STEMi Makers of Africa

Global Institute for AI Policy Research and Education

From Practice to Policy: Building Future-Ready STEM-AI Educators via Project-Based Learning – A Multi-Country Analysis of Teacher Competency Gains in 9 African Nations



DESCRIPTION:

This policy paper analyzes evidence from Botswana, Cabo Verde, Cameroon, Ghana, Kenya, Liberia, Malawi, Nigeria, and South Africa, identifies practical success factors and barriers, and translates classroom findings into scalable strategic policy recommendations for teacher training, curriculum support, and system-level adoption—helping build future-ready STEM-AI educators across the continent.

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www.stemimakersafrica.org

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This policy paper outlines teacher competency data, barriers, success factors, and an actionable roadmap to scale PBL for African STEM-AI educators and teachers.

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IMPACT HIGHLIGHT

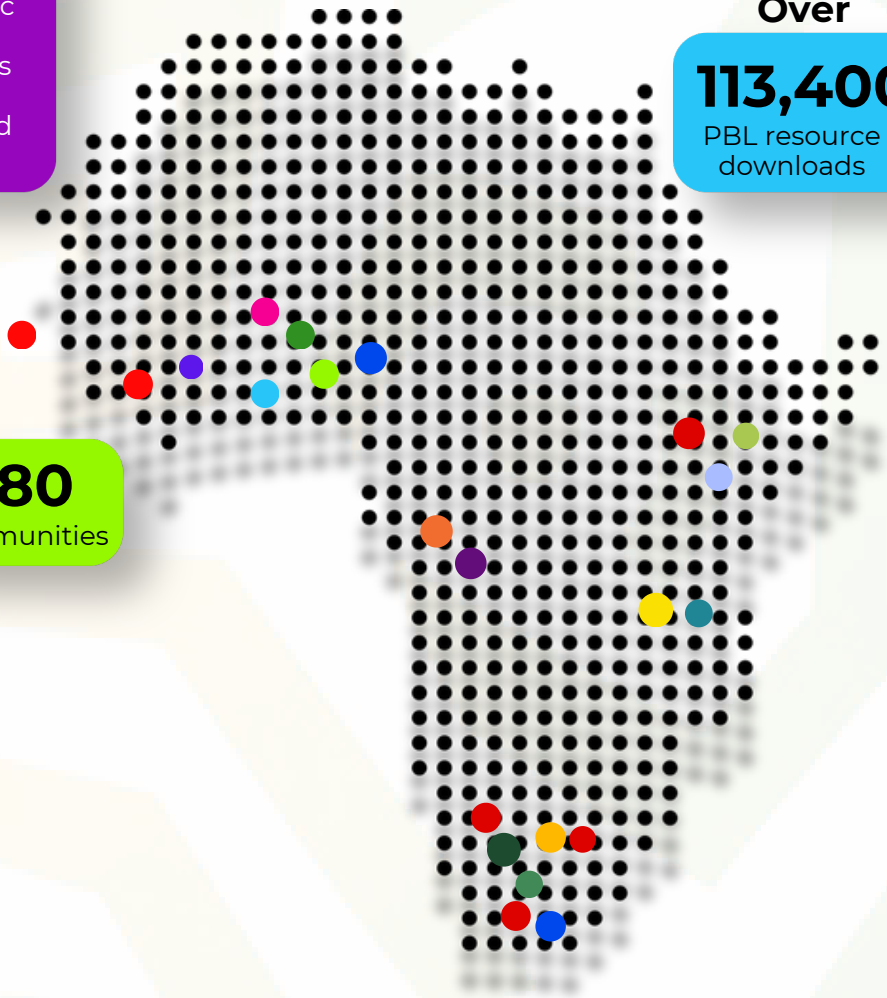
What educators believe and what implementation requires

More than **7,000** teachers were impacted across public and private high schools These teachers reach an estimated **225,000** students aged 13 -19 years old

Over

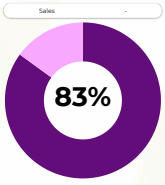
113,400

PBL resource downloads



280

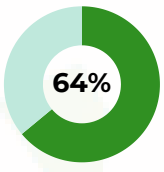
Communities



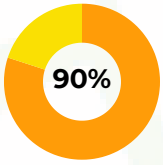
83% of 5,620 surveyed STEM educators rated Project-Based Learning as Highly Effective or Effective in improving student understanding of STEM concepts.



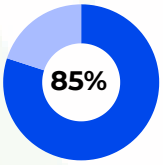
99% of educators agreed or strongly agreed that PBL prepares students for real-life problem-solving and future careers in Africa



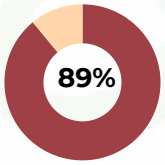
A school-based PET bottle project in Malawi achieved a 64% reduction in total school waste while integrating Mathematics and Chemistry.



Successful local projects included anti-theft door mats from recycled materials, school irrigation systems, electronic voting prototypes, and award-winning life-saving jackets.

