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Scaling Equity in U.S. Science Education: A Multicultural Curriculum and Educator-Training Framework for Underserved Secondary Schools

From Principles to Practice: A Replicable Model for Curriculum Quality, Educator Capacity, Student Belonging, and STEM Pathway Access

Bienvenido Delos Angeles Bacalla Jr.

Science Educator and Curriculum-Development Practitioner

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Executive Summary

The United States needs more than isolated examples of excellent science teaching. It needs a practical way for schools serving economically disadvantaged, multilingual, culturally diverse, rural, urban, and otherwise underserved learners to examine who has access to rigorous science, improve what is taught, strengthen how it is taught, and measure whether opportunity gaps are narrowing. The National Academies has called for equitable access to high-quality science learning across K-16 and has emphasized that scientific literacy supports economic opportunity, public problem-solving, and democratic participation. This follow-up white paper responds to that need with a concrete, scalable model for secondary schools.1

The proposed endeavor is to design, pilot, evaluate, and disseminate a multicultural and culturally responsive STEM curriculum and professional-learning framework for U.S. middle and high schools. The framework is not a single course, textbook, workshop, or school-based initiative. It is an adaptable improvement system comprising standards-aligned instructional modules, curriculum-equity audits, educator training and coaching, accessible, multilingual learning supports, student and community engagement, and a data-driven evaluation toolkit. Its design allows schools to preserve state standards and local decision-making while strengthening relevance, rigor, accessibility, and accountability.

> **Core proposition.** When rigorous science content is connected to students' cultures, languages, communities, and future pathways - and when teachers receive sustained support to make those connections well - schools can improve engagement and belonging without lowering academic expectations.

The urgency is measurable. In the 2024 National Assessment of Educational Progress, the average grade 8 science score was four points lower than in 2019; only 31 percent of eighth-graders performed at or above NAEP Proficient, while 38 percent performed below NAEP Basic. NAEP cautions that its achievement levels are not the same as state grade-level standards, but the national trend still signals a serious loss of momentum. At the same time, only 28 percent of eighth graders reported a high level of interest and enjoyment in science in 2024, down from 38 percent in 2019, and only 14 percent reported

1 National Academies of Sciences, Engineering, and Medicine, Call to Action for Science Education: Building Opportunity for the Future (2021), https://nap.nationalacademies.org/resource/other/dbasse/cta-science-education/ (accessed August 15, 2026).

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frequent participation in inquiry-related classroom activities. These results point to a combined challenge of performance, engagement, and opportunity.[2,3]

The framework outlined here addresses that challenge through a pilot-to-scale strategy. Initial implementation would begin with a limited group of underserved and multilingual secondary schools, establish baseline measures of opportunity and experience, co-design standards-aligned modules with educators and community participants, provide a structured sequence of professional learning and coaching, and evaluate implementation using disaggregated but privacy-protected data. Lessons from the pilot would be documented in a replication toolkit and shared through district partnerships, practitioner networks, workshops, and openly accessible resources.

The expected public value extends beyond participating classrooms. The model is designed to strengthen the quality of science instruction, expand access to advanced coursework and authentic inquiry, increase educator capacity, improve student belonging and agency, strengthen family-school connections, and contribute to a larger and more representative STEM talent pipeline. It is also structured for use across multiple districts and organizational settings, allowing resources and lessons learned in one community to reduce duplication and accelerate improvement in others.

1. The National Challenge: Unequal Opportunity, Declining Engagement, and Workforce Demand

1.1 Science learning is an access issue as well as an achievement issue

Science outcomes cannot be understood solely by looking at test scores. Students' opportunities to learn are shaped by course availability, laboratory resources, instructional time, teacher preparation, academic advising, language access, disability access, and whether students experience science as relevant to their lives. The U.S. Department of Education's Civil Rights Data Collection measures access

2 U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress, 'NAEP Science: Opportunities in Education' (2024), https://www.nationsreportcard.gov/reports/science/2024/opportunities-in-education/ (accessed August 15, 2026). NAEP notes that questionnaire associations do not establish causation.

3 U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress, 'NAEP Science: National Trends and Student Skills' (2024), https://www.nationsreportcard.gov/reports/science/2024/national-trends/ (accessed August 15, 2026). NAEP states that achievement levels are to be interpreted with caution and that NAEP Proficient is not the same as state-determined grade-level proficiency.

to mathematics, science, and computer science courses precisely because course availability and participation are civil-rights and educational-opportunity concerns. The 2021-22 collection covered virtually every public school in the nation and reported student access by characteristics including race or ethnicity, sex, English learner status, and disability.4

A scalable solution, therefore, must examine both formal and lived access. Formal access asks whether a course, laboratory, device, or advanced pathway exists. Lived access asks whether students are encouraged to enroll, receive the language and academic supports needed to participate, see their identities and communities represented, and are given meaningful opportunities to investigate phenomena, develop models, analyze data, construct explanations, and design solutions.

