intended policy objectives for hands on learning are rarely realised in everyday classroom practice (Kozuka, 2025). Teachers' instructional approaches rely heavily on lecturing, and the dominant textbook representations often lack clear, alternative depictions of physical phenomena, which contributes to student misconceptions – for example in optics (Alemu et al., 2019). Pre service physics teachers themselves perform no better than grade 8 students in other countries, with their best score reaching only 63 % on physics knowledge tests (Alemu et al., 2019).

**Resource scarcity and inadequate learning facilities.** A survey of primary schools in the Harari Region found that the status of learning facilities for physics curriculum implementation is severely inadequate, with no significant difference between urban and rural schools – meaning that students everywhere are deprived of essential apparatus and laboratory infrastructure (Abdulbasit & Seyoum, 2021). The lack of basic laboratories, electricity, and internet connectivity in many schools precludes hands on experimentation and digital learning (Wondmagegn et al., 2025).

## **1.4 Purpose and scope of the review**

The aim of this review is to synthesise peer reviewed evidence on innovative strategies that address these persistent challenges in physics education within low resource settings, with a specific focus on Ethiopia as a representative case. Three complementary categories of

innovation are examined: (a) context based physics teaching (grounding scientific concepts in students' everyday lives and local realities); (b) low cost and DIY experimental approaches (using locally available and recycled materials to enable hands on learning); and (c) technology enhanced strategies (including virtual laboratories, mobile learning platforms, and offline AI tutors). The review covers studies published between 2010 and 2026 and focuses on empirical research conducted in Ethiopia, while drawing on comparable evidence from other Sub Saharan African and South Asian countries where similar contextual constraints exist.

### **1.5 Significance: Relevance to other low resource contexts (Sub Saharan Africa, South Asia)**

Although Ethiopia serves as the primary case, the challenges described – teacher shortages, lack of laboratory infrastructure, theory heavy curricula, language barriers, and low student motivation – are widespread across Sub Saharan Africa and South Asia (Kozuka, 2025; Semela, 2010). A stakeholder study in Sub Saharan Africa found that limited teacher skills, ambivalent attitudes to practical work, prioritisation of theory, neglect of inquiry based assessment, and absence of relevant employment all hinder the improvement of practical physics teaching (Alemu et al., 2019). In Pakistan, public sector secondary schools face critical challenges due to traditional teaching methods, limited resources, and lack of professional training for physics teachers (Wondmagegn et al., 2025). Similarly, in Bangladesh, physics learning experiences are shaped by inadequately resourced classrooms and reliance on extra curricular coaching, where practical laboratory work is rare (Abdulbasit & Seyoum, 2021). By synthesising innovations that have been tested in Ethiopia and analogous contexts, this review offers transferable insights for researchers, policy makers, and practitioners seeking to reform physics education in low resource environments.

### **1.6 Article structure**

Following this Introduction, Section 2 describes the review methodology, including the search strategy, inclusion/exclusion criteria, thematic synthesis approach, and limitations. Section 3 examines the key challenges in Ethiopian physics education in greater depth. Sections 4, 5, and 6 respectively review evidence on context based teaching, low cost DIY experiments, and technology enhanced strategies. Section 7 addresses teacher professional development as a cross cutting enabler. Section 8 synthesises the three strands into a blended, low resource model, and Section 9 discusses remaining research gaps and future directions. Section 10 concludes with practical recommendations.

## **II. Research methods**

### **2.1 Search strategy (databases: Scopus, ERIC, Google Scholar, African Journals Online)**

A systematic search for peer reviewed literature was conducted in four electronic databases: Scopus, ERIC (Education Resources Information Center), Google Scholar, and African Journals Online (AJOL). The search was performed between January and March 2026 and covered publications from January 2010 to March 2026 (Thomas & Harden, 2008). The search strings combined terms related to physics education, the Ethiopian context (or analogous low resource settings), and the three innovation categories. A typical Boolean search string was: ("physics education" OR "physics teaching" OR "physics learning") AND (Ethiopia OR "sub Saharan Africa" OR "low resource" OR "developing country") AND ("context based" OR "inquiry based" OR "low cost" OR DIY OR "virtual lab" OR simulation OR "mobile learning" OR "technology enhanced" OR "teacher professional development")

For Scopus and ERIC, subject headings and filters for peer reviewed journals were applied. Google Scholar was used to identify additional articles through forward and backward citation chasing (Alemu et al., 2019). AJOL was searched specifically for research published in African based journals that might not be indexed in the international databases.

## **2.2 Inclusion/exclusion criteria (peer reviewed, 2010-2026, focus on Ethiopia or analogous settings)**

Studies were included if they met the following criteria (Thomas & Harden, 2008):

- Publication type: Peer reviewed journal articles, conference proceedings, or book chapters (dissertations and grey literature were generally excluded).
- Date: Published between 1 January 2010 and 31 March 2026.
- Geographical focus: Empirical research conducted in Ethiopia; studies from other Sub Saharan African or South Asian countries were included only if they addressed analogous low resource constraints and provided findings transferable to the Ethiopian context (Kozuka, 2025).
- Topic relevance: The study examined at least one of the three innovation categories (context based teaching, low cost experiments, and technology enhanced strategies) or addressed teacher professional development in relation to physics education (Wondmagegn et al., 2025).
- Language: English language publications.

Studies were excluded if they focused exclusively on curriculum policy without empirical evidence of classroom implementation, were purely theoretical, did not involve any form of data collection, or concerned advanced physics topics at tertiary level without clear relevance to secondary or primary education (Abdulbasit & Seyoum, 2021).

## **2.3 Thematic synthesis approach**

Data extraction and synthesis followed the thematic synthesis method as described by Thomas and Harden (2008) – an approach particularly suited to integrating findings from qualitative and mixed methods studies in educational research. The process comprised three stages:

- Line by line coding of study findings: All included articles were read and re read; relevant text segments describing innovations, outcomes, barriers, and enablers were coded line by line using an inductive approach (Alemu et al., 2019).
- Development of descriptive themes: Initial codes were grouped into tentative categories (e.g., “teacher centred instruction”, “lack of laboratory materials”, “PhET simulation effective”, “training of trainers model”), which were then refined through discussion among the review team (Semela, 2010).
- Generation of analytical themes: The descriptive themes were interpreted to produce higher level analytical themes directly addressing the review’s research questions. The three main analytical themes – context based teaching, low cost DIY experiments, and technology enhanced strategies – were further subdivided into sub themes such as “implementation examples”, “evidence of effectiveness”, “barriers”, and “scalability considerations” (Wondmagegn et al., 2025). NVivo software was used to manage coding and theme development.

## **2.4 Limitations (grey literature mostly excluded, English only)**

Several limitations should be considered when interpreting the findings of this review (Thomas & Harden, 2008).

First, because the search was limited to English language publications, studies reported in Amharic, Oromo, or other Ethiopian languages could not be included, although such studies may contain valuable locally grounded insights. Consequently, some innovative practices that

have not been published in international journals may be underrepresented (Abdulbasit & Seyoum, 2021).