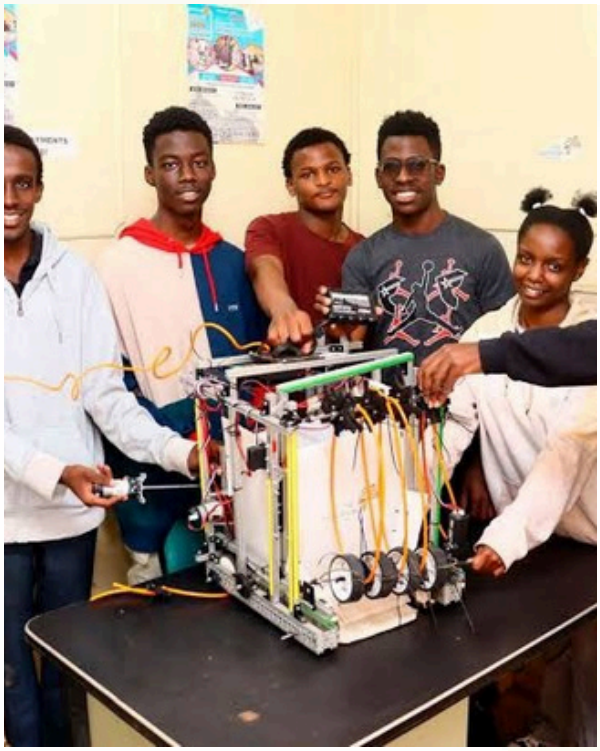


Average teacher confidence across six core PBL competencies reached moderate levels (2.59–3.08/5), with the strongest gains reported in collaboration management.



In one documented Malawi case, girls' Mathematics performance rose from 34% to 89% after sustained practical and project-based approaches

EXECUTIVE SUMMARY



This policy paper presents empirical insights from a comprehensive multi-country survey encompassing 5,620 STEM educators across ten African nations—including Ghana, Botswana, Nigeria, Malawi, Liberia, Cameroon, South Africa, Kenya, and Cabo Verde. The findings uncover a pivotal implementation paradox: while pedagogical conviction among educators is overwhelmingly high, systemic barriers constrain routine classroom practice, presenting a critical leverage point for educational reform across the continent.

Educators demonstrate near-universal consensus regarding the efficacy of Project-Based Learning (PBL). A full 83% rate PBL as highly effective or effective in deepening conceptual understanding in STEM, while 99% affirm that it is essential for preparing youth for an increasingly AI-influenced economy.

However, average teacher self-efficacy across core instructional competencies remains strictly moderate—ranging from 2.59 to 3.08 on a five-point scale. Consequently, regular PBL implementation stands at only 15%, with a quarter of surveyed teachers having never integrated PBL into their instructional practice.

Structural and systemic constraints dominate the landscape of implementation challenges: acute shortages of instructional materials and resources (1,460 mentions), high student-to-teacher ratios (1,424), inadequate laboratory infrastructure (1,399), insufficient formal professional development (1,366), and rigid examination-driven syllabi (1,318).

Conversely, educator preferences for institutional support are clear and highly actionable: experiential design workshops (1,489 mentions), open-access contextualised lesson repositories, structured practitioner mentorship, authentic assessment frameworks, and guidance on leveraging low-cost, locally available resources.

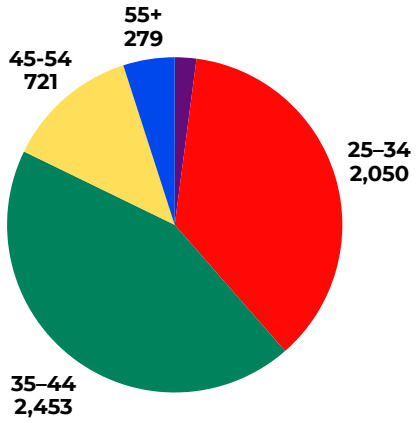
9
Countries
5,620 STEM educators surveyed across 9+ African countries

+83%
Effectiveness Rate
Rated Project-based learning as Highly Effective or Effective

6
Core Competencies
Core Project based learning competencies measured and tracked

These findings offer a strategic blueprint for high-impact educational policy. By making targeted investments in teacher instructional design, introducing curricular flexibility, fostering local resource ecosystems, and realigning assessment models, African education systems can bridge the gap between teacher conviction and classroom execution. Transforming STEM educators into future-ready STEM-AI facilitators will equip the next generation of African learners with the critical thinking, agency, and collaborative problem-solving capabilities required to lead in the global digital economy.