1.2 Multilingual classrooms are a permanent feature of U.S. public education

Multilingualism is not a niche condition. In fall 2021, approximately 5.3 million public-school students 10.6 percent of enrollment - were identified as English learners, up from 9.4 percent in fall 2011. State proportions ranged widely, demonstrating that local needs differ even though the national need is persistent. Science curricula that treat language support as an afterthought risk separating language development from the very practices that make science comprehensible: observation, modeling, experimentation, evidence-based discussion, and multimodal representation.5

An effective framework should therefore build language development into the architecture of each science module. Vocabulary, discourse routines, visual models, structured collaboration, multilingual glossaries, and multiple ways to demonstrate understanding should be planned from the beginning. These are not replacements for academic English or disciplinary precision. They are bridges to both.

1.3 The education challenge is connected to national innovation capacity

The long-term stakes extend to the workforce. National Science Foundation indicators continue to show uneven participation in STEM employment across demographic groups. In 2021, Black workers represented 8.2 percent of STEM workers compared with 11.0 percent of all workers, while Hispanic workers represented 14.8 percent of STEM workers compared with 18.2 percent of all workers. These

4 U.S. Department of Education, Office for Civil Rights, 'Civil Rights Data Collection for the 2021-22 School Year,' https://www.ed.gov/laws-and-policy/civil-rights-laws/civil-rights-data-collection-crdc/civil-rights-data/civil-rights-data-collection-crdc-2021-22-school-year (accessed August 15, 2026).

5 National Center for Education Statistics, Condition of Education, 'English Learners in Public Schools' (updated May 2024), https://nces.ed.gov/programs/coe/indicator/cgf (accessed August 15, 2026).

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patterns reflect many forces, but secondary-school experiences affect whether students develop confidence, complete prerequisite courses, understand career pathways, and persist into postsecondary STEM education or skilled technical work.6

Demand strengthens the case for action. The Bureau of Labor Statistics projects STEM employment to grow 8.1 percent from 2024 to 2034, compared with 2.7 percent for non-STEM employment. In 2024, the median annual wage for STEM occupations was $103,580, more than twice the median for non-STEM occupations. Expanding access to rigorous and engaging secondary science is therefore connected to workforce readiness, regional economic mobility, and the nation's ability to sustain scientific and technological leadership.7

2. Public Value and National Relevance

The framework has educational, social, economic, and institutional value. Its immediate purpose is to help schools improve science teaching and learning. Its broader purpose is to create a reusable method through which diverse communities can expand opportunity without sacrificing rigor, local context, or accountability.

2.1 Educational value: rigorous learning with meaningful access

The Institute of Education Sciences' Framework for Equitable Opportunities to Learn in STEM states that equitable STEM learning requires access to high-quality experiences that integrate STEM domains and affirm students' identities, strengths, and cultures. The proposed framework operationalizes that principle. It connects standards-based learning goals to locally meaningful phenomena, diverse scientific contributions, community questions, and multiple modes of participation. This design aims to increase the number of students who can successfully engage in rigorous scientific practices rather than to create separate or less demanding curricula for underserved learners.8

6 National Center for Science and Engineering Statistics, National Science Foundation, The State of U.S. Science and Engineering 2024, 'Distribution of Select Racial and Ethnic Groups in the Workforce, by Occupational Group: 2021,' https://ncses.nsf.gov/pubs/nsb20243/figure/1 (accessed August 15, 2026).

7 U.S. Bureau of Labor Statistics, 'Numbers, Research, and Discovery: STEM Employment Projected to Take Off!' The Economics Daily (December 9, 2025), https://www.bls.gov/opub/ted/2025/numbers-research-and-discovery-stem-employment-projected-to-take-off.htm (accessed August 15, 2026).

8 Institute of Education Sciences, Regional Educational Laboratories, 'Framework for Equitable Opportunities to Learn in STEM' (June 2024), https://ies.ed.gov/use-work/resource-library/resource/other-resource/framework-equitable-opportunities-learn-stem (accessed August 15, 2026).

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2.2 Social value: belonging, agency, and public scientific literacy

Students need scientific literacy not only for careers but also for decisions about health, technology, energy, the environment, and community well-being. A culturally responsive approach can make these decisions visible in the curriculum. Students might examine heat islands in their neighborhood, water quality near local infrastructure, hereditary health questions discussed in their families, or the environmental effects of land-use decisions. Such work helps students see science as a method for investigating questions that affect people they know.

Belonging is equally important. Students are more likely to view STEM as a possible future when classroom materials portray scientific achievement as a human enterprise involving many cultures and when teachers communicate high expectations with concrete support. The goal is not symbolic representation alone. It is a change in participation: who asks questions, leads investigations, explains evidence, enrolls in advanced courses, and imagines a future in science or technology.