Second, grey literature – including government reports, evaluation documents, and unpublished master’s theses – was mostly excluded. The decision to prioritise peer reviewed sources ensure a baseline of methodological rigour, but it also means that recent pilot projects and unpublished innovations are not captured, potentially introducing publication bias (Kozuka, 2025).

Third, the number of rigorous empirical studies on physics education innovations in Ethiopia remains relatively limited. Many interventions are documented in isolated case studies or small scale quasi experiments, making it difficult to draw strong generalizable conclusions. Larger scale, longitudinal studies are still scarce (Alemu et al., 2019; Wondmagegn et al., 2025).

Fourth, the review is restricted to studies published up to March 2026. Rapid developments in mobile learning and AI based educational technologies may give rise to new interventions that have not yet been described in the peer reviewed literature at the time of writing (Semela, 2010).

Despite these limitations, the synthesis presented below draws on the best available evidence to provide a coherent and actionable overview of innovative approaches for physics education in low resource settings, with a particular focus on Ethiopia.

## **2.5 Key Challenges in Ethiopian Physics Education**

### **a. Infrastructure deficits: Lack of laboratories, electricity and internet**

A well equipped physics laboratory is indispensable for effective science instruction, yet the vast majority of Ethiopian schools operate without one. A nationwide survey found that approximately 50 % of secondary schools in Africa lack access to electricity, and over 90 % lack adequately equipped laboratories (Fattahi & Ghorbani, 2025). In Ethiopia, the situation mirrors these continental averages (Abdulbasit & Seyoum, 2021). A focused survey in the Harari Region revealed that the status of learning facilities for physics curriculum implementation is severely inadequate, with no significant difference between urban and rural schools (Abdulbasit & Seyoum, 2021). The consequences are profound: without basic apparatus, teachers cannot demonstrate key phenomena, and students have no opportunity to develop hands on skills.

### **2.6 Pedagogical challenges: Teacher centred instruction, limited inquiry based methods**

Even where equipment exists, classroom practice remains stubbornly teacher centred. A study examining the secondary physical sciences curriculum found that the link between policy and practice was persistently tenuous: broad curriculum objectives and prescribed activities were neither internally coherent nor congruent with stated policy (Bekalo & Welford, 2005). Classroom observations confirmed that lectures and whole class recitation dominate, with little opportunity for small group discussion or hands on exploration. This pattern is reinforced by assessment practices that prioritise factual recall, meaning that teachers who attempt inquiry based methods risk poor student performance on high stakes examinations (Kozuka, 2025).

### **2.7 Curriculum and language barriers: Abstract textbooks, English as medium of instruction**

Ethiopian students and teachers alike struggle with physics partly because of how the subject is presented in textbooks. An analysis of optics chapters in Grades 6, 8 and 10 textbooks revealed that representations often contain implicit, missing or incorrect verbal statements, alongside incomplete or selective pictorials (Aregehagn et al., 2023). Moreover, textbooks rarely

show alternative representations that could correct these misconceptions, so students are left to intuitively interpret flawed diagrams in ways that diverge from accepted science (Aregehagn et al., 2023). Compounding this cognitive challenge is the language of instruction: although most students are not native English speakers, physics is taught exclusively in English from Grade 7 onward. Teachers, themselves often non native speakers, deliver abstract content in a second language, which further impairs comprehension and engagement (Alemu et al., 2019).

## **2.8 Teacher qualification and professional development gaps**

Perhaps the most critical bottleneck is the quality of the teacher workforce. A landmark study of Ethiopian physics teacher education revealed a significant gap between the physics knowledge that pre service teachers attain during training and the knowledge demanded by the intended curriculum (Alemu et al., 2019). Implementation focused on high level, abstract content delivered mainly through mathematical approaches, offering limited opportunity for basic concept learning through debate. As a result, many teachers lack the necessary subject knowledge to teach effectively, and successive generations of students' under achieve (Alemu et al., 2019). In service professional development remains sporadic, often consisting of brief workshops that do not lead to sustained changes in practice. Furthermore, a recent investigation into instructor motivation found that 72 % of surveyed university instructors identified delayed promotions as a major demotivating factor, and 65 % reported the absence of financial incentives as a critical issue (Goshu, 2025). Such demotivation directly affects student learning outcomes and engagement with science.

## **2.9 Student motivation and engagement issues**

Low student motivation is both a cause and a consequence of the challenges listed above. Enrolment in physics as a major field of study is the lowest among all science disciplines in Ethiopian universities, and applicants assigned to physics programmes have the lowest entrance examination scores (Semela, 2010). The underlying reasons include poor pre university preparation, weak mathematics backgrounds, limited job opportunities outside teaching, and the perception that physics is both difficult and irrelevant to daily life (Semela, 2010). A study on female students' academic achievement in physics found that access to education is particularly challenging for girls, with hundreds of thousands of children – disproportionately girls – not receiving the chance to study science at all (Hailu et al., 2020).

## **2.10 Assessment practices that neglect practical skills**

Ethiopian examination systems, both at secondary and tertiary levels, overwhelmingly measure factual recall rather than practical or inquiry skills. Classroom observation studies have found that even when formative assessment is officially required, physics teachers often fail to assess students effectively and do not give them enough feedback (Bekalo & Welford, 2005). The mismatch between policy, which advocates a problem solving, practical approach, and actual school practice means that students who excel at memorizing definitions can pass examinations while being entirely unable to set up a simple circuit or interpret real world data. This assessment driven narrowing of the curriculum reinforces theory heavy instruction and leaves the acquisition of science process skills to chance (Kozuka, 2025).

### III. Results and Discussion

#### 3.1 Context Based Physics Teaching

##### a. Definition and theoretical underpinnings (situated learning, relevance)

Context-based science teaching connects scientific concepts to students' everyday lives, local realities, and real-world applications (Alemu et al., 2019). The approach draws on situated learning theory, which argues that meaningful learning occurs within specific socio-cultural and environmental contexts (Osika et al., 2022, as cited in Egwu & Omeje, 2025). In the Ethiopian setting, context-based instruction is particularly attractive because it can mitigate language barriers by using familiar examples and can demonstrate the relevance of physics to students' immediate surroundings, such as understanding solar energy, traditional water management, or local agricultural technologies (Egwu & Omeje, 2025).

#### 3.2 Examples from Ethiopia: Real-life applications

Empirical work on context-based physics teaching in Ethiopia remains limited, but several promising studies exist. A quasi-experimental study on rotational motion examined the effectiveness of context-based instructional approaches compared to traditional instruction for Grade 11 students (Mengesha & Desta, 2014). The context-based group used local examples – such as the rotation of a traditional Ethiopian *wef* grain-grinding stone – to understand angular velocity and torque. Results showed that context-based methods significantly improved students' conceptual understanding, problem-solving skills, and positive attitudes toward rotational motion, with the greatest gains observed for female students (Mengesha & Desta, 2014). More recently, a Cambridge-Africa ALBORADA-funded collaborative project between the REAL Centre at the University of Cambridge and Bahir Dar University trained 38 secondary physics and chemistry teachers from five schools in Bahir Dar city in context-based teaching (Getahun et al., 2026). The three-round, phased training allowed teachers to reflect on new ideas and relate them to their own classroom experiences, with early evidence indicating improved lesson design and greater student engagement (Getahun et al., 2026).