Age group distribution of teachers

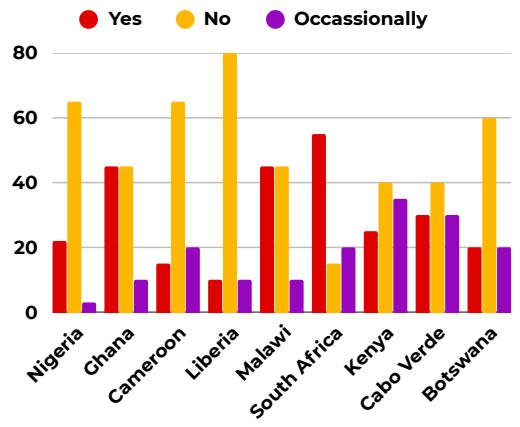


18–24 Years **2.1%**
25–34 Years **36.5%**
35–54 Years **43.6%**
45-54 Years **12.8%**
55+ Years **5%**

45.7% Female

54.3% Male

Access to resource tools & support



% of familiarity of PBL by Country



Not familiar **40.9%**
Slighlty familiar **15.5%**
Moderately **22.7%**
Very familiar **20.9%**

15%
Efficiency
15% of teachers currently implement PBL and STEM hands-on regularly

6,050
PBL requests
6,050 teachers requests for ready-made PBL lesson resources

44%
Awareness
44% of respondents had received some formal STEM/PBL training

CONTEXT AND RATIONALE

The rapid acceleration of artificial intelligence, automation, and digital technologies is fundamentally reconfiguring global labor markets and knowledge systems. For African nations, this transformation presents both a profound challenge and an unprecedented opportunity. Positioning the continent as a hub of technological innovation requires moving beyond passive technology consumption toward driving local problem-solving. Achieving this transition demands an educational ecosystem that systematically develops higher-order cognitive capabilities, interdisciplinary inquiry, and adaptive technical agency.



Despite widespread policy endorsement of competency-based education across Africa, high-quality PBL remains fragmented in classroom practice. Teachers often work in environments that lack dedicated professional development, flexible instructional timetables, basic material ecosystems, and aligned assessment incentives. Consequently, a persistent gap remains between macro-level policy aspirations and micro-level classroom practice.

Traditional, lecture-oriented STEM instruction remains widespread but is ill-suited to modern technological demands. Didactic methods often produce compartmentalized, fragile knowledge focused on rote recall rather than practical application. Project-Based Learning provides a rigorous pedagogical alternative. Through authentic, community-anchored projects, learners apply scientific and mathematical concepts over extended intervals, iterate solutions, collaborate in teams, and build human-centric skills that complement emerging AI capabilities.

PBL Resource Support

Strong leadership support reported by nearly half of respondents

PBL Curriculum

High demand for curriculum time flexibility and assessment reform

Data Outcome

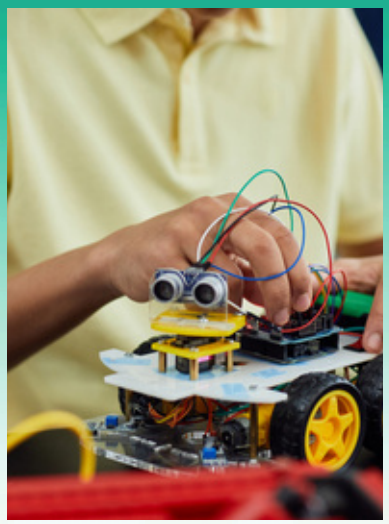
Clear pathway established for future-ready STEM-AI educators in Africa

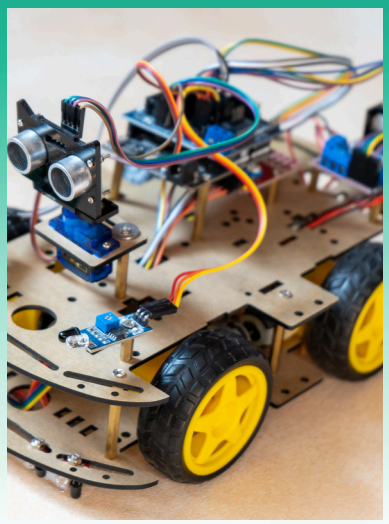
This study addresses that evidence gap by examining STEM educator readiness across 5,620 primary, secondary, and tertiary instructors. By evaluating specific competency thresholds, structural bottlenecks, and high-priority support mechanisms, this paper establishes an empirical foundation for actionable policy design and system-wide pedagogical scaling.

THEORY OF CHANGE

The strategic logic guiding this policy framework is structured around five key intervention stages:

If ministries of education and teacher training institutions systematically cultivate educator competencies in designing, facilitating, assessing, and sustaining high-quality, locally contextualised PBL units;
And if these capacity-building efforts are reinforced by protected instructional time, accessible low-cost resource kits, supportive school leadership, professional learning communities, and balanced assessment frameworks;
Then educators will transition from ad-hoc instructional projects to consistent, high-rigour PBL execution;
Which will yield measurable improvements in student conceptual mastery, technological fluency, collaborative problem-solving, creative confidence, and gender-inclusive participation across STEM-AI disciplines;
Ultimately driving the emergence of a resilient, innovative generation of African youth equipped to spearhead sustainable socio-economic development.