2.3 Economic value: broadening pathways into high-growth work

A stronger and more representative STEM pipeline expands the pool of students prepared for postsecondary science, engineering, computing, health, and skilled technical programs. This is especially important in communities where students may have limited exposure to STEM professionals or may not understand how secondary courses connect to credentials and employment. Each module should therefore include at least one explicit pathway connection: a local occupation, a postsecondary program, an apprenticeship, a public-sector application, or a community-based technical role.

2.4 Institutional value: a reusable improvement system

Many schools want to improve equity and relevance but lack staff time to conduct curriculum audits, design new modules, build professional learning, and evaluate results. A common framework reduces that burden. It provides shared tools that districts can adapt instead of requiring each institution to begin from zero. The value grows as participating schools contribute tested materials, implementation lessons, and improvement data back to a cross-district knowledge base.

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3. The Scalable Multicultural STEM Framework

The proposed model contains six mutually reinforcing components. Schools may enter through different components depending on local readiness, but lasting improvement requires the components to function as a coherent system.

Component 1: Curriculum-Equity Audit

The audit establishes a baseline before new materials are introduced. It examines standards coverage, rigor, course access, representation, local relevance, language demands, disability access, assessment design, laboratory opportunity, and pathway visibility. The audit uses document review, enrollment and outcome data, educator input, student experience surveys, and family or community consultation. It is diagnostic rather than punitive: its purpose is to locate barriers and identify practical points of leverage.

- **Standards and rigor.** Do all students encounter grade-appropriate disciplinary core ideas, science and engineering practices, and crosscutting concepts?
- **Access and participation.** Who enrolls in advanced courses, completes laboratory work, receives prerequisite preparation, and is referred to enrichment opportunities?
- **Representation and relevance.** Whose scientific contributions, community questions, and forms of knowledge appear in the curriculum, and whose are absent?
- **Language and accessibility.** Where do unnecessary linguistic, sensory, physical, or response-format barriers prevent students from demonstrating science understanding?
- **Assessment and feedback.** Do assessments capture scientific reasoning through more than one mode, and do students receive actionable feedback?

Component 2: Standards-Aligned Multicultural Science Modules

The module library translates audit findings into classroom-ready resources. Each module preserves rigorous learning goals while connecting science to culturally and locally meaningful contexts. The Next Generation Science Standards' resources for all students emphasize that learners from diverse backgrounds can engage in scientific practices when given equitable opportunities and provide case-based strategies for groups historically underserved in science.9

9 Next Generation Science Standards, 'NGSS for All Students,' https://www.nextgenscience.org/resources/ngss-all-students (accessed August 15, 2026); see also NGSS Appendix D, All Standards, All Students.

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Each module follows a common architecture: (1) a compelling phenomenon or design problem; (2) explicit alignment to applicable state or NGSS-based performance expectations; (3) cultural and community context reviewed for accuracy and respect; (4) inquiry or engineering-design tasks; (5) language-development routines; (6) accessibility options; (7) formative and summative assessments; (8) a STEM pathway connection; and (9) teacher reflection prompts. A shared architecture makes modules easier to review, compare, revise, and scale.

Component 3: Educator Professional Learning and Coaching

A curriculum cannot implement itself. Teachers need time to understand the design, adapt it responsibly, rehearse difficult discussions, examine student work, and improve practice. The professional-learning model therefore combines an initial institute, short application modules, collaborative planning, classroom coaching, peer observation, and professional learning communities. Training addresses cultural responsiveness, high-expectation scaffolding, inquiry facilitation, multilingual supports, accessible design, assessment literacy, and the use of disaggregated data.

Professional learning is organized around authentic teacher work. Participants revise an existing lesson, teach or simulate it, collect evidence of student participation and understanding, and use a structured reflection protocol. This cycle is more likely to produce durable change than a stand-alone presentation because educators practice the target methods in the context of their actual curriculum.

Component 4: Accessible and Multilingual Learning Design

The framework incorporates Universal Design for Learning and asset-based language practices. CAST's UDL Guidelines 3.0 emphasize learner identity, belonging, diverse perspectives, respect across languages and dialects, multiple ways of knowing, and multiple means of engagement, representation, and expression. These principles are embedded in module templates and quality-review rubrics.[10]

Examples include captioned media, visual and tactile models, accessible digital formats, structured oral rehearsal before writing, multilingual glossaries, sentence frames that support rather than limit reasoning, alternative methods for recording observations, and options for students to communicate understanding through diagrams, models, demonstrations, oral explanations, or written analysis. The learning target remains common even when the pathways to it vary.