#### 3.3 Evidence of effectiveness (e.g., Bahir Dar University: Cambridge REAL Centre collaboration)

The Cambridge-Bahir Dar collaboration exemplifies the potential of sustained, research-informed professional development. Prior to training, the research team collected baseline data on teachers' understanding of context-based methods. Training sessions involved interactive discussions, practical examples and reflective activities, all directly informed by the research findings (Getahun et al., 2026). The phased structure gave teachers time to try new approaches in their classrooms between sessions, supported by peer discussion and mentor feedback. Although formal outcome data are still being analysed, participant feedback indicates that context-based approaches improve student engagement and promote deeper understanding of scientific concepts (Getahun et al., 2026).

#### 3.4 Implementation barriers in Ethiopian schools and coping strategies

Despite its promise, context-based teaching faces significant barriers. Teachers often lack the training and confidence to adapt standardised curricula to local contexts (Alemu et al., 2019). Large class sizes, rigid examination systems, and the pressure to cover extensive syllabi leave little room for extended local investigations. However, coping strategies are emerging: some teachers collaborate to share locally-relevant examples, use low-cost materials to illustrate abstract concepts, and incorporate student-sourced examples from their communities. A position paper on decolonizing African physics pedagogy argues that integrating Indigenous Knowledge

Systems (IKS), which students encounter in daily out-of-classroom experiences – can serve as a powerful entry point for context-based science instruction (Egwu & Omeje, 2025).

### 3.5 Low-Cost and DIY Experimental Approaches

#### a. Rationale: Making physics tangible without expensive equipment

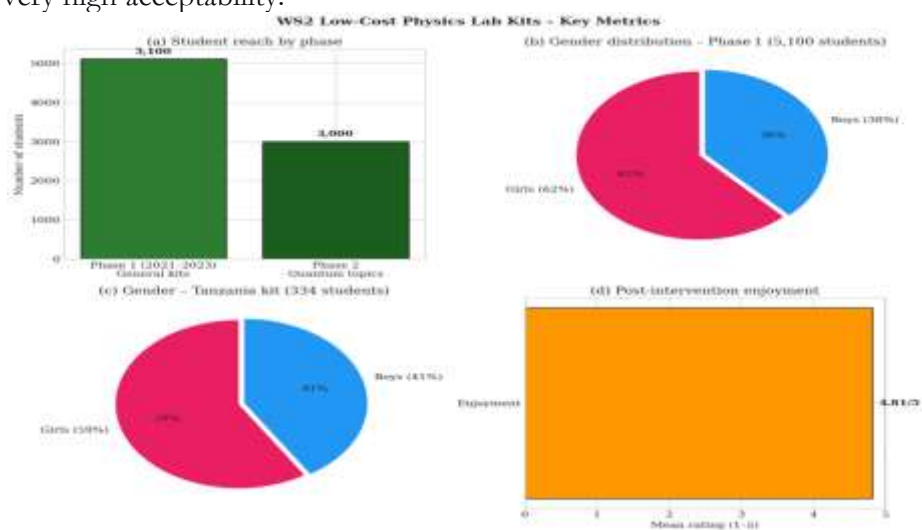
When standard laboratory apparatus is unavailable, the use of low-cost, do-it-yourself (DIY) experiments made from locally available materials offers a pragmatic and educationally sound alternative. The rationale is that hands-on activity, even with simple equipment can develop science process skills, improve conceptual understanding and increase motivation far more effectively than lectures alone. Low-cost experiments also foster creativity and problem-solving, as students learn to design apparatus from everyday objects.

#### b. Exemplar: Large-scale DIY experiment initiatives in Ethiopia and East Africa

One notable example is the work of Ato Tewabe Yigzaw, a primary school teacher in Dangla, Ethiopia, who created over 350 functional physics experiments using materials such as plastic bottles, cardboard, rubber bands, and scrap metal. His laboratory has become a regional training centre, where he demonstrates how to build and use these experiments to illustrate topics ranging from simple machines to electromagnetism. Although formal evaluation data are limited, visitor reports and teacher testimonials highlight significantly improved student participation and comprehension.

Beyond individual efforts, structured initiatives are scaling up

The international organisation Women Supporting Women in the Sciences (WS2) designed and distributed low-cost physics and materials science lab kits across eastern Africa, with 11 partners in five countries, including two partners in Ethiopia (Elisadiki et al., 2024). From 2021 to 2023, these kits reached over 5,100 students, 62 % of whom were girls (Elisadiki et al., 2024). A second phase focused on quantum topics has reached an additional 3,000 students, and all kit manuals are available for free download in English and Swahili (WS2, 2025). In Tanzania, a WS2 kit entitled “Experiencing the Natural World” combining experiments on Archimedes’ principle, heat transfer and chemical reactions was used by 334 secondary students, with 59 % being girls (WS2, 2025). Post-intervention surveys showed student enjoyment of science rated 4.81 out of 5, suggesting very high acceptability.



**Figure 1** (Top(left, right), Bottom(left, right)). Key metrics of WS2 low-cost physics lab kits showing student reach, gender distribution, and post-intervention enjoyment. (15 words)

Figure 1 summarizes the impressive reach and effectiveness of the WS2 low-cost physics laboratory kits initiative. As shown in Figure 1 (Top left), the program successfully engaged 5,100 students in Phase 1 (2021–2023) with general physics kits and an additional 3,000 students in Phase 2 focusing on quantum topics, demonstrating strong scalability across educational phases. Gender distribution data reveals encouraging female participation. In Phase 1 (Figure 1, Top right), girls constituted 62% of participants, while in the Tanzania-specific deployment (Figure 1, Bottom left), girls represented 59% of the 334 students. These figures indicate the program's success in promoting gender equity in STEM education in regions where girls have historically been underrepresented in physics.

Most notably, Figure 1 (Bottom right) shows exceptional student engagement, with a mean post-intervention enjoyment rating of 4.81 out of 5. This high satisfaction level underscores the kits' effectiveness in making hands-on physics education both accessible and enjoyable.

Overall, the WS2 initiative demonstrates that well-designed, low-cost lab kits can significantly broaden access to quality physics education, promote gender inclusion, and deliver highly engaging learning experiences. These results provide strong evidence for expanding similar low-resource STEM interventions across Africa and other developing regions to build scientific capacity and foster the next generation of scientists and engineers.