This theory rests on three evidence-based assumptions derived from the survey data: (1) teacher belief in PBL efficacy is established and high; (2) competency gaps in design, facilitation, and assessment are specific and addressable through targeted training; and (3) primary structural barriers can be mitigated through innovative pedagogical strategies and low-cost resource ecosystems without requiring immediate, resource-intensive infrastructure upgrades.
The pathway from classroom practice to system change therefore runs through deliberate capacity building, enabling conditions and aligned incentives rather than through isolated pilot projects or one-off awareness workshops.

4-PHASED TIMELINE

SEPT '25 — **JAN '26** — **APR '26** — **AUG '26**

METHODOLOGY AND SAMPLE DEMOGRAPHICS

1,424

No. of educators that mention large class sizes as a major challenge

1,460

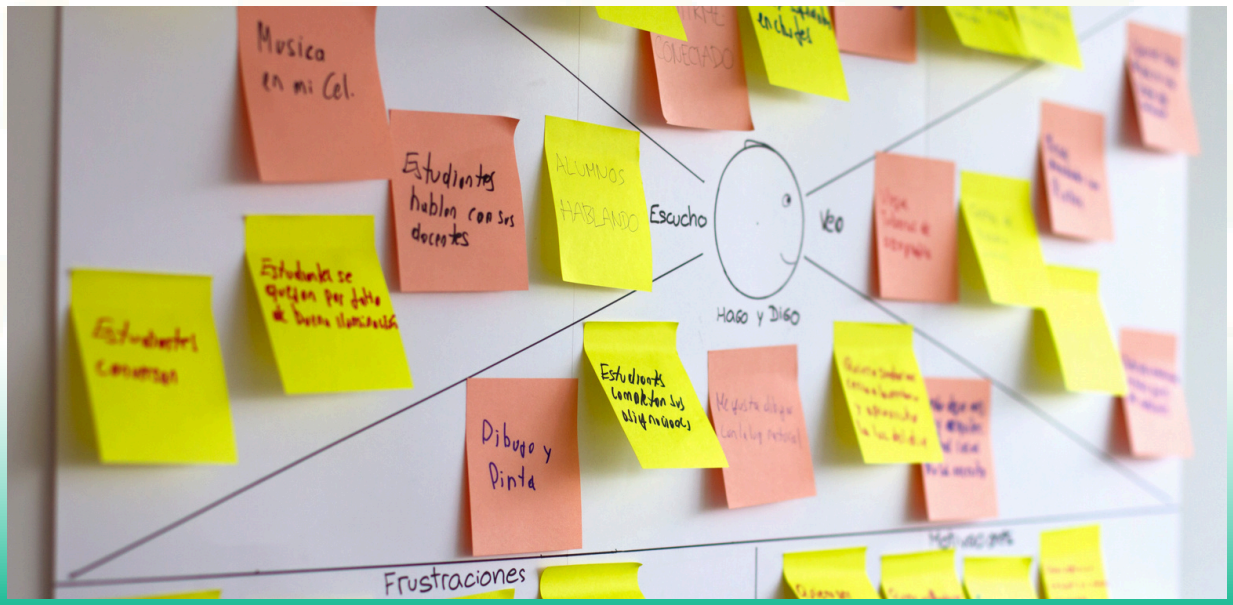
No. of educators that mention lack of teaching materials as top barrier

1,269

No. of educators prioritized mentoring by experienced PBL teachers

This analysis utilizes a cross-sectional empirical survey of 5,620 STEM educators across ten African nations. Respondents represent a comprehensive cross-section of the educational ecosystem, including classroom teachers, departmental heads, teacher educators, and school administrators across primary, junior secondary, senior secondary, and tertiary levels.

The sample displays balanced demographic characteristics: 54% male and 46% female representation, with extensive teaching experience (over 60% possessing more than a decade of instructional service). Qualifications span diploma, bachelor's, master's, and doctoral degrees, ensuring that insights reflect mature professional perspectives across diverse socio-economic context zones.



The instrument captured quantitative ratings of familiarity, implementation frequency, perceived effectiveness, and confidence across six core PBL competencies, leadership support and system promotion of PBL, as well as multi-select data on challenges, preferred professional development, and open-ended qualitative insights on benefits, girls' participation, successful examples and recommendations. Analysis focused on descriptive statistics, frequency counts of multi-select items, mean confidence scores, and patterns across countries and experience levels.

STEM Teacher (Ghana)
"Before the practical PBL workshops, I struggled to move beyond lectures. Now my students design real projects like water filters and data surveys. Their confidence, especially the girls, has grown remarkably, and they finally see Mathematics as useful for solving community problems."

School Administrator (Botswana)
"Protecting timetable space for projects was difficult at first, but the results convinced us. Teachers are more motivated, students collaborate better, and our school now showcases local innovations. Leadership support and simple resource guides made the difference."