10 CAST, CAST Universal Design for Learning Guidelines, Version 3.0 (2024), https://udlguidelines.cast.org/more/about-guidelines-3-0/ (accessed August 15, 2026).

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The National Academies have concluded that STEM materials are more effective when English learners are considered throughout the design process rather than added later through supplemental accommodations. It also recognizes home language, culture, community experience, and multimodal meaning-making as resources for STEM learning. This finding supports integrating language access into the core module design.11

Component 5: Student, Family, and Community Engagement

Community engagement is a source of curricular quality, not merely public relations. Students and families can identify local phenomena, cultural knowledge, ethical concerns, and practical applications that curriculum writers may overlook. Community-based scientists, health professionals, engineers, environmental workers, technicians, tradespeople, and university partners can provide authentic problems, mentorship, career visibility, and feedback on student projects.

Engagement should be structured and reciprocal. Schools should explain how community input will be used, compensate or otherwise recognize substantial contributions when feasible, avoid extracting cultural knowledge without permission, and return results to participants in accessible formats. Student advisory groups can review module relevance, clarity, workload, and whether classroom participation feels inclusive.

Component 6: Data-Driven Evaluation and Continuous Improvement

Evaluation connects activity to outcomes. The framework measures implementation fidelity, educator learning, student experience, participation, achievement, and pathway access. Data are disaggregated where appropriate to detect whether aggregate improvement conceals persistent gaps. Quantitative measures are paired with student work, classroom observations, educator reflections, and community feedback so that interpretation is not reduced to a single test score.

The evidence base supports active, inclusive course design. A large meta-analysis of undergraduate STEM courses found that active learning narrowed examination-score gaps by 33 percent and passing-rate gaps by 45 percent for underrepresented students compared with traditional lecturing; the authors emphasized that deliberate practice and inclusive teaching must work together. Although the study

11 National Academies of Sciences, Engineering, and Medicine, English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives (Washington, DC: The National Academies Press, 2018), doi:10.17226/25182, https://www.nationalacademies.org/read/25182/chapter/11 (accessed August 15, 2026).

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concerns postsecondary courses, its central design lesson is relevant to secondary implementation: activity alone is insufficient unless participation structures are inclusive and connected to meaningful learning goals.12

4. Curriculum Module Design Protocol

To support consistent quality across subjects and districts, curriculum teams should use a common nine-step protocol.

1. **Define the performance target.** Identify the disciplinary content, science and engineering practice, crosscutting concept, and level of cognitive demand students must demonstrate.
2. **Select a meaningful phenomenon.** Choose a real event, system, problem, or design challenge that is observable, investigable, and connected to students' communities or broader public concerns.
3. **Map cultural and community connections.** Identify relevant histories, knowledge systems, occupations, ethical questions, or lived experiences. Verify accuracy and avoid presenting any culture as monolithic.
4. **Anticipate barriers.** Analyze vocabulary, syntax, background knowledge, sensory demands, technology access, physical participation, and assessment formats before instruction begins.
5. **Design inquiry and collaboration.** Specify what students will observe, measure, model, test, discuss, and revise. Assign collaborative roles that distribute intellectual authority rather than routine tasks alone.
6. **Build language with science.** Plan opportunities to use everyday language, home language, diagrams, gestures, and models as bridges toward precise scientific explanation and argumentation.
7. **Provide high-support access to rigor.** Use exemplars, chunked tasks, questioning sequences, vocabulary supports, and formative feedback while preserving the core reasoning demand.
8. **Assess in multiple ways.** Collect evidence through performance tasks, models, data analysis, oral defense, lab notebooks, constructed response, and standards-aligned selected response where appropriate.
9. **Connect learning to pathways.** Show how the concepts and practices appear in further coursework, local work, public service, research, or skilled technical occupations.

12 Elli J. Theobald et al., 'Active Learning Narrows Achievement Gaps for Underrepresented Students in Undergraduate Science, Technology, Engineering, and Math,' Proceedings of the National Academy of Sciences 117, no. 12 (2020): 6476-6483, doi:10.1073/pnas.1916903117, https://pmc.ncbi.nlm.nih.gov/articles/PMC7104254/ (accessed August 15, 2026).

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Quality safeguard. Cultural relevance must deepen the scientific task. A context is not sufficient merely because it mentions a cultural group; it should help students ask better questions, interpret evidence, or understand how science operates in society.