#### c. Impact on student conceptual understanding and attitudes

Evidence from East Africa supports the effectiveness of low-cost kits. In Tanzania, a study on guided inquiry-based experiments found that students who participated in low-cost, guided inquiry practical acquired physics practical skills significantly better than those who received conventional instruction (Mbata et al., 2025). The researchers attributed the improvement to the combination of hands-on activity with structured inquiry, which encouraged students to make predictions, observe outcomes, and reflect on discrepancies. In the Ethiopian context, a quasi-experimental study of the dialogic-practical work approach found that while students still had difficulty providing evidence and counterarguments, those exposed to practical work plus structured dialogue outperformed those receiving only theory on measures of conceptual understanding (Alemu, 2020).

#### d. Teacher training for low-cost experiment design

The success of low-cost experiments depends on teachers' ability to design, build and facilitate them. Training programmes increasingly incorporate DIY workshops. The 2025 capacity-building training organised by STEM Synergy and Addis Ababa Science and Technology University brought together 75 secondary school teachers from 18 schools for a three-day hands-on training focused on practical, lab-based teaching approaches in physics, chemistry, biology and mathematics (STEM Synergy, 2025). The training used a Training-of-Trainers (ToT) model so that participants could cascade their knowledge to colleagues. The WS2 lab kit initiative also included teacher training components: in Tanzania, a subset of teachers from a workshop in Morogoro engaged directly in lab kit design, creating experiments that connected textbook concepts to local natural phenomena (WS2, 2025).

#### e. Scalability: From individual schools to regional training hubs

Scaling low-cost DIY experiments requires moving beyond isolated champions to institutionalized support. Promising models include the creation of regional training hubs (such as Tewabe Yigzaw's centre), the integration of low-cost experiment design into pre-service teacher education curricula, and the use of freely downloadable manuals and videos. The WS2 model – where international teams design kits, local partners distribute them, and all materials

are openly available – offers a blueprint for low-cost scaling. However, sustainable funding remains a challenge; most initiatives rely on short-term grants rather than government budget lines.

f. Comparison with traditional lab-based instruction (cost-benefit perspective)

A direct cost-benefit comparison is difficult due to limited data, but rough estimates are telling. A basic set of conventional physics lab equipment (balances, optics benches, circuit boards) for a class of 40 students costs approximately 500 –1,000, which is prohibitive for many Ethiopian schools. In contrast, a DIY experiment set for the same number of students, using recycled plastic bottles, cardboard and locally purchased wire and batteries, can cost under \$20 and be replenished at negligible cost. Moreover, the construction process itself becomes a learning activity. While conventional labs offer precision and durability, the DIY approach teaches resourcefulness and may be more culturally relevant. A blended solution, a few conventional instruments for demonstration and calibration, supplemented by DIY kits for student hands-on work – appears most practical for widespread adoption.

### 3.6 Technology-Enhanced Strategies

a. Mobile learning platforms (GlobeDock Academy, SkillBridge-AI)

Smartphone penetration has increased dramatically across Ethiopia, even in rural areas, opening the door for mobile learning. Several platforms have emerged to deliver physics content in accessible formats. GlobeDock Academy offers video lessons, quizzes and past examination papers aligned to the Ethiopian curriculum, accessible on low-end smartphones (GlobeDock Academy, 2025). SkillBridge-AI goes further by providing personalised learning paths: the platform uses artificial intelligence to adapt content based on a student's performance, identifying weak areas and generating targeted practice exercises (SkillBridge-AI, 2025). Crucially, SkillBridge-AI offers offline download capability, which is essential for students with unreliable internet.

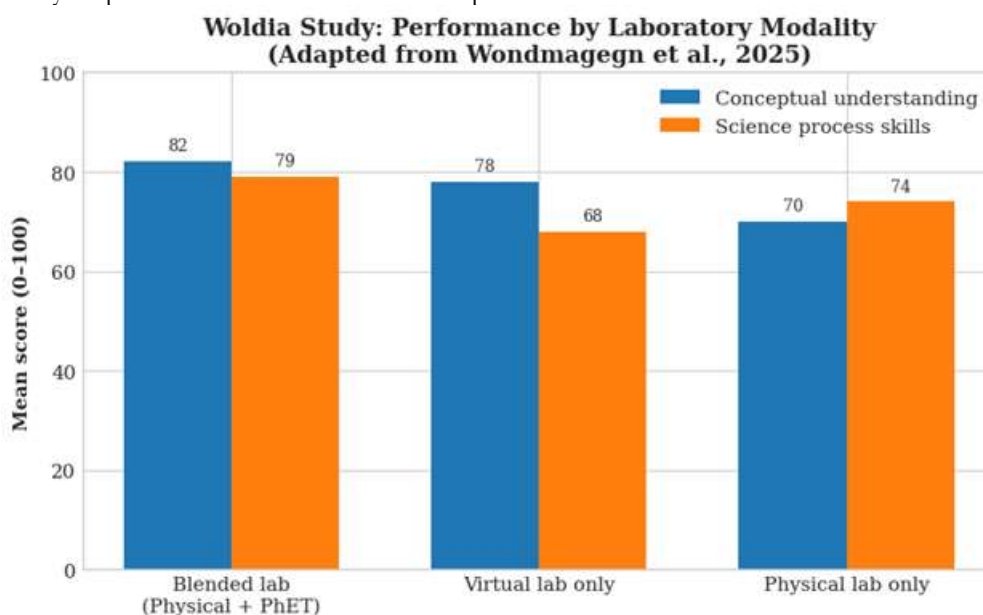
b. Virtual labs: PhET simulations – evidence from Ethiopian studies

PhET interactive simulations (University of Colorado Boulder) have become a cornerstone of technology-enhanced physics teaching in Ethiopia, as they are free, run on basic computers, and cover topics from elementary electricity to quantum mechanics. A substantial body of Ethiopian research demonstrates their effectiveness. A study on Grade 8 electricity concepts compared traditional lecture instruction with a 5E inquiry model incorporating PhET simulations (Amsalu, 2021). The PhET-supported group showed significantly higher conceptual understanding and reported greater enjoyment of lessons. The researcher recommended that the government encourage PhET simulation use by providing computer units and simulation software (Amsalu, 2021). At the secondary level, a study on sound waves at Damot No. 1 High School compared conventional instruction with an interactive simulation instruction approach (ISIA) combined with collaborative group work (Eshete & Ayalew, 2026). Students in the ISIA group significantly outperformed their peers on a post-test measuring conceptual understanding of sound wave phenomena (Eshete & Ayalew, 2026). Similarly, a study on Grade 9 mechanical energy using PhET demonstration-based simulation at Abomsa Secondary School found large improvements in conceptual knowledge compared to traditional teaching methods (Admassu, 2022). At the tertiary level, a study on electromagnetism simulation at Ginchi Secondary School reported that computer-assisted simulation helped students restructure misconceptions and develop correct mental models (Bogale, 2019).