Min. of Education Official (Malawi)
"The multi-country evidence confirmed what we observed in the field: teachers believe in Project-Based Learning, yet lack design skills and materials. This policy direction gives us a clear roadmap to scale practical training and curriculum flexibility nationwide."

Teacher Trainer (South Africa)
"Mentoring combined with hands-on design workshops produced far better results than one-off theoretical training. Teachers leave with ready-to-use project plans and greater confidence."

Senior Secondary Mathematics Teacher (Malawi)
"Using real school data collection projects helped my students master percentages, averages and graphs while solving an actual problem. The learning stuck far better than traditional exercises."

Curriculum Developer (Nigeria)
"Linking projects tightly to existing syllabus objectives removed the biggest fear teachers had. When assessment begins to value process and real-world application alongside examinations, Project-Based Learning will move from optional to essential across our STEM curriculum."

Science Teacher (Cameroon)
"One-off theoretical sessions never worked. The combination of hands-on design workshops, mentoring, and low-cost local material strategies is what teachers actually need. We are already seeing stronger lesson plans and more purposeful student projects emerging."

Ministry Advisor (Ghana)
"This multi-country analysis gives policymakers the practical roadmap we needed: focus on teacher design skills, low-cost materials, timetable flexibility and assessment alignment."

District Official (Cameroon)
"Schools that combined leadership support, peer learning networks, and access to simple resource guides are already showing stronger student collaboration and more innovative project outcomes."

KEY EMPIRICAL FINDINGS

A. Pedagogical Alignment vs. Implementation Realities

Educators demonstrate strong alignment with active learning paradigms: 83% rate PBL as highly effective or effective in boosting STEM mastery, and 99% affirm its necessity for real-world preparation in an AI-influenced workforce. However, actual implementation reflects a significant implementation gap: only 15% report regular PBL deployment, 39% engage in occasional use, 17% have attempted it sporadically, and 25% have never implemented PBL in their classrooms.

B. Current Familiarity and Implementation

Familiarity is reasonably widespread: roughly 32 percent describe themselves as “Very familiar,” 28 percent “Moderately familiar,” 35 percent “Slightly familiar,” and only about 5 percent “Not familiar at all.” Implementation, however, lags significantly. Approximately 39 percent report occasional use, 15 percent regular use, 17 percent having tried it once or twice, and 25 percent never having implemented PBL. This belief–practice gap is one of the central policy challenges identified by the study.

C. Granular Assessment of Teacher Competency

Self-reported confidence across core PBL competencies highlights specific targets for professional development (measured on a 1.00–5.00 scale). The majority of respondents cluster at level 3 across most competencies, indicating functional but not yet robust mastery. Designing coherent, rigorous, multi-week projects and integrating digital tools emerge as the weakest areas, while managing collaboration is relatively stronger.



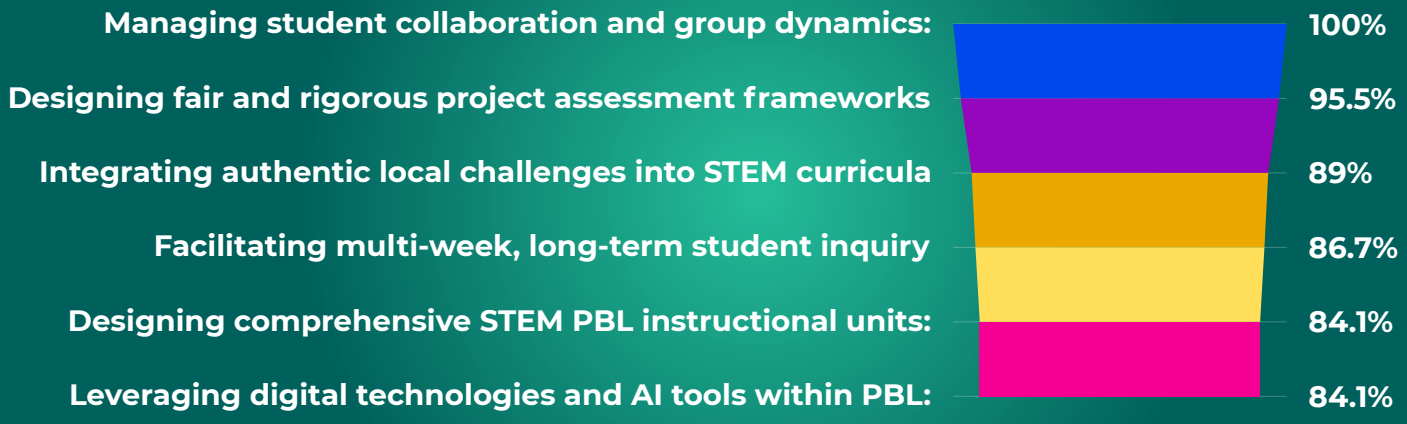
D. Access to PBL Materials and Hands-on Practice

Only about 17 percent of respondents report reliable access to tools and reusable materials for student projects; half report no access. Hands-on or practical STEM activities occur “Rarely” for the largest single group of teachers, although weekly and daily practice is also reported by substantial minorities. Dominant teaching methods remain a mixture of lecture and practical activities, with pure lecture-based approaches still significant in many contexts.