5. Educator-Training and Coaching Model

The educator-development system is designed as a sequence rather than a one-time event. Federal education research is currently investing in the development and testing of culturally responsive professional development intended to improve teacher knowledge, beliefs, practices, student engagement, relationships, attendance, and academic outcomes. The proposed model contributes to this practice-oriented direction by pairing training content with implementation evidence.13

5.1 Learning sequence

- **Foundation institute.** A two- or three-day learning experience introduces the framework, equity-audit process, module architecture, high-expectation scaffolding, multilingual supports, UDL, and data-use principles.
- **Application studio.** Teacher teams revise one existing unit or adopt one prototype module, align it to local standards and pacing, and anticipate student-access needs.
- **Coaching cycle.** A coach and teacher identify a focused practice, review a lesson plan, observe or examine recorded evidence where permitted, analyze student participation and work, and agree on a next step.
- **Professional learning community.** Monthly or biweekly meetings use shared protocols to examine student work, discuss implementation barriers, and calibrate expectations across classrooms.
- **Facilitator development.** Experienced participants learn to lead modules, facilitate data conversations, and coach peers so that the model can expand without relying on a single trainer.

5.2 Training competencies

Participants should demonstrate competency through artifacts and practice, not attendance alone. Evidence may include a revised lesson, an accessibility review, a student-work analysis, an observation

13 Institute of Education Sciences, 'Culturally Responsive Teaching for Student Equitable Achievement (CuRTSEA): A Professional Development Program,' Award R305A210146 (2021-2027), https://ies.ed.gov/use-work/awards/culturally-responsive-teaching-student-equitable-achievement-curtsea-professional-development (accessed August 15, 2026). This is a development and testing project; the citation supports the federal research focus, not a claim of completed efficacy findings.

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reflection, and an implementation plan. Core competencies include: maintaining rigorous science goals; connecting content to student and community contexts; facilitating equitable scientific discourse; supporting multilingual meaning-making; designing accessible materials; recognizing bias in examples and assessments; using data responsibly; and engaging families and community partners.

5.3 Role of instructional coordination

The work requires a curriculum-and-instruction function that connects standards, materials, teacher learning, implementation, and evaluation. The Bureau of Labor Statistics describes instructional coordinators as professionals who oversee curriculum and teaching standards, develop and implement materials, conduct teacher training, analyze student data, recommend instructional techniques, develop implementation procedures, and mentor or coach educators. That integrated role is essential because curriculum revision without educator support, or training without aligned materials and evaluation, produces fragmented reform.14

6. Pilot-to-Scale Implementation Roadmap

Implementation should proceed in phases so that the model can be tested, improved, and documented before wider dissemination. The following roadmap is deliberately adaptable to district size and local calendars.

Phase	Indicative Period	Core Activities	Primary Deliverables
1. Readiness	Months 1-3	Partnership agreements; baseline data; curriculum audit; stakeholder mapping; pilot selection	Readiness profile; audit report; measurement plan
2. Co-design	Months 4-6	Module development; educator institute; student and community review; accessibility checks	Prototype modules; training materials; review rubric
3. Pilot	Months 7-18	Classroom implementation; coaching;	Pilot dataset; revised modules;

14 U.S. Bureau of Labor Statistics, Occupational Outlook Handbook, 'Instructional Coordinators,' https://www.bls.gov/ooh/education-training-and-library/instructional-coordinators.htm (accessed August 15, 2026).

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Phase	Indicative Period	Core Activities	Primary Deliverables
		PLCs; formative data collection; rapid-cycle revisions	implementation guide
4. Expansion	Months 19-36	Additional schools and facilitators; train-the-trainer; comparative learning across sites	Facilitator cohort; district toolkit; cross-site report
5. Dissemination	Years 3-5	Open resources; workshops; practitioner briefs; regional partnerships; replication support	Replication toolkit; public learning products; sustainability plan

6.1 Pilot site selection

Pilot sites should reflect the settings the framework is intended to serve. Selection criteria may include high proportions of economically disadvantaged or multilingual learners, limited access to advanced science, evidence of science engagement challenges, leadership commitment, teacher willingness, and the practical ability to collect baseline and follow-up data. A small number of contrasting sites - for example, urban, suburban, and rural - can help distinguish universal design features from context-specific adaptations.

6.2 Adaptation with fidelity

Scale does not mean identical implementation. The framework distinguishes core elements from adaptable elements. Core elements include alignment with standards, a documented equity audit, structured educator learning, student access supports, implementation evidence, and continuous improvement. Adaptable elements include local phenomena, cultural connections, pacing, partnership roles, delivery format, and selected outcome indicators. This distinction protects quality while respecting local control.

6.3 Dissemination infrastructure

Materials should be released in practical formats: editable module templates, facilitator slides, audit instruments, student-experience surveys, coaching protocols, implementation checklists, short research

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briefs, and exemplars of revised student work. Dissemination should include workshops and virtual learning communities to ensure users understand the design principles rather than copying materials out of context.

7. Evaluation and Evidence-Building Plan

The evaluation strategy serves three purposes: accountability to participating communities, continuous improvement during implementation, and evidence for responsible replication. It does not assume that one measure can capture equitable science learning.