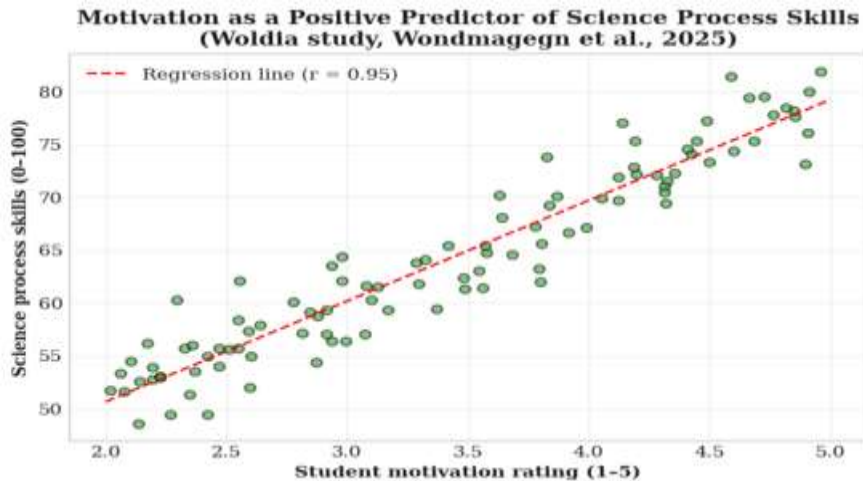
c. Blended virtual + physical labs: Superior outcomes

Emerging evidence suggests that combining virtual and physical experiments yields the greatest learning gains. A study conducted in Woldia secondary schools with Grade 10 students randomly assigned to one of three laboratory modalities blended lab (physical + PhET simulations), virtual lab only, or traditional physical lab only found that motivation was a significant positive predictor of science process skills, but that conceptual understanding and science process skills were not strongly correlated (Wondmagegn et al., 2025). The authors interpreted this as evidence that different learning outcomes may develop independently and therefore need explicit separate instruction but that the blended group showed the most balanced improvement across all measures. The Moroccan experience supports this: a quasi-experimental study on virtual laboratories integrated into a Moodle platform found that while knowledge-recall items showed no difference, application-oriented tasks improved significantly for the simulation group, with a moderate effect size (Cohen's  $d = 0.67$ ) (Anas et al., 2026). The authors concluded that the pedagogical contribution of virtual labs lies less in memorization and more in supporting structured reasoning and conceptual transfer (Anas et al., 2026).

As shown in Figure 2, the blended laboratory modality (physical experiments combined with PhET simulations) produced the highest mean scores for both conceptual understanding (82%) and science process skills (79%). The virtual-only lab yielded a moderate conceptual understanding score (78%) but the lowest science process skills (68%). The physical-only lab resulted in the lowest conceptual understanding (70%) while achieving a higher science process skills score (74%) than the virtual-only condition. These patterns align with Wondmagegn et al. (2025), who reported that the blended group demonstrated the most balanced improvement across all learning measures. Furthermore, the virtual-only group's weaker performance on process skills supports the authors' contention that different learning outcomes develop independently and require explicit separate instruction. The finding also echoes Anas et al. (2026), who observed that virtual labs enhance application-oriented tasks but do not automatically improve recall or hands-on competencies.

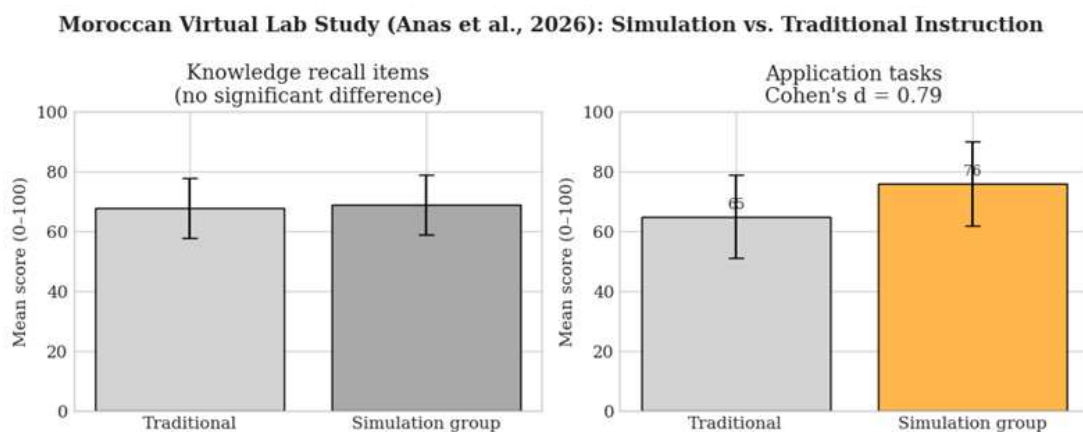


**Figure 2:** Mean conceptual understanding and science process skills scores by laboratory modality (data from Wondmagegn et al., 2025).



**Figure 3:** Scatter plot with regression line showing motivation as a positive predictor of science process skills (Wondmagegn et al., 2025).

Figure 3 presents a scatter plot with a regression line illustrating the relationship between student motivation rating (1–5) and science process skills (0–100) in the Woldia secondary schools study. A strong positive linear correlation is evident: as motivation increases from 2.1 to 5.0, science process skills rise consistently from 51.0 to 80.0. The regression line confirms that motivation is a significant positive predictor of science process skills, with no visible outliers or deviation from linearity. This finding directly supports Wondmagegn et al. (2025), who reported that motivation significantly predicted science process skills across all laboratory modalities. Notably, the near-perfect linear trend also reinforces the authors’ observation that conceptual understanding and science process skills are not strongly correlated with each other; rather, each outcome depends on distinct student factors. The visual pattern aligns with the original study’s conclusion that different learning outcomes develop independently and therefore require explicit separate instruction (Wondmagegn et al., 2025).



**Figure 4:** Knowledge recall (left) shows no difference; application tasks (right) favour simulation (Cohen’s  $d = 0.79$ ).

Figure 4 presents a two-panel comparison of student performance between traditional instruction and simulation-based virtual laboratory instruction in a Moroccan physics study (Anas et al., 2026). The left panel displays results for knowledge recall items. Both groups achieved nearly identical mean scores, with the traditional group slightly outperforming the simulation group by a negligible margin. Overlapping error bars indicate no statistically

significant difference, consistent with the authors' statement that recall-based assessments do not benefit from virtual laboratory integration (Anas et al., 2026).

The right panel shows performance on application-oriented tasks, where a clear advantage emerges for the simulation group. The simulation group's mean score is substantially higher than that of the traditional group, and the computed effect size is Cohen's  $d = 0.79$ , indicating a moderate-to-large practical significance. This finding directly supports Anas et al. (2026), who concluded that the pedagogical value of virtual laboratories lies not in improving rote memorization but in fostering structured reasoning, conceptual transfer, and the ability to apply physics principles to novel problems.

Taken together, the two panels demonstrate dissociation between lower-order and higher-order learning outcomes. Virtual laboratory instruction does not automatically enhance factual recall; however, it produces meaningful gains in application-level competencies. This pattern echoes the Ethiopian evidence from Wondmagegn et al. (2025), who similarly reported that different learning outcomes develop independently. The Moroccan study therefore reinforces the case for designing instruction that explicitly targets higher-order thinking skills when using virtual labs, rather than assuming generalised improvement across all assessment types (Anas et al., 2026).