E. Training and System Support

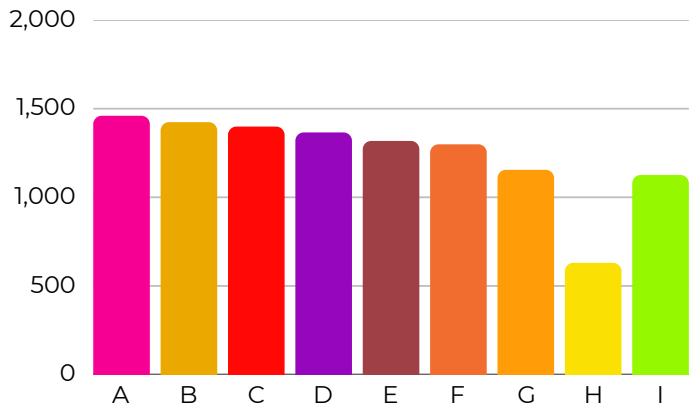
Just over half of respondents (54%) report haven received formal training on STEM integration or PBL; 35% have not and 11% are uncertain. School leadership support is mixed: roughly half of respondents describe leadership as supportive or very supportive, while the remainder report neutral, unsupportive, or very unsupportive environments. Approximately 61 percent indicate that their school or education system currently promotes PBL, yet this promotion often lacks the practical follow-through in time, materials, training, and assessment alignment needed for sustained practice





F. Hierarchy of Implementation Constraints

Quantitative analysis of barrier frequency reveals the primary challenges hindering widespread adoption:



A teachers **1,460**

B teachers **1,424**

C teachers **1,399**

D teachers **1,366**

E teachers **1,318**

F teachers **1,219**

G teachers **1,155**

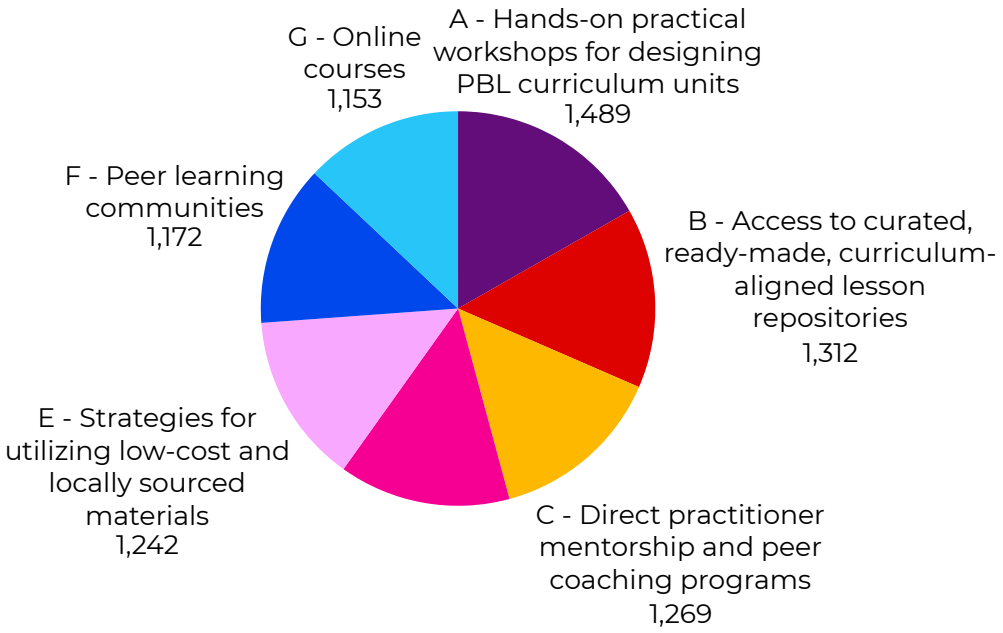
H teachers **630**

I teachers **630**

A - Shortage of instructional materials and learning resources
B- High student-to-teacher ratios and large class sizes
C - Inadequate laboratory infrastructure and equipment
D - Insufficiency of formal, practical teacher training in PBL
E - Overloaded timetables and limited curricular flexibility
F - High-stakes examination pressure and syllabus coverage demands
G - Student readiness / previous learning habits
H - Lack of support from school leadership
I - Assessment and grading difficulties

G. Preferred Support Interventions

Educators identified prioritized avenues for professional capacity building



A - Shortage of instructional materials and learning resources
B- High student-to-teacher ratios and large class sizes
C - Inadequate laboratory infrastructure and equipment
D - Insufficiency of formal, practical teacher training in PBL
E - Overloaded timetables and limited curricular flexibility
F - High-stakes examination pressure and syllabus coverage demands
G - Student readiness / previous learning habits

DEEP INSIGHTS AND ANALYTICAL SYNTHESES

Synthesizing quantitative trends and qualitative responses yields several high-level policy insights:

- The Core Bottleneck is Systemic Enabling, Not Motivation: The data refutes the premise that teacher resistance hinders active learning. Educators strongly endorse PBL. The challenge lies in equipping teachers with design capabilities and establishing supportive school environments.

