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Connecting applied sciences through local problem-based interdisciplinary teaching

Saipova Maral

Lecturer, Osh State University Osh, Kyrgyzstan

email: maral.saipova@mail.ru; **orcid**: 0009-0008-0953-5366

Abstract: This article examines how local problems can provide a rigorous organizing context for interdisciplinary teaching in applied sciences. A comparative document analysis considers five sources on integrated STEM, interdisciplinary understanding, undergraduate STEM reform, sustainability education, and community-engaged learning. The sources were coded for problem authenticity, disciplinary integration, community context, and assessment of integrated understanding. Results show broad conceptual support for authentic and contextual problems, but less explicit guidance on assessing whether students actually integrate disciplinary knowledge. On that basis, the article proposes a local-problem design matrix and a staged project cycle that connects a community question to disciplinary tools, evidence, prototypes, and public explanation. A worked example on urban heat and water use demonstrates how engineering, environmental science, data analysis, and communication can contribute without being collapsed into one undifferentiated project. The analysis is a transparent synthesis of selected documents, not a classroom intervention or evidence of learning gains. Its contribution is an assessment-oriented framework that instructors can pilot and refine against local conditions.

Keywords: interdisciplinary education; applied sciences; problem-based learning; STEM; local knowledge; assessment.

Introduction

The present article addresses a question that is central to connecting applied sciences through local problem-based interdisciplinary teaching: how can educators move from broad commitments to a defensible, observable design? The problem matters because a concept can be endorsed in policy or scholarship without specifying what a teacher, learner, or analyst should do. This paper therefore brings together a bounded set of influential sources and develops a practical analytic model. Its claim is deliberately limited: it offers a transparent synthesis and a proposition for further testing, not a causal estimate or a report of participant outcomes.

The topic is especially relevant in Uzbekistan, where educational institutions work across changing linguistic, cultural, disciplinary, and technological conditions. A model imported without adaptation may overlook local curriculum, access, institutional policy, and the knowledge communities learners bring. The analysis consequently treats local context as part of the research question. It does not assume a single learner profile or present national generalizations unsupported by data.

The paper has three objectives. First, it identifies how selected sources address the dimensions most relevant to the topic. Second, it reports an explicit cross-source coding matrix so readers can inspect the basis of the synthesis. Third, it translates the pattern into a design sequence, an implementation matrix, and a set of questions for empirical follow-up. The contribution lies in connecting theory and policy to a replicable decision process.

Three research questions guide the work: (1) which dimensions receive explicit attention in the selected source set; (2) where does the comparison reveal an operational gap or tension; and (3) what design principles can address that gap while preserving the intellectual aims of the field? These questions structure the methods and results below.

Methods and Materials

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Five sources were selected to represent complementary perspectives: the National Research Council's integrated STEM report (2014); Boix Mansilla's framework for interdisciplinary understanding (2005); the National Academies' 2025 report on undergraduate STEM education; UNESCO's Education for Sustainable Development framework (2020); and literature on community-engaged learning represented by Bringle and Hatcher (1996). Together they address disciplinary integration, authentic contexts, intended learning, and public relevance. The selection is illustrative and does not claim systematic-review coverage.

The document-analysis matrix contains four criteria. Authentic problem asks whether the source supports problems with consequential, open-ended context. Integration asks whether learners must connect disciplinary concepts rather than merely place subjects side by side. Community context asks whether local stakeholders or place-based evidence have a role. Integrative assessment asks whether criteria can reveal the quality of cross-disciplinary reasoning. A criterion was coded explicit when a source gave direct conceptual or practical support; partial when it was implied or left to design; and not explicit when the examined text did not supply it. Counts in the figure convert explicit and partial presence only for a descriptive overview; the matrix retains nuance.

Analytic framework and procedure

The unit of analysis was a source-level statement or concept relevant to one of the four dimensions listed in Table 1. Explicit, partial, and not explicit categories were used to prevent absence of a detailed procedure from being mistaken for rejection of a principle. During synthesis, the analyst compared the coded pattern with the intended educational task, noted contradictions, and drafted a design response. Counts are descriptive bookkeeping for this selected corpus. They are not inferential statistics, prevalence estimates, or evidence of effectiveness. A replication should specify exact editions, passages, coder training, and adjudication rules.

Ethical and evidentiary boundaries

No human participants, student records, classroom observations, or unpublished institutional data were collected for this article. The worked examples and proposed tools are illustrative. Citations identify the source base; interpretations and matrices are the author's synthesis. This distinction is necessary because a useful framework can be analytically original without being mislabeled as an intervention result.

Results

Comparative document-analysis results

Table 1 presents the source-level crosswalk. "Explicit" means directly addressed in the examined source; "partial" indicates conceptual relevance without a full operational procedure; "not explicit" means that the dimension was not developed in the passages reviewed. Table values are judgments under the stated codebook, not independent ratings of source quality.

Table 1. Cross-source analytic matrix

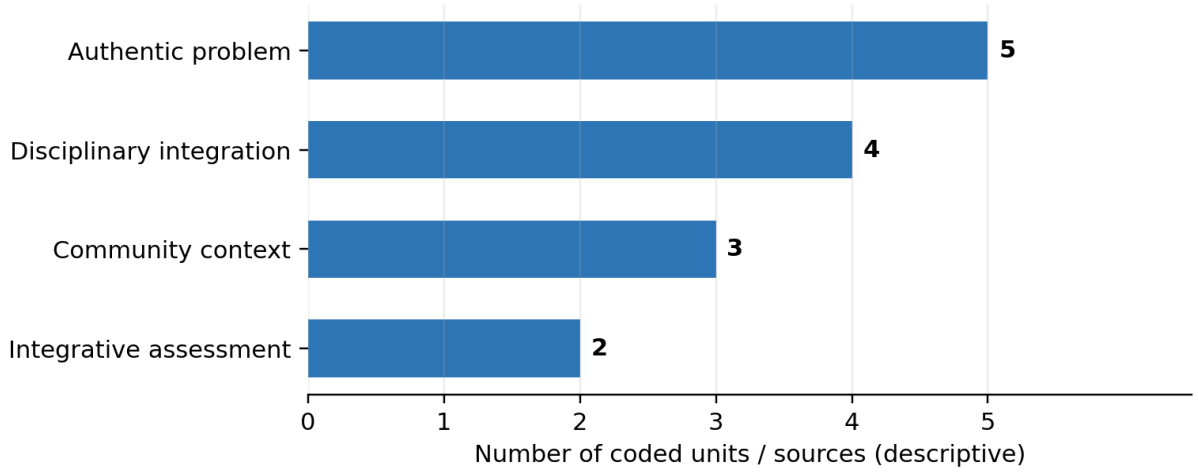
Source	Authentic problem