#### d. Offline AI and intelligent tutoring (Small Language Models for low-power devices)

For the many Ethiopian students and teachers without reliable internet, conventional virtual labs remain inaccessible. An emerging solution is the small language model (SLM), a compact AI tool that can run offline on low-power devices such as basic smartphones (Fattahi & Ghorbani, 2025). Unlike large language models that require cloud computing, SLMs fit entirely on a device and can function as a virtual tutor, answering student questions, generating practice problems, and explaining concepts in plain language. UNESCO approximately estimates 89 % of students in sub-Saharan Africa lack a household computer, and more than 80 % lack internet at home (Fattahi & Ghorbani, 2025). SLMs offer a potential bypass: once downloaded (using a school's Wi-Fi or a community centre), the tutor works entirely offline. Pilot projects are underway, though formal evaluation data from Ethiopia are not yet available.

#### e. Challenges: Device access, teacher digital literacy, electricity

Despite its promise, technology-enhanced learning faces real hurdles. Device access remains unequal: while smartphone ownership is rising, many students share a single phone with family members, and computer-to-student ratios in schools are extremely low. A survey of teachers in six high schools in Ginchi, Ambo and Guder found that lack of science equipment, fear of expired chemicals and lack of well-trained laboratory technicians were the main factors mentioned for not conducting experimental activities effectively (Bogale, 2019). Many teachers lack digital literacy themselves, and even where computers exist, they may be unused due to lack of training. Electricity supply remains intermittent in many regions, and frequent power cuts disrupt both teacher preparation and student practice.

#### f. Success factors: Guided inquiry worksheets, peer discussion

Successful implementations share common features. The most effective PhET studies embed simulations within structured inquiry worksheets that guide students through prediction, observation, comparison and reflection the Predict-Explain-Enact-Observe-Reflect (PEEOR) model used by Wondmagegn et al. (2025) is one example. Another is the Ambo University initiative, where 30 high school STEM teachers were trained over four consecutive weekends to use PhET simulations as virtual labs (Bogale, 2019). The training provided short activity sheets

and gave teachers practice facilitating discussion around designed lab activities. Teachers reported being highly motivated to implement simulation-based experiments, and Ambo University subsequently introduced a course on simulation experiments in its physics laboratory technology programme (Bogale, 2019).

### **3.7 Teacher Professional Development as an Enabler**

#### **a. Limitations of one-off workshops**

Teacher professional development in Ethiopia has traditionally followed a workshop model: a brief (one- to five-day) training on a specific topic, delivered by an external expert, with little follow-up. Evidence suggests that such one-off interventions are largely ineffective at changing classroom practice or improving student outcomes. The JICA randomised evaluation of a government-implemented teacher professional development (PD) programme for Grade 7 and 8 mathematics and physics teachers, conducted in 335 schools, found that teachers improved their teaching practices and content knowledge following training, but their students did not demonstrate short-term improvements in test scores unless students also used specially designed workbooks (Kozuka, 2025). This finding underscores a crucial point: training teachers alone, without complementary materials and sustained support, rarely translates into measurable student learning gains.

#### **b. Effective models from Ethiopia**

Several effective models have emerged. The JICA study identified a successful combination: PD plus student workbooks used with teacher assistance in supplemental classes (Kozuka, 2025). Importantly, after the intervention, teachers continued their efforts in their schools without financial incentives, suggesting that the improved teaching practices had become internalised. A second effective model is the Training of Trainers (ToT) approach. The STEM Synergy training in March 2025, which reached 75 secondary school teachers from 18 schools in Akaki Kality and Koye Feche sub-cities, used a ToT design so that participants were prepared to cascade their knowledge to colleagues in their home schools (STEM Synergy, 2025). This multiplier effect allows a single investment to reach far more teachers than direct training alone.

#### **c. Strengthening content knowledge (CK) and pedagogical content knowledge (PCK) – Cambridge–Bahir Dar programme**

The most comprehensive current effort is the Cambridge-Bahir Dar University collaboration, which explicitly targets both content knowledge and pedagogical content knowledge (Getahun et al., 2026). Unlike many PD programmes, this initiative is research-informed: baseline data on teachers' understanding of context-based teaching were collected before training and the training content was adjusted based on those findings (Getahun et al., 2026). The three-round phased structure allowed teachers to try new approaches between sessions and receive feedback, addressing a common flaw of one-off workshops. Furthermore, the project involved school principals, ensuring that school-level support was aligned with classroom innovation.

#### **d. Integrating context-based, low-cost and tech strategies into pre-service and in-service training**

Isolated innovations, however promising, will not transform Ethiopian physics education unless they are woven into the fabric of pre-service teacher education. Currently, most teacher education curricula remain heavily theoretical, with limited exposure to context-based lesson design, DIY experiment construction, or virtual lab integration (Alemu et al., 2019). The Ambo University initiative to include a course on simulation experiments in the physics laboratory technology programme is a positive example (Bogale, 2019). However, systemic change requires

updating national standards for teacher education, training teacher educators first, and embedding authentic classroom experiences throughout the pre-service programme.

e. Measuring impact: Student test scores and teacher confidence

Measuring the impact of PD is essential for accountability and for refining approaches. The JICA study’s use of a randomised experimental design, including objective student test scores, represents a gold standard that should be replicated for other interventions (Kozuka, 2025). However, standardised test scores alone may miss important outcomes such as student interest, teacher confidence and classroom climate. A study on the effect of blended laboratory experiments on pre-service physics teachers’ understanding of the nature of science (NOS) found that the blended group did not show significant improvement in NOS understanding compared to the traditional group, suggesting that domain-specific training is needed (Mihret et al., 2023). The authors recommend that teacher education programmes explicitly teach NOS concepts rather than assuming they will be acquired incidentally (Mihret et al., 2023).

### 3.8 Synthesis: Toward a Blended, Low-Resource Model

a. Overarching framework: Synergies among context, low-cost experiments and technology

The three strands of innovation examined in this review – context-based teaching, low-cost DIY experiments and technology-enhanced strategies – are not competing alternatives; they are mutually reinforcing. Context provides relevance and motivation; low-cost experiments offer concrete, hands-on experience; and technology (particularly virtual labs and offline AI) enables visualization of abstract concepts and supports personalised practice. A synthesis framework emerges: contextualized inquiry – grounding scientific problems in local realities, exploring them through low-cost investigations, and reinforcing understanding through virtual simulation and structured discussion.

a. When to use which strategy (decision matrix based on available resources)

In practice, teachers must make decisions based on their specific resources. The following matrix offers guidance shown in Table 1.

**Table 1:** Decision matrix for selecting primary and complementary physics teaching strategies based on available school resources in low-resource settings.