- Need for Targeted Skill-Building: Broad instructional workshops yield limited returns. Capacity building must focus on operational competencies: structuring multi-week inquiry, scaffolding group tasks in large classes, establishing objective rubric criteria, and integrating digital and AI tools.

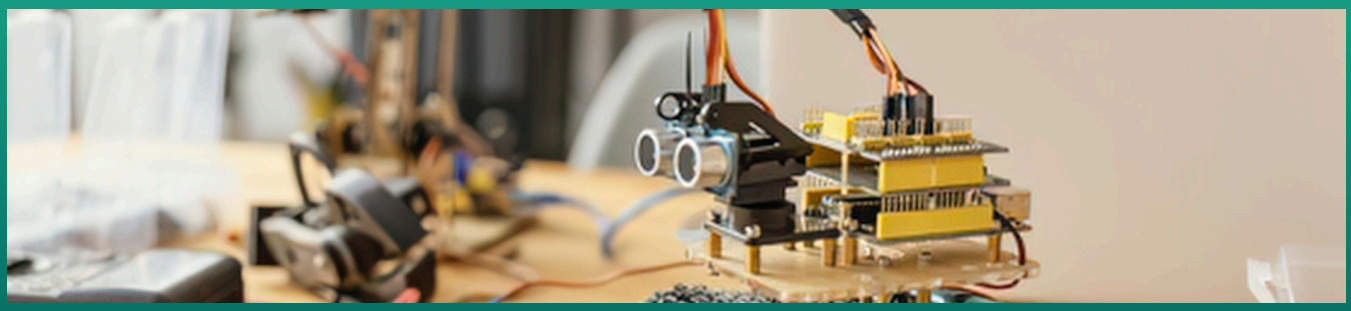
- Resourcefulness over Infrastructure Delays: While lab infrastructure remains an asset, high-impact PBL can thrive using locally available materials, community issues (such as waste management or agricultural optimization), and open-source software. Policy should prioritize resourcefulness frameworks alongside physical infrastructure builds.

- Assessment Realignment is Critical: High-stakes, recall-oriented national examinations create strong disincentives for project-based inquiry. Until continuous, performance-based assessment is integrated into national qualification systems, teachers will face conflicting priorities regarding project work.. Assessment systems currently act as a powerful disincentive. When high-stakes examinations reward rapid coverage of content and devalue process, collaboration, and real-world application, even well-trained and motivated teachers face structural pressure to abandon or dilute projects. Curriculum and examination reform must therefore accompany capacity building.

- Equity and Gender Inclusion Catalyst: Qualitative findings indicate that collaborative, real-world project structures increase confidence and participation among female students. Designing gender-responsive PBL tasks serves as a high-leverage strategy to advance equity across STEM-AI fields.

- Finally, country variations exist, but the core patterns—belief, moderate confidence, material and time constraints, and preference for practical workshops and mentoring—are remarkably consistent. This consistency supports the feasibility of regional and continental programmes with national adaptation rather than requiring entirely separate national inventions.

STRATEGIC RECOMMENDATIONS



Professional Development & Capacity Building

- Integrate mandatory, practice-based PBL unit design, facilitation, and assessment modules into pre-service teacher education accreditation frameworks.
- Establish continuous professional development credits centered on practical design labs, large-class management strategies, and local resource adaptation.
- Institutionalize peer-mentoring networks pairing master PBL practitioners with early-stage educators, supported by protected co-planning schedules.
- Build open-access digital repositories housing localized, curriculum-mapped PBL units complete with rubrics and low-cost material specifications.
- Include teacher trainers and college lecturers as priority participants in capacity-building programmes so that the multiplier effect reaches successive cohorts of new teachers.

Curriculum Adaptation & Structural Flexibility

- Formally mandate dedicated project windows within national STEM curriculum frameworks, requiring at least one interdisciplinary PBL unit per academic term.
- Streamline overloaded subject syllabi to prioritize depth of understanding and practical application over superficial content coverage.
- Provide curriculum mapping toolkits connecting project tasks directly to examination objectives, ensuring instruction remains aligned with standards.
- Encourage interdisciplinary projects that connect mathematics, science, technology and real community challenges, thereby increasing relevance and efficiency of learning time.

Assessment Alignment & Institutional Enabling

- Rebalance national assessment architectures to allocate substantial weight to school-based project portfolios, practical demonstrations, and collaborative competencies.
- Establish micro-grant funding streams and local maker-kit distribution networks to equip schools with reusable, cost-effective STEM equipment.
- Incorporate instructional leadership modules into principal and administrator certification programs, focusing on supporting active pedagogies and flexible scheduling.
- Create national and regional communities of practice—both face-to-face and digital—where teachers can share projects, troubleshoot challenges, and celebrate successes.
- Monitor implementation through simple, teacher-friendly indicators (frequency of substantial projects, teacher confidence self-ratings, student artefact quality samples) rather than solely through examination scores.
- Embed gender-responsive instructional strategies within all PBL training initiatives. Mandate structured group role rotation, track gender-disaggregated performance data, and highlight female leadership across project-based STEM activities to promote equitable outcomes.

NEXT ACTION PLAN

This table turns the data analysis into a clear next-action plan where each barrier is directly countered by a proven success factor and mapped to concrete, time-bound actions in the phased roadmap.

S/N	BARRIERS & CHALLENGES	PRACTICAL SUCCESS FACTORS	MATCHING ROADMAP ACTIONS
1	Large classes elucidate the difficulty of managing materials and providing individual guidance	Clear student roles, structured collaboration protocols, and transparent assessment rubrics; Gradual scaling starting with manageable projects	**Phase 1 (Months 1–18):** Practical PBL design workshops that explicitly include large-class management strategies and role protocols; Establish initial district-level practitioner networks for peer support
2	Limited materials make ambitious projects impractical	Access to at least basic materials or the knowledge and permission to use local and recycled resources creatively	**Phase 1 (Months 1–18):** Launch localized low-cost resource guides and creative-use toolkits using recycled and locally available materials
3	Overloaded curricula and examination pressure leave little time for iterative, reflective work	Projects tightly linked to existing curriculum objectives and local visible problems; Gradual scaling	**Phase 1:** Issue formal policy directives on timetable flexibility. **Phase 2 (Years 2–4)**: Reform national continuous assessment guidelines to include project portfolios
4	Incomplete training leaves teachers uncertain how to design rigorous projects or assess them fairly	Teachers who have received practical, design-focused training; Opportunities for teachers to see successful examples, share practice with peers, and receive ongoing mentoring	**Phase 1:** Roll out practical PBL design workshops for current educators and master trainers. **Phase 2:** Embed PBL competencies into pre-service teacher education; Expand regional mentorship structures and open-access lesson repositories
5	Weak leadership support removes the organisational cover teachers need to innovate	School leadership that protects timetable space, publicly values innovative teaching, and reduces purely bureaucratic pressures	**Phase 1:** Issue formal policy directives that give school leaders explicit authority and accountability for protecting project time **Phase 2–3:** System consolidation and institutionalization that include leadership performance metrics for supporting innovative pedagogy
6	Barriers are mutually reinforcing; addressing any single barrier in isolation produces only limited and fragile gains. A full enabling ecosystem is required	All success factors working together within existing resource envelopes when policy deliberately prioritizes them	**All Phases (Systems Approach):** Sequential but interconnected actions; Phase 1 builds immediate capacity and enabling conditions; Phase 2 embeds into pre-service, assessment, and repositories; Phase 3 institutionalises holistic STEM-AI pedagogy and continuous refinement

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INSTITUTIONS

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- Kenyatta University, Kenya
- Kweneng District of Education, Botswana
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- Malawi University of Business and Applied Sciences (MUBAS)
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Acknowledgment here does not imply any organization's endorsement of the report or its recommendations, which are presented only by STEMi Makers of Africa

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About STEMi Makers of Africa

STEMi Makers of Africa is a pan-African education organisation dedicated to strengthening STEM teaching and learning through practical, hands-on, and project-based approaches. We work with teachers, schools, teacher training institutions, and education systems to build the capacity of educators so they can confidently design and facilitate meaningful learning experiences for young people. Our focus is on Project-Based Learning (PBL) as a powerful method for developing critical thinking, problem-solving, collaboration, creativity, and real-world application of science, technology, engineering, and mathematics. We believe these competencies are essential for preparing African learners to thrive in an increasingly technology-driven and AI-influenced future. We support educators through practical training workshops, mentoring, ready-to-use learning resources, guidance on low-cost and locally available materials, and communities of practice. By combining classroom-level support with insights for policy and system improvement, we help turn innovative teaching from isolated practice into scalable, sustainable approaches across schools and countries.

About Global Institute for AI Policy, Research and Education:

The Global Institute for AI Policy, Research and Education is an independent research institute based in Switzerland, established to advance rigorous, evidence-based understanding of artificial intelligence and its implications for society, governance, and learning. We work at the intersection of three critical domains: AI policy, interdisciplinary research, and education. Our mission is to generate high-quality analysis, support informed decision-making, and strengthen the capacity of institutions and individuals to engage responsibly with artificial intelligence. The Institute conducts and commissions research on the opportunities, risks, and governance of AI systems. We examine questions of regulation, ethics, safety, equity, economic impact, and international cooperation. Our work aims to provide policymakers, educators, researchers, and the public with clear, accessible, and actionable insights.

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