International Research Journal of Education and Technology (IRJEdT)
‖ ISSN: 2581-7795, Impact Factor 5.007 ‖
‖ Peer-Reviewed | Open Access | International Journal ‖
‖ Volume: 09 | Issue: 08 | Aug- 2026 | www.irjweb.com ‖

Developing and Disseminating a Scalable, Data-Driven Secondary Mathematics Intervention and Computational Thinking Framework Using Graph Theory and Real-World Problem Solving for Underserved U.S. Schools

A multi-site framework for mathematics recovery, computational reasoning, teacher capacity, and STEM readiness

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Abstract

Persistent mathematics achievement gaps and incomplete post-pandemic recovery continue to limit students' readiness for advanced STEM education and computationally intensive careers. This white paper presents a scalable, data-driven secondary mathematics intervention and computational thinking framework designed for underserved U.S. schools. The framework integrates diagnostic learning profiles, tiered instructional support, evidence-based algebra strategies, graph theory, computational thinking, real-world mathematical modeling, teacher professional development, and continuous evaluation. Graph theory provides a distinctive instructional foundation through accessible investigations involving networks, routes, scheduling, facility monitoring, resource allocation, and identifying codes. These applications are intended to strengthen abstraction, decomposition, pattern recognition, algorithmic reasoning, optimization, mathematical justification, and problem-solving transfer.

The proposed framework extends beyond conventional classroom instruction through replicable curriculum modules, common diagnostic and outcome measures, professional-development cohorts, implementation guides, teacher-leader preparation, district and university partnerships, and multi-site dissemination. Its phased implementation model begins with curriculum development and an Arizona-based multi-school pilot, followed by regional replication and eventual multi-state expansion. Student learning, engagement, teacher capacity, implementation quality, equitable access, and institutional sustainability will be assessed through baseline and post-intervention measures, performance tasks, instructional records, surveys, and Plan–Do–Study–Act improvement cycles. By connecting foundational mathematics recovery with computational reasoning and applied graph-theory instruction, the framework seeks to strengthen mathematical agency, expand access to advanced STEM learning, and develop a replicable model for improving secondary mathematics education in resource-constrained school communities.

Keywords

Secondary mathematics education; mathematics intervention; computational thinking; graph theory; identifying codes; data-driven instruction; tiered instructional support; algebra education; mathematical modeling; problem-solving; STEM education; teacher professional development; curriculum development; underserved schools; educational equity; formative assessment; instructional improvement; Plan–Do–Study–Act cycles; multi-site implementation; STEM workforce readiness.

Executive Summary

The United States faces a consequential challenge in secondary mathematics. National assessment data show that mathematics achievement has not fully recovered from the disruption of the COVID-19 period, while the country's economic and scientific ambitions increasingly depend on workers who can reason quantitatively, represent complex systems, interpret data, and solve unfamiliar problems. The 2024 National Assessment of Educational Progress assessed approximately 117,900 fourth-grade students, 115,200 eighth-grade students, and 19,300 twelfth-grade students. Although fourth-grade performance improved relative to 2022 and eighth-grade performance was statistically unchanged, average mathematics scores at Grades 4, 8, and 12 remained significantly below 2019 levels. The National Science Board accordingly describes an incomplete recovery in elementary and secondary STEM achievement.[1 2]

At the same time, the National Science Foundation identifies STEM education as a foundation for a well-informed citizenry and a capable workforce of scientists, technicians, engineers, mathematicians, and educators. Recent NSF investments explicitly connect K–12 mathematics with workforce preparation in artificial intelligence, biotechnology, and quantum technologies. These priorities do not imply that every mathematics lesson has national reach. They do establish a policy environment within which a replicable, measurable, and disseminated intervention can contribute to a larger public objective.[3 4]

This white paper proposes a scalable, data-driven secondary mathematics intervention and computational thinking framework for underserved U.S. schools. The framework combines diagnostic assessment, tiered instructional response, evidence-based algebra instruction, graph theory, computational thinking, real-world modeling, teacher professional learning, and continuous improvement. Its central premise is straightforward: students learn advanced reasoning more successfully when instruction identifies their actual misconceptions, makes mathematical structures visible, connects abstract concepts to authentic systems, and gives teachers practical tools for adapting instruction.