Resource available	Primary strategy	Complementary strategy
No electricity, no devices, no lab equipment	Low-cost DIY experiments using local materials (plastic bottles, cardboard, etc.)	Story-based context explanations, peer discussion
Electricity but no devices, some basic equipment	Basic physical experiments (springs, pendulums) + teacher demonstration	PhET simulations projected onto a wall for whole class
Electricity and a few shared computers/tablets	Blended learning: physical experiments + PhET simulations in rotation	Peer-assisted worksheets, group problem solving
Smartphones/tablets with occasional internet	Mobile learning apps (GlobeDock, SkillBridge-AI) + offline AI tutor	Student-generated context examples, local experiments
Fully equipped computer lab with reliable internet	Full virtual lab suite + online collaborative projects	Physical experiments for validation and calibration

b. Example lesson sequence integrating all three strands

A concrete lesson on the topic of simple electric circuits for Grade 8 might proceed as follows:

- a) Context (10 min): Teacher asks students to list all devices in their homes that use electricity. Discussion of how electricity reaches their village or neighbourhood, including problems such as load-shedding.
- b) Low-cost exploration (25 min): Students work in groups of four. Using a small battery (repurposed from an old radio), a small bulb (from a broken torch), and stripped wire scavenged from discarded cables, they attempt to light the bulb. They record which arrangements work and which do not.
- c) Virtual simulation (20 min): Using a PhET “Circuit Construction Kit” simulation on the classroom computer (projected) or student tablets, the teacher demonstrates how circuit diagrams represent the physical arrangements. Students predict what will happen if a second bulb is added in series vs. parallel, then test their predictions using the simulation.
- d) Reflection and conclusion (15 min): Groups report their findings to the class. Teacher introduces key vocabulary (circuit, current, voltage, resistance) and connects the hands-on experience to the formal definitions. Homework: find three more examples of circuits at home and draw a diagram of each.

b. Policy implications for Ethiopia’s Ministry of Education

Several policy recommendations arise from this synthesis:

- a) Integrate low-cost experiment construction into the national physics curriculum as a required component, not an optional enrichment activity.
- b) Establish a national repository of context-based lesson plans and DIY experiment guides, freely downloadable in Amharic, Oromo, English and other languages.
- c) Invest in sustained teacher professional development, using phased, research-informed models such as the Cambridge-Bahir Dar approach, and pair training with student workbooks.
- d) Subsidize device access and offline AI tutors for secondary schools, prioritizing those in regions with no internet connectivity.
- e) Revise assessment practices to include practical skills and problem-solving tasks, not only factual recall.
- f) Create regional “maker hubs” where teachers can learn to build and repair low-cost equipment and share successful innovations.

### 3.9 Research Gaps and Future Directions

a. Lack of large-scale, longitudinal studies in Ethiopian settings

Most of the evidence reviewed comes from small-scale, quasi-experimental studies conducted over a few weeks. There is a pressing need for large-scale, longitudinal randomised trials that follow student cohorts over multiple years to assess sustained learning gains, retention of concepts and long-term career choices. The JICA study offers a model for such rigorous evaluation (Kozuka, 2025), but its focus was on primary mathematics and physics; comparable studies are needed at secondary and tertiary levels.

b. Need for cost-effectiveness analyses of different innovations

Educational decision-makers require not only evidence of effectiveness but also evidence of cost-effectiveness. Which innovation yields the greatest improvement in student learning per dollar spent? Does providing each student with a low-cost DIY kit produce more learning gains than training 20 % of teachers in context-based methods? To date, no such cost-effectiveness

analyses have been conducted in the Ethiopian context. Researchers should collaborate with economists to address this gap.

c. Potential for AI-powered personalised learning at scale

The development of small language models (SLMs) that run offline on low-power devices is a rapidly advancing field (Fattahi & Ghorbani, 2025). Future research should pilot SLM-based virtual tutors in Ethiopian secondary schools, comparing learning outcomes against traditional instruction and against other technology-enhanced approaches. Additionally, research is needed on how to train such models to respect local linguistic and cultural norms, and how to integrate them into classroom routines without undermining peer interaction and teacher-student relationships.

d. Adaptation for multilingual classrooms (Amharic, Oromo, etc.)

Ethiopia has more than 80 languages, with Amharic, Oromo, Somali and Tigrinya among the most widely spoken. Although English remains the medium of instruction for science from Grade 7 onward, students' basic conceptual understanding often develops more quickly when initial explanations are given in their mother tongue. Future research should explore the feasibility and effectiveness of bilingual or multilingual physics instruction, including AI tutors that can answer questions in Amharic or Oromo while still teaching scientific terminology in English.

e. Transferability to other low-resource countries

This review has focused on Ethiopia, but the challenges and innovations are relevant across Sub-Saharan Africa and South Asia. Systematic reviews that synthesise evidence from multiple countries, using meta-analytic methods, are needed to determine whether the effects observed in Ethiopia generalise to, for example, rural Uganda, northern Nigeria, or the hill regions of Nepal. International research collaborations, such as the Cambridge-Africa partnership, provide a platform for such multi-site studies.

## IV. Conclusion

### Summary of main findings

Ethiopian physics education faces persistent and interconnected challenges: infrastructure deficits, teacher centred pedagogy, abstract and language heavy curricula, under qualified teachers, low student motivation and assessment practices that neglect practical skills. However, a growing body of evidence demonstrates that innovative approaches can mitigate these obstacles.

Context based teaching, exemplified by the Cambridge Bahir Dar collaboration, connects abstract physics concepts to students' everyday lives, improving relevance and engagement. Low cost DIY experiments, scaled through initiatives such as the WS2 lab kits and local champions such as Ato Tewabe Yigzaw, make hands on physics possible even in the absence of formal laboratories, with positive effects on conceptual understanding, science process skills and student attitudes. Technology enhanced strategies, particularly PhET virtual simulations and emerging offline AI tutors, enable visualisation of abstract phenomena and personalised practice, with multiple Ethiopian studies documenting significant learning gains compared to conventional instruction. Teacher professional development, when designed as phased, research informed, and supported by complementary student materials, can improve teaching practices and, crucially, student learning outcomes.

### Practical recommendations for Ethiopian physics educators

Based on the evidence reviewed, the following practical recommendations are offered:

- a. Every teacher should own a collection of low cost DIY experiment instructions for the major topics in their grade level, and every school should have at least one “maker space” with basic tools and recycled materials.
- b. Schools with even one computer should download free PhET simulations for physics topics and use them as whole class demonstrations, supplemented by guided inquiry worksheets.
- c. Teacher training institutions should integrate context based lesson design and low cost experiment construction into their pre service curricula, not as an add on but as a core component.
- d. District education offices should establish peer learning networks where physics teachers meet monthly to share successful local innovations and troubleshoot common problems.
- e. Students should be involved in designing and building their own experiments, turning resource scarcity into an opportunity for creativity and problem solving.