7.1 Logic model

- **Inputs.** Curriculum leadership, educator time, school partnerships, community expertise, standards documents, instructional materials, data access, and technology.
- **Activities.** Audits, co-design, professional learning, coaching, classroom implementation, student and family engagement, assessment, and dissemination.
- **Outputs.** Modules produced; educators trained; coaching cycles completed; classrooms reached; community partners engaged; resources disseminated.
- **Short-term outcomes.** Improved teacher knowledge and confidence; increased use of inquiry, accessibility, and culturally responsive practices; stronger student engagement and belonging.
- **Intermediate outcomes.** Improved science achievement and course completion; narrower subgroup gaps; increased enrollment in advanced science and STEM enrichment; stronger family-school STEM engagement.
- **Long-term outcomes.** Expanded postsecondary and workforce pathways; a more diverse STEM talent pool; sustained district capacity; adoption of tested practices across multiple regions.

7.2 Measurement domains

Domain	Illustrative Measures	Interpretive Question
Implementation	Module use; coaching participation; observation rubric; adaptation log	Was the model implemented, and how did local adaptations affect fidelity?
Educator capacity	Knowledge checks; lesson artifacts; self-efficacy; practice indicators	Did educators gain the skills and confidence to sustain the approach?

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Domain	Illustrative Measures	Interpretive Question
Student experience	Belonging; relevance; voice; inquiry participation; confidence	Did students experience greater access to meaningful and rigorous science learning?
Academic outcomes	Common assessments; performance tasks; course grades; completion	Did science understanding improve, and for whom?
Pathway access	Advanced-course enrollment; STEM clubs; dual credit; career exposure	Did participation in higher-level opportunities expand?
System capacity	Facilitators trained; modules adopted; partnerships; budget integration	Can the work continue and spread without excessive external dependence?

7.3 Disaggregation and responsible interpretation

Outcome data should be reviewed by race or ethnicity, economic disadvantage, English learner status, disability, sex, course level, and other locally relevant categories when sample sizes and privacy rules permit. Disaggregation is essential because averages can improve while some groups remain excluded. However, subgroup results should be interpreted as indicators of opportunity and system performance, not as evidence of fixed student ability.

7.4 Privacy and data governance

Evaluation agreements must define what data are needed, who may access them, how they will be secured, when they will be destroyed, and how results will be reported. The U.S. Department of Education explains that personally identifiable education records may be shared for specified studies or evaluations only under applicable FERPA conditions, often including written agreements and purpose limitations; properly de-identified information may be shared without identifying individual students. The framework should default to data minimization, de-identification, small-cell suppression, and school-controlled access.15

15 U.S. Department of Education, Student Privacy Policy Office, 'May an Educational Agency or Institution Disclose Personally Identifiable Information from Students' Education Records for the Purpose of a Specified Audit, Evaluation, or for Compliance and Enforcement Purposes under FERPA?' https://studentprivacy.ed.gov/faq/may-educational-agency-or-institution-disclose-personally-identifiable-information-students-0 (accessed August 15, 2026); see also 34 C.F.R. sections 99.31 and 99.35.

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7.5 Improvement cycles

At least once per instructional cycle, implementation teams should review evidence and make a documented decision: retain, revise, expand, or discontinue a strategy. Each decision should identify the evidence used, equity implications, responsible owner, and date for reassessment. This turns evaluation into a management practice rather than a report produced after decisions are already complete.

8. Why a Networked, Cross-Institution Delivery Model Is Necessary

The problem is distributed across schools, districts, curriculum systems, professional-learning structures, and community pathways. It cannot be solved efficiently through isolated classroom improvement or a model confined to a single institution. A networked delivery structure allows the framework leader to collaborate with public schools, districts, regional service agencies, universities, professional associations, nonprofits, cultural institutions, museums, and workforce partners according to local need.

This structure creates several public benefits. First, it allows common tools to be adapted across locations, reducing duplication. Second, it makes it possible to compare implementation across contexts and identify which elements travel well. Third, it permits specialized partners to contribute without requiring a single institution to possess every capability. Fourth, it enables smaller or under-resourced districts to participate in shared professional learning and access materials that would be costly to develop alone. Fifth, it supports dissemination through multiple channels rather than relying on the internal priorities or budget cycle of one school system.

The National Science Foundation's INCLUDES initiative uses a similar systems logic: shared vision, partnerships, goals and metrics, leadership and communication, and expansion, sustainability, and scale. It is designed to move beyond locally concentrated success by building collaborative infrastructure for broader participation in STEM. The proposed secondary-school framework adopts these principles at a practice level, with districts retaining control over adoption and implementation.16

16 National Science Foundation, 'Eddie Bernice Johnson INCLUDES Initiative,' https://www.nsf.gov/funding/opportunities/nsfs-eddie-bernice-johnson-inclusion-across-nation (accessed August 15, 2026).

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8.1 Governance

A light but accountable governance structure should include a framework director, a practitioner advisory group, participating-site leads, student and community advisors, and an evaluation partner where feasible. The advisory group reviews module quality, cultural accuracy, accessibility, evidence standards, and dissemination priorities. Participating sites approve local adaptations and data-use terms. The framework director coordinates work across institutions, maintains shared tools, and ensures that learning from each site contributes to the common knowledge base.

8.2 Partnership principles

- **Non-exclusive participation.** Schools and partners may use the framework without surrendering local curriculum authority or committing to one vendor or organization.
- **Mutual contribution.** Partners contribute expertise, implementation evidence, access to learning environments, mentorship, or dissemination capacity and receive usable resources in return.
- **Transparency.** Roles, decision rights, authorship, data use, costs, and intellectual-property expectations are documented before implementation.
- **Community respect.** Cultural and local knowledge is used with attribution, consent, and attention to context.
- **Practical evidence.** Claims about effectiveness are proportionate to the quality and scope of available data.

9. National Replication and Sustainability

National relevance does not require immediate nationwide operation. It requires a design capable of producing transferable benefits and a credible path from local testing to broader use. The framework advances this goal through common templates, documented adaptation, facilitator development, comparative evaluation, open dissemination, and partnerships that can reach multiple regions.

9.1 Replication toolkit

The toolkit should contain a readiness assessment, curriculum audit instruments, module templates, sample biology and general science units, accessibility and cultural review rubrics, educator training materials, coaching protocols, student and family engagement guides, survey instruments, data dictionaries, implementation checklists, and sample partnership agreements. A district should be able to

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understand the model, estimate the resources required, and conduct a small pilot without recreating the entire design process.

9.2 Train-the-trainer strategy

Scale depends on local capacity. Facilitators should complete the core educator sequence, demonstrate competent implementation, co-facilitate a training, receive feedback, and then lead supported cohorts. Certification within the framework, if used, should reflect demonstrated performance and renewal through evidence of continued practice rather than simple attendance.

9.3 Sustainable resourcing

Potential support may include district professional learning budgets, curriculum adoption funds, federal or state education grants, private foundations, university partnerships, industry sponsorship for career-connected learning, and cost-sharing among regional cohorts. The model should avoid dependence on a single funding stream. Core tools can be made openly available, while tailored audits, facilitation, coaching, evaluation, and implementation support may be funded through transparent service agreements or grants.

9.4 Alignment with national investment

Federal law and programs recognize the connection between K-12 STEM learning, underrepresented learners, rural communities, and the future workforce. The CHIPS and Science Act authorizes research and development on effective approaches to engaging PreK-12 students, including historically underrepresented and rural students, with purposes that include compelling STEM learning, expansion of the workforce pipeline, and broader participation. The framework contributes at the implementation level by giving secondary schools concrete curriculum, training, and evaluation mechanisms that can translate broad policy goals into classroom practice.17

17 CHIPS and Science Act of 2022, Pub. L. No. 117-167, section 10311, 136 Stat. 1366; enrolled text available at https://www.congress.gov/bill/117th-congress/house-bill/4346/text/enr (accessed August 15, 2026). Section 10311 addresses PreK-12 STEM education, research on effective engagement approaches, workforce-pipeline expansion, broad participation, and outcome-oriented evaluation.

10. Implementation Risks and Mitigation

A credible scaling plan must identify risks early and treat them as design constraints.

- **Risk: cultural content becomes superficial or stereotyped.** Mitigation: require source verification, community review, multiple perspectives, and a test of whether the context deepens scientific reasoning.
- **Risk: rigor is perceived as being reduced.** Mitigation: begin with explicit standards and performance targets, publish alignment maps, and review student tasks for cognitive demand.
- **Risk: educator workload undermines implementation.** Mitigation: provide editable ready-to-use resources, protected collaboration time, pacing options, and incremental entry points.
- **Risk: one-time training produces little classroom change.** Mitigation: require application artifacts, coaching, PLC follow-up, observation evidence, and facilitator accountability.
- **Risk: local adaptation weakens fidelity.** Mitigation: distinguish core and adaptable elements, document changes, and review adaptations against a common rubric.
- **Risk: data are overinterpreted or privacy is compromised.** Mitigation: predefine measures, use comparison and qualitative evidence where feasible, minimize data, suppress small cells, and report limitations.
- **Risk: the model remains locally concentrated.** Mitigation: build dissemination and facilitator development into the pilot budget, create public tools early, and recruit contrasting sites.
- **Risk: political or community disagreement blocks participation.** Mitigation: use transparent objectives, standards-based language, local consultation, parent communication, and clear opportunities to review materials before use.

11. Anticipated Benefits to the United States

If implemented responsibly, the framework can generate benefits at multiple levels.

Students

Students gain more consistent access to rigorous scientific inquiry, materials that connect with their lives and communities, language and accessibility supports, clearer STEM pathways, and a stronger sense that they can contribute to science. These gains are especially consequential for learners who have historically received fewer advanced opportunities or have been treated as deficient because of language, disability, income, race, ethnicity, sex, geography, or school assignment.

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Educators

Educators gain a practical method for revising curriculum, supporting multilingual and diverse learners, facilitating inquiry, examining participation, and using evidence to improve instruction. Coaching and professional communities reduce isolation and create a pipeline of local facilitators.

Schools and districts

Schools and districts gain audit tools, standards-aligned modules, evaluation instruments, implementation procedures, and access to a cross-site learning network. The framework can help align curriculum, professional development, family engagement, advanced-course access, and improvement planning around common science-learning goals.

Communities and the national workforce

Communities gain opportunities to shape science learning around local conditions and to connect young people with mentors and careers. Over time, wider participation can strengthen the workforce pipeline in health, engineering, computing, environmental science, advanced manufacturing, energy, education, research, and skilled technical fields. The broader benefit is a population better prepared to use evidence, evaluate claims, and participate in decisions involving science and technology.

12. Recommendations for Action

For school and district leaders

- **Begin with evidence.** Conduct a curriculum and opportunity audit before selecting interventions.
- **Protect educator time.** Include collaborative planning, coaching, and data review in the implementation schedule and budget.
- **Pair access with support.** Expand advanced-course opportunity while ensuring prerequisite preparation, advising, language support, and accessible instruction.
- **Engage students early.** Use student experience and work samples to shape module design and evaluate whether intended changes are being felt in classrooms.

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For educators

- **Preserve rigor while changing access.** Maintain common learning goals and vary context, scaffolds, representation, collaboration, and demonstration of understanding.
- **Treat culture and language as resources.** Invite students to connect science with community knowledge while teaching the norms and precision of scientific discourse.
- **Examine participation, not only completion.** Observe who asks questions, uses equipment, explains evidence, leads groups, receives feedback, and enrolls in further opportunities.

For universities, nonprofits, museums, and workforce partners

- **Offer authentic problems and mentors.** Help schools connect learning to current scientific, environmental, health, and technical work.
- **Support evaluation and dissemination.** Contribute research expertise, facilitator preparation, venues, networks, and translation of findings into practical resources.
- **Invest in underserved settings.** Direct sustained resources toward schools that have had fewer laboratory, course, professional-learning, and career-connected opportunities.

For funders and policymakers

- **Fund complete implementation systems.** Support curriculum, professional learning, coaching, community engagement, evaluation, and dissemination rather than materials alone.
- **Require evidence and learning.** Support pilots that publish implementation lessons, measure subgroup opportunity, and revise models before expansion.
- **Enable cross-district participation.** Create grant and partnership structures that allow smaller districts to share expertise and infrastructure.

Conclusion

Advancing equity in U.S. science education requires a shift from isolated good intentions to a disciplined system of curriculum design, educator learning, community partnership, evaluation, and replication. The proposed multicultural curriculum and educator-training framework offers that system. It begins with the premise that underserved students do not need less science; they need reliable access to rigorous science that recognizes their identities, languages, communities, and capacity.

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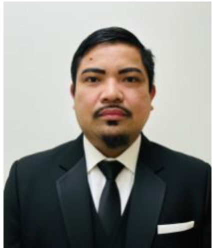
The framework is deliberately practical. It specifies what schools can audit, what curriculum teams can build, what teachers can learn and practice, what communities can contribute, what evaluators can measure, and how tested resources can move from an initial pilot to wider use. It also recognizes that a national challenge requires flexible collaboration across institutions. By making tools reusable and learning cumulative, the model can produce benefits beyond the first classrooms in which it is tested.

The opportunity is substantial. Better science education can strengthen achievement, belonging, public scientific literacy, economic mobility, and the future STEM workforce at the same time. Progress will require careful implementation and honest evaluation, but the direction is clear: high-quality science learning should be designed so that every student can enter, participate, contribute, and advance.



About the Author

Bienvenido Delos Angeles Bacalla Jr. is a science educator with more than 14 years of experience in multicultural classrooms in the Philippines and the United States. He currently serves at Waukegan High School in Illinois. His practice includes biology and general science, standards-aligned curriculum, differentiated and culturally responsive instruction, and leadership as a district cultural coordinator and multicultural club adviser. This follow-up paper translates principles from his earlier white paper, Advancing Equity in U.S. Science Education: A Multicultural Framework for Inclusive and Culturally Responsive STEM Learning, into an implementation pathway of curriculum audits, instructional modules, educator development, community engagement, evaluation, and dissemination.