Graph theory supplies a distinctive but disciplined element. In graph theory, a network is modeled through vertices and edges representing objects and their relationships. Identifying codes, the subject of Ranara and colleagues' 2018 article, use selected vertices to distinguish every vertex through unique neighborhood patterns. The concept has recognized theoretical relevance to detection and location problems. Within secondary education, it can support accessible investigations involving transportation routes, communication networks, facility monitoring, social connections, scheduling, and resource allocation. The framework does not present graph theory as a substitute for algebra, geometry, statistics, or foundational numeracy. It uses graph-based problems as a bridge between these domains and the habits of decomposition, abstraction, pattern recognition, algorithmic reasoning, and verification associated with computational thinking.[5 6]

The proposed model is designed to move beyond a single classroom. It produces a replicable intervention toolkit, educator training cohorts, implementation guides, common measures, anonymized evaluation reports, and dissemination through district partnerships, conferences, practitioner publications, and modular digital resources. Its initial implementation can begin in Arizona, where practical classroom knowledge and relationships support a feasible pilot, but its design anticipates adaptation across rural, urban, tribal, border-region, and other under-resourced educational contexts.

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Success will be determined through evidence rather than aspiration. Baseline and post-intervention measures will examine conceptual understanding, procedural fluency, problem solving, student engagement, course completion, and teacher implementation. A Plan–Do–Study–Act cycle will allow participating educators to test modules, inspect results, and refine delivery. The long-term aim is not a branded collection of worksheets; it is an adaptable improvement infrastructure that helps schools translate research into consistent mathematics practice.

1. The National Mathematics Challenge

1.1 Achievement, recovery, and readiness

Mathematics performance must be understood as both an educational outcome and a capacity constraint. Students who have not developed proportional reasoning, algebraic thinking, spatial reasoning, quantitative literacy, and problem-solving confidence face barriers in advanced coursework and in technical occupations. The National Science Board identifies elementary and secondary mathematics and science education as the foundation for entry into postsecondary STEM majors and a wide range of STEM-related occupations. It also emphasizes that competence in mathematics and science contributes to individual opportunity, national prosperity, and competitiveness.[7]

The 2024 NAEP record provides an objective baseline. National results cover Grades 4, 8, and 12 and allow comparisons with prior administrations. The most responsible interpretation is neither that every student has failed nor that a single intervention can reverse national trends. The evidence shows persistent, system-level weakness and unequal recovery. State and district snapshot reports also present results by race or ethnicity and economic disadvantage, allowing leaders to examine whether overall averages conceal gaps in opportunity and outcomes.[1 8]

Secondary schools inherit accumulated learning gaps. A student entering Algebra I may struggle not only with variables but with fractions, negative numbers, ratios, reading mathematical notation, or explaining a strategy. Conventional pacing can then widen the gap: new content assumes prior knowledge that has not been secured. Effective intervention must therefore diagnose prerequisite understanding and respond without reducing instruction to repetitive remediation.

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1.2 Underserved schools and the implementation gap

Underserved schools are not defined by student potential. They are shaped by uneven access to experienced teachers, advanced courses, instructional technology, professional development, stable staffing, and time for collaborative improvement. Rural schools may face distance and staffing constraints; urban schools may serve large numbers of students with diverse needs; border-region schools may support multilingual communities; and tribal communities may require locally responsive partnerships and respect for community authority. A scalable framework must therefore be modular rather than rigid.

A second problem is the distance between research and classroom practice. The Institute of Education Sciences notes that evidence-based approaches can improve algebra learning, but that time constraints, competing priorities, and uncertainty about how to operationalize research can limit consistent implementation. Its middle- and high-school algebra toolkit responds with professional-learning modules, data tools, and a Plan–Do–Study–Act cycle. This white paper adopts the same implementation logic: useful evidence must be converted into routines teachers can carry out, study, and improve.[9 10]

2. Design Principles

The framework rests on eight design principles. Together they prevent the work from becoming either a narrow remediation program or an advanced enrichment project disconnected from student need.

- Diagnose before prescribing. Instruction begins with short, standards-aligned probes that reveal misconceptions, strategy use, and prerequisite gaps.
- Preserve grade-level ambition. Intervention supplies scaffolds and prerequisite repair while keeping students connected to meaningful secondary content.
- Make reasoning visible. Students compare worked examples, explain choices, analyze errors, and represent relationships in multiple forms.
- Integrate computational thinking without requiring a separate computer science course. Decomposition, abstraction, algorithms, pattern recognition, and testing are embedded in mathematics tasks.
- Use graph theory as an applied reasoning strand. Networks and identifying-code ideas enrich algebra, geometry, discrete mathematics, probability, optimization, and modeling.
- Build teacher capacity. Materials are paired with training, collaborative planning, observation, feedback, and usable implementation guidance.

- Measure both outcomes and implementation. Student results are interpreted alongside dosage, fidelity, adaptations, and educator feedback.
- Design for transfer. Every module includes standards mapping, prerequisites, adaptation notes, assessment items, and facilitation guidance so another school can implement it.

3. Conceptual Foundation: Graph Theory and Computational Thinking

3.1 Why graph theory belongs in secondary mathematics

Graph theory studies relational structures. Vertices can represent cities, people, devices, courses, rooms, or tasks; edges can represent roads, communication links, prerequisites, doors, or dependencies. Because the same mathematical structure can describe many contexts, graph theory gives students a powerful lesson in abstraction: different stories may share the same underlying model.

Ranara, Loquias, Estrada, Punzalan, and Enriquez examined identifying codes for special graphs. An identifying code is a dominating set whose intersections with closed neighborhoods distinguish the vertices of a graph. Their paper establishes results for selected graph families and contributes to a broader research area involving location and detection. In school-level adaptation, the formal definitions can be introduced gradually. Students might first determine the minimum number of monitors needed to distinguish rooms in a simplified facility, then justify why each location produces a unique alert pattern. More advanced students can generalize results or write a search procedure.[5]

This use must remain intellectually honest. A classroom task inspired by identifying codes is not itself a deployed security system. The educational value lies in modeling constraints, proving uniqueness, optimizing a solution, and testing edge cases. These are transferable habits relevant to mathematics, computing, engineering, and data science.

3.2 Computational thinking as mathematical practice

Computational thinking is often mistaken for coding alone. In mathematics education, it can include breaking a complex problem into components, representing essential features, designing a repeatable procedure, recognizing patterns, analyzing efficiency, and checking whether a solution works in all cases. A 2023 systematic review found growing research on the integration of computational thinking into K–12 mathematics while also identifying a need for clearer explanations of how computational-thinking activities support mathematics learning. That caution supports an explicit design requirement: every

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computational activity in this framework must identify the mathematical objective, the computational practice, and the evidence of learning.[11]

Teacher knowledge is equally important. A 2026 Regional Educational Laboratory study developed a measure of middle-school mathematics teachers' pedagogical content knowledge for computational thinking. Its premise is practical: teachers need knowledge of the mathematics, knowledge of computational-thinking practices, and knowledge of how to teach the two together. The framework therefore includes teacher learning before classroom rollout, rather than assuming that attractive digital tasks will implement themselves.[12]

4. The Intervention Architecture

4.1 Component One: diagnostic learning profiles

Each instructional cycle begins with a brief learning profile, not a high-stakes label. The diagnostic set combines selected-response items, short constructed responses, error analysis, and one applied problem. It examines prerequisite knowledge, current-course concepts, representation, and reasoning. Teachers review not only whether an answer is correct but how the student approached it.

Diagnostic results place needs into actionable categories: conceptual misunderstanding, procedural error, vocabulary or notation barrier, prerequisite gap, strategy-selection difficulty, or incomplete explanation. This categorization guides small-group instruction and module selection. Students may move between supports as evidence changes; the profile is a planning tool, not a permanent track.

4.2 Component Two: tiered instructional response

Tier One strengthens core instruction for all students through worked examples, multiple representations, structured discussion, and frequent formative checks. Tier Two adds targeted small-group modules for students with shared misconceptions. Tier Three provides more intensive, individualized support, greater practice density, and closer progress monitoring. The tiers differ in intensity and responsiveness, not in expectations about students' capacity to reason.

The What Works Clearinghouse guide for middle- and high-school algebra recommends using solved problems to engage students in analyzing algebraic reasoning and strategies. It also emphasizes teaching students to use the structure of algebraic representations and to choose among alternative strategies. These recommendations inform the module template: launch with a diagnostic or worked example, compare strategies, make structure explicit, practice with fading support, and conclude with an application and explanation.[13]

4.3 Component Three: graph-theory and real-world modules

The applied strand consists of short modules that can be integrated into existing courses. A route-optimization task can reinforce systems, inequalities, distance, and constraints. A facility-monitoring task can introduce neighborhoods and identifying patterns. A course-prerequisite network can support directed graphs and logical sequencing. A social-network task can raise questions about centrality, sampling, privacy, and the limits of a model. A resource-allocation problem can connect optimization with fairness and explicit assumptions.

Each module contains six elements: a real problem; a mathematical model; representations by hand and, where appropriate, with technology; a solution or algorithm; a justification; and a transfer task in a different context. Technology remains optional where device or connectivity access is limited. The essential intellectual work can be completed with paper models, cards, grids, and discussion.

Framework component	Core product	Evidence generated
Diagnostic profile	Short probes, misconception categories, student reasoning samples	Baseline skill patterns and module-placement decisions
Tiered instruction	Core routines plus targeted and intensive modules	Formative growth, response to support, dosage
Applied graph tasks	Network, location, routing, scheduling, and optimization investigations	Modeling, proof, algorithmic reasoning, transfer
Teacher learning	Workshops, planning protocols, coaching, and exemplars	Teacher knowledge, confidence, implementation quality
Continuous improvement	Plan–Do–Study–Act cycles and adaptation logs	Outcome trends, fidelity, adaptations, stakeholder feedback

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5. Teacher Professional Development

Scale depends on teacher learning. A curriculum can be distributed quickly, but consistent instructional change requires opportunities to understand the content, rehearse practice, study student work, receive feedback, and adapt responsibly. The professional-development model uses cohorts of educators from participating schools. Each cohort completes an initial institute, recurring collaborative sessions, and an end-of-cycle evidence review.

The initial institute introduces the national and local mathematics context; diagnostic interpretation; evidence-based algebra routines; graph-theory foundations; computational-thinking practices; differentiation; and ethical use of student data. Teachers solve the same tasks they will facilitate, anticipate common approaches, and practice questioning that reveals reasoning without taking over the problem.

Monthly learning sessions center on actual implementation. Teachers bring anonymized student work, examine patterns, compare adaptations, and choose a small change for the next cycle. The facilitator documents changes so that local responsiveness does not become undocumented drift. In later phases, selected participants become teacher leaders who can facilitate cohorts, coach colleagues, and contribute tested adaptations to the shared toolkit.

The model treats professional learning as a two-way process. Classroom educators are not passive recipients of a finished product. Their evidence and practical knowledge improve the materials. This orientation is consistent with NSF’s support for research, development, and evaluation of STEM learning and teaching in formal and informal settings.[14]

6. Measurement and Evaluation

6.1 A theory of change

The theory of change begins with inputs: technical mathematics expertise, classroom experience, partnerships, curriculum-development time, teacher participation, and secure data processes. Activities include diagnostics, tiered modules, graph-based investigations, professional learning, coaching, and improvement cycles. Immediate outputs include trained teachers, completed modules, student participation, implementation records, and revised materials. Near-term outcomes include stronger conceptual understanding, procedural fluency, mathematical explanation, computational reasoning, engagement, and teacher confidence. Longer-term outcomes may include improved course completion, readiness for advanced STEM coursework, sustained adoption, and expansion to additional schools.

6.2 Measures

No single test should carry the entire evaluation. The measurement system combines curriculum-aligned assessments, common performance tasks, student work rubrics, course indicators, brief engagement surveys, teacher knowledge measures, implementation logs, and qualitative feedback. Where available and legally permissible, schools may examine existing benchmark or state data, but the framework will not attribute broad score changes to the intervention without an appropriate design.

The evaluation distinguishes outcome, implementation, and equity questions. Outcome questions ask what changed. Implementation questions ask what was delivered, to whom, and with what adaptations. Equity questions ask whether access, participation, experience, and improvement differ across student groups. Data will be disaggregated only when sample sizes and privacy rules allow responsible interpretation.

Evaluation domain	Illustrative indicators	Review cadence
Student learning	Concept inventory, algebra performance, modeling rubric, transfer task	Baseline, every 6–8 weeks, end of term
Engagement and agency	Task persistence, explanation, attendance, student survey	Monthly and end of module
Teacher capacity	Content knowledge, computational-thinking pedagogy, confidence, artifact quality	Pre-training, mid-cycle, post-cycle
Implementation	Modules delivered, instructional minutes, adaptations, coaching participation	Weekly logs and monthly review
Scale and sustainability	Schools, teachers, students, trained facilitators, renewal and adoption	Semester and annual review

6.3 Evaluation design and responsible claims

The pilot phase can use a pre/post design with repeated formative measures and matched comparison classrooms where feasible. As participation grows, evaluators may use quasi-experimental methods, staggered implementation, or randomized assignment if partners and conditions support them. The design should be chosen before outcomes are examined, and limitations should be reported transparently.

The What Works Clearinghouse exists to provide a trusted source of scientific evidence and applies standards to education studies. The framework will use that orientation as a quality benchmark: document the intervention, define outcomes, retain implementation evidence, address attrition and missing data, and distinguish correlation from causal evidence.[15]

7. Dissemination and Multi-Site Expansion

Broader impact depends on dissemination architecture. The framework will produce a core toolkit containing an implementation handbook, diagnostic bank, tiered modules, graph-theory investigations, teacher-learning guides, assessment rubrics, adaptation templates, and data dictionaries. Materials may be released through a mixed model: selected open resources for access and review, together with licensed or partnership-supported professional development that sustains coaching and quality control.

Expansion will proceed through evidence gates rather than publicity alone. A new site should receive readiness guidance, leadership orientation, teacher training, a local data plan, and scheduled implementation reviews. Sites will retain flexibility over course sequencing, calendars, language supports, and community-relevant contexts while preserving the framework's core instructional and measurement functions.

Dissemination channels include district workshops, state and national mathematics conferences, peer-reviewed or practitioner publications, webinars, university partnerships, educator networks, and a digital resource hub. Publications should report both favorable and unfavorable findings, explain modifications, and make clear the populations and conditions to which results apply.

8. Partnership Model

No individual educator can create national reach through classroom effort alone. The partnership model distributes responsibilities. Schools provide instructional settings, educators, schedules, and authorized data access. Districts support alignment, professional learning, and expansion. Universities can contribute content review, research design, preservice-teacher engagement, and independent evaluation. Community and STEM organizations can provide authentic problem contexts, mentoring, and dissemination. Funders can support release time, materials, technology, evaluation, and access for resource-constrained schools.

Partnership agreements should specify purpose, roles, intellectual-property terms, data governance, publication review, student privacy, accessibility, and exit conditions. Letters of interest are useful at the planning stage, but implementation agreements should identify concrete contributions, dates, participant numbers, and decision authority.

9. Phased Implementation Roadmap

Phase	Time horizon	Principal activities	Decision gate
I. Design and readiness	Months 1–6	Needs assessment; advisory group; prototype diagnostics; 6–8 modules; evaluation and privacy plan	Technical review and pilot commitments
II. Arizona pilot	Months 7–18	Two or more schools; teacher cohort; baseline and repeated measures; coaching; adaptation logs	Evidence of feasibility, usability, and early learning
III. Regional replication	Months 19–36	Additional districts; facilitator preparation; external evaluation; expanded toolkit; conference reporting	Replicable outcomes across differing contexts
IV. Multi-state dissemination	Years 4–5	Digital hub; university and professional partners; publications; train-the-trainer model; sustainability plan	Quality maintained while reach expands

Phase I converts the concept into testable products. An advisory group of mathematics educators, school leaders, researchers, and community representatives reviews standards alignment, cultural responsiveness, accessibility, and feasibility. Prototype modules undergo content review and small usability tests before student outcome claims are made.

Phase II pilots the framework in more than one school so that implementation is not confounded by a single classroom. Teachers receive training and coaching, administer common measures, and document adaptations. The end-of-phase report addresses feasibility, educator experience, student response, outcome trends, privacy, and resource requirements.

Phase III tests transfer. Additional sites should differ in at least some important respects—such as geography, enrollment, student demographics, course structure, or technology access. Independent evaluators or university partners can strengthen credibility. Teacher leaders begin facilitating new cohorts under quality standards.

Phase IV emphasizes sustainable dissemination. Expansion is warranted only if the framework retains instructional quality and produces interpretable evidence. The digital hub will maintain version control, accessibility, standards mappings, and a record of revisions. A sustainability plan may combine grants, district agreements, university partnerships, and professional-development revenue while protecting access for underserved schools.

10. Risks, Safeguards, and Limitations

The framework faces predictable risks. First, novelty may overshadow fundamentals. Graph-theory tasks must serve identified learning objectives rather than displace essential algebra or numeracy. Second, implementation may vary. Training, observation, adaptation logs, and core-component definitions help distinguish productive localization from loss of program integrity. Third, technology access may be unequal. Every essential module will have a low-technology pathway.

Fourth, data can be overinterpreted. Small samples, selection effects, changes in staffing, and concurrent interventions can influence outcomes. Reports will identify limitations and avoid causal language unless supported by design. Fifth, deficit framing can stigmatize students and communities. Materials will describe opportunity and instructional conditions, preserve high expectations, and involve local educators in adaptation.

Sixth, intellectual claims must remain bounded. Identifying codes have theoretical applications in locating and detection systems, but school modules do not establish operational advances in cybersecurity, telecommunications, or infrastructure. Seventh, rapid expansion can reduce quality. Evidence gates, facilitator standards, and versioned materials are designed to ensure that reach does not outrun capacity.

11. Illustrative Learning Progression

A coherent learning progression is necessary because graph theory and computational thinking can otherwise appear as isolated enrichment. The proposed progression begins with relational reasoning and moves toward formal modeling, optimization, and proof. It can be used within Algebra I, Geometry, Algebra II, integrated mathematics, mathematics intervention, or an elective, with the depth adjusted to the course.

11.1 Entry module: seeing relationships

Students begin by converting familiar situations into vertices and edges. A school transportation map, for example, can be represented as stops and direct routes. Learners compare two maps that look different spatially but have the same connectivity, introducing the idea that a graph describes relationships rather than physical scale. They calculate degree, identify paths and cycles, and explain what information the model preserves or omits. The diagnostic purpose is also important: teachers observe whether students organize information, interpret constraints, communicate a rule, and revise an initial representation.

11.2 Intermediate module: routes, constraints, and systems

The second stage connects networks to familiar secondary content. Students assign distances, costs, capacities, or time windows to edges. They compare routes under different objectives and discover that the "best" route depends on the question. An algebra class can write inequalities describing time and cost limits; a geometry class can contrast network distance with Euclidean distance; a statistics class can examine how uncertain travel times change a recommendation. Students must state assumptions and test whether a solution remains feasible when a condition changes.

11.3 Identifying-code module: distinguishability and optimization

The identifying-code sequence begins with a small facility network. A detector placed at a vertex covers its closed neighborhood. Students seek a set of detector locations such that every vertex produces a nonempty and unique coverage pattern. They construct a table of neighborhoods, test candidate sets, and explain why certain vertices cannot be distinguished. Advanced learners examine twin vertices, determine whether a graph is identifiable, and compare a valid code with a minimum code. The task integrates sets, logical conditions, proof by counterexample, combinatorial search, and optimization.

A low-technology implementation uses cards and colored markers. A technology-supported version can use a spreadsheet, dynamic graph tool, or short program to enumerate candidate subsets. In both versions, students must explain the mathematics. The program's output is evidence only after the learner verifies the definitions, interprets the result, and accounts for special cases.

11.4 Transfer module: community systems

In the culminating task, students select or are given a locally relevant network problem: emergency supply distribution, evacuation routes, bus connections, community-service access, irrigation channels, communication links, or course pathways. They define the vertices and edges, identify an objective, state constraints, analyze at least two solutions, and communicate limitations. Community context must be used respectfully. Students should not be asked to disclose sensitive personal information, and teachers should avoid presenting simplified models as definitive accounts of complex local conditions.

The transfer task can serve as a common performance assessment across sites. A shared rubric evaluates model construction, mathematical accuracy, computational strategy, justification, sensitivity to assumptions, and communication. The contexts may differ, allowing local relevance while preserving comparable dimensions of reasoning.

12. Equity, Accessibility, and Student Agency

An intervention intended for underserved schools must treat equity as a design property, not a concluding aspiration. Access begins with scheduling. Students should not lose essential core instruction or valued electives solely because they need mathematics support. Schools should examine who is referred, who participates in advanced graph-theory tasks, and whether movement between levels of support occurs when evidence changes.

Instructional accessibility requires multiple representations, explicit vocabulary support, worked examples, visual organization, and opportunities to explain reasoning orally, symbolically, graphically, and in writing. Materials should be compatible with screen readers where possible, use readable contrast, provide alt text for diagrams, and avoid relying on color as the only carrier of meaning. Multilingual learners should have access to language scaffolds that preserve mathematical complexity rather than replacing meaningful reasoning with simplified work.

Student agency is measured through choices and explanations. Learners can compare strategies, select a context, propose a model, challenge an assumption, and revise work after feedback. Surveys and focus groups should ask whether tasks feel relevant, whether students understand the purpose of interventions, and whether they experience themselves as capable mathematical thinkers. These responses complement achievement measures and can reveal implementation problems that scores alone will miss.

Equity review also applies to scale. A digital resource hub can increase access, but it does not erase differences in devices, bandwidth, planning time, staffing, or coaching. The dissemination budget should therefore include low-technology materials, facilitator support, educator release time, and targeted subsidies. Adoption counts should be reported alongside the intensity of support each site receives.

13. Research and Publication Agenda

A deliberate research agenda converts implementation experience into cumulative knowledge. The first study should address feasibility: Can teachers use the diagnostic categories reliably? Are modules completed within realistic schedules? Which supports are necessary? Do students understand the task formats? The second study should address early outcomes and variation: Which domains improve, for whom, and under what implementation conditions? Later studies can examine replication, facilitator models, cost, and sustained use.

Research questions may include whether graph-based modeling improves transfer to unfamiliar algebraic problems; whether explicit computational-thinking instruction changes the quality of student explanations; whether teacher pedagogical-content knowledge predicts implementation; and whether tiered modules reduce course-failure risk. Each question requires a defined comparison, measure, and analytic plan. Exploratory findings should be labeled accordingly.

The publication plan includes an annual technical report, practitioner briefs, conference presentations, module design notes, and peer-reviewed studies. Public reports should describe the participating settings without exposing students, document revisions by version, and provide sufficient detail for readers to judge transferability. Where agreements permit, de-identified instruments, coding guides, and analytic syntax can be shared to improve transparency.

An external advisory group should review the evidence at least annually. Its role is not ceremonial endorsement. Members should examine methods, question favorable interpretations, identify blind spots, and recommend whether expansion is justified. This review helps protect the initiative from confirmation bias and strengthens the reliability of claims made to schools, funders, and the public.

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14. Leadership and Capacity

Jesus Lim Ranara brings a combination of advanced mathematics training, research experience, and long-term classroom practice. He earned a Master of Science in Mathematics from the University of San Carlos and coauthored the 2018 study on identifying codes of special graphs. His professional record includes teaching mathematics and physics in the Philippines and secondary mathematics and science in Arizona. His work has included instructional-material preparation, lesson planning, assessment, grading, and instruction for regular and struggling learners.

This background supports the framework's initial design and pilot leadership, but credible scale requires complementary expertise. The recommended leadership structure therefore includes a curriculum-development lead, school implementation partners, an evaluation advisor, a data-privacy contact, and teacher leaders. Independent technical review will strengthen both the mathematics and the research design.

15. Expected Contributions

The framework is designed to make five durable contributions. First, it offers underserved secondary schools a structured method for connecting diagnosis to instruction. Second, it translates evidence-based mathematics recommendations into modular routines and professional learning. Third, it introduces graph theory and computational thinking through mathematically substantive, accessible problems. Fourth, it creates a common measurement and improvement process across sites. Fifth, it develops teacher leadership so that capacity remains within participating schools.

The initiative also responds to the direction of federal STEM investment. NSF's STEM K–12 program supports fundamental, applied, and translational research that advances STEM teaching and learning. NSF's recent mathematics investments connect K–12 learning to a workforce prepared for AI, biotechnology, and quantum technologies. A well-executed multi-site framework can contribute at the point where these priorities become classroom practice: teachers, tasks, student reasoning, and evidence. [3 4 16]

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Conclusion

The United States does not need another broad declaration that mathematics matters. It needs practical, testable, and transferable approaches that help educators respond to actual learning needs while preparing students for increasingly computational forms of work and civic life. The proposed framework addresses that need by joining diagnostic instruction, evidence-based algebra practice, graph-theory applications, computational thinking, teacher development, continuous improvement, and disciplined dissemination.

Its value will depend on execution. The work must produce usable modules, secure authentic school partnerships, train cohorts of educators, measure outcomes and implementation, publish limitations, and expand only when evidence supports replication. Beginning with a multi-school Arizona pilot provides a feasible foundation. Designing from the outset

for adaptation, common measures, external review, and teacher leadership creates a credible path beyond the initial sites.

Graph theory gives the framework a distinctive intellectual core, but its larger contribution is a method: see relationships, model constraints, test solutions, explain reasoning, and improve through evidence. Those habits are central to mathematics, computational thinking, and the workforce the nation is seeking to develop. When combined with rigorous implementation and equitable access, they can help underserved schools build not only higher scores, but stronger mathematical agency and durable STEM opportunity.

About the Author

Jesus Lim Ranara is a Mathematics Education and Computational Thinking Specialist with more than three decades of experience teaching mathematics, physics, and science in the Philippines and the United States. He holds a Master of Science in Mathematics from the University of San Carlos and coauthored the 2018 research article "Identifying Code of Some Special Graphs." His professional and scholarly interests include secondary mathematics intervention, graph theory, mathematical modeling, curriculum development, and computational thinking. Through his first white paper, he proposes a scalable educational approach that connects diagnostic instruction, applied mathematics, teacher development, and real-world problem-solving to strengthen mathematical achievement and STEM readiness in underserved U.S. schools.

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