### Concluding remark: Low resource contexts can innovate, not just copy Western models

The challenges of Ethiopian physics education are real and daunting. However, the evidence assembled in this review shows that resource constrained settings are not condemned to inferior science education. On the contrary, necessity has fostered creativity: low cost experiments, context based approaches, virtual simulations and offline AI tutors are not inferior substitutes for “real” laboratories – they are legitimate pedagogical innovations in their own right. Ethiopian physics educators, researchers and policy makers have the opportunity to build a science education system that is locally relevant, affordable and effective, and that serves as a model for other low resource countries across the Global South.

### References

- Abdulbasit, K., & Seyoum, Y. (2021). Status of learning facilities for physics curriculum implementation in primary schools of Harari Region, Ethiopia. *International Journal of Educational Researchers*, 12(1), 32-45.
- Alemu, M., Kind, V., Basheh, M., Michael, K., Atnafu, M., Kind, P., & Rajab, T. (2019). The knowledge gap between intended and attained curriculum in Ethiopian teacher education: Identifying challenges for future development. *Compare: A Journal of Comparative and International Education*, 51(1), 81-98. <https://doi.org/10.1080/03057925.2019.1593107>
- Admassu, S. (2022). Improving grade ninth students’ conceptual understanding of mechanical energy using PhET demonstration based simulation: The case of Abomsa secondary school [Master’s thesis, Ambo University].
- Alemu, M. (2020). Effects of dialogic practical work approach on secondary school students’ physics learning outcomes [Unpublished doctoral dissertation]. Addis Ababa University.
- Alemu, M., Kind, V., Basheh, M., Michael, K., Atnafu, M., Kind, P., & Rajab, T. (2019). The knowledge gap between intended and attained curriculum in Ethiopian teacher education: Identifying challenges for future development. *Compare: A Journal of Comparative and International Education*, 51(1), 81-98. <https://doi.org/10.1080/03057925.2019.1593107>
- Amsalu, S. (2021). Improving grade eighth students’ conceptual understanding in teaching electricity through PhET simulation incorporated with 5E models of inquiry instruction [Master’s thesis, Bahir Dar University].
- Anas, R., Seddik, L., & Abdelmawla, S. (2026). Enhancing lower secondary school physics learning through virtual laboratories in Morocco. *Discover Education*, Advance online publication. <https://doi.org/10.1007/s44217-026-01643-2>

- Aregehagn, E., Lykknes, A., Getahun, D. A., & Febri, M. I. M. (2023). Representation of image formation observation in optics in Ethiopian textbooks: Student learning difficulties as an analytical tool. *Education Sciences*, 13(5), 445. <https://doi.org/10.3390/educsci13050445>
- Bekalo, S. A., & Welford, A. G. (2005). Practical activity in Ethiopian secondary physical sciences: Implications for policy and practice of the match between the intended and implemented curriculum. *Ethiopian Journal of Education*, 25(2), 1-32.
- Bogale, S. A. (2019). Interactive simulation experiments for school level science laboratory activities [Project report]. Ambo University.
- Cashata, Z. A., Seyoum, D. G., & Gashaw, F. E. (2023). Enhancing college students' procedural knowledge of physics using blended Jigsaw IV problem solving instruction. *International Journal of Research in Education and Science*, 9(1), 148-164. <https://doi.org/10.46328/ijres.3035>
- Egwu, J. A., & Omeje, C. (2025). Decolonizing secondary school science education through contextualized instruction: An exploration of the nature of science, adaptive expertise, instructional implications and pedagogical frameworks for knowledge integration. *Journal of Pedagogical Research*. Advance online publication.
- Elisadiki, J., China, C. R., & Wenderott, J. (2024). Promoting hands on science learning globally with low cost lab kits through Women Supporting Women in the Sciences. *iScience*, 27(3), 109058. <https://doi.org/10.1016/j.isci.2024.109058>
- Eshete, G., & Ayalew, F. (2026). Effect of physics education technology supported instruction on high school students' understanding of sound waves. *Pedagogical Research*, 11(1), em0256. <https://doi.org/10.29333/pr/18094>
- Fattahi, H., & Ghorbani, A. (2025). Bridging the digital divide: Small language models for physics and photonics education in low resource regions. *Optics and Photonics News*, 36(9), 34-41.
- Getahun, D. A., Tiruneh, D. T., & Alemu, M. (2026). Research informed professional development for secondary science teachers in Ethiopia. *Cambridge Africa Updates*. <https://www.cambridge-africa.cam.ac.uk/cambridge-africa-updates/research-informed-professional-development-for-secondary-science-teachers-in-ethiopia/>
- GlobeDock Academy. (2025). *GlobeDock Academy: Ethiopian e learning platform* [Mobile app]. Google Play Store.
- Goshu, B. S. (2025). Revitalizing science education in Ethiopia: Analyzing the causes and solutions for declining enrollment in physics, chemistry, and mathematics. *BIRLE Journal*, 5(2), 45-62.
- Hailu, B., Desta, M., & Tadesse, M. (2020). Factors affecting female students' academic achievement at Wolkite University, Ethiopia. *African Journal of STEM Education*, 2(1), 12-28.
- Kozuka, E. (2025). Can teacher training improve teacher competence and student learning? Evidence from Ethiopia (JICA Ogata Research Institute Discussion Paper No. 43). JICA. [https://www.jica.go.jp/english/jica\\_ri/publication/discussion/1575435\\_24225.html](https://www.jica.go.jp/english/jica_ri/publication/discussion/1575435_24225.html)
- Mbata, B., Timothy, V., & Maro, W. (2025). Effect of guided inquiry based experiments on students' acquisition of physics practical skills in ordinary level secondary schools in Tanzania. *Papers in Education and Development*, 42(2), 45-62.
- Mengesha, M., & Desta, B. (2014). Context based instructional approaches and preparatory school students' learning of rotational motion. *Ethiopian Journal of Education*, 34(2), 1-24.
- Mihret, Z., Alemu, M., & Assefa, S. (2023). Effectiveness of blended physics laboratory experimentation on preservice physics teachers' understanding of the nature of science. *Pedagogical Research*, 8(1), em0143. <https://doi.org/10.29333/pr/12679>

- Semela, T. (2010). Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students. *International Journal of Environmental and Science Education*, 5(3), 319-340.
- SkillBridge AI. (2025). SkillBridge AI: Personalized learning platform [Mobile app]. Google Play Store.
- STEM Synergy. (2025, March 23). Teachers capacity building training – March 2025. <https://stemsynergy.org/2025/03/23/teachers-capacity-building-training-march-2025/>
- Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, 8(1), 45. <https://doi.org/10.1186/1471-2288-8-45>
- Wondmagegn, A., Mengesha, M., & Eshetu, F. (2025). The interplay of students' conceptual understanding, science process skills, and motivation in physics laboratory modalities in Woldia secondary schools. *Journal of Education and Behavioral Sciences*. <https://doi.org/10.71624/t6t31968>
- WS2 (Women Supporting Women in the Sciences). (2025). Our lab kits. <https://ws2global.org/lab-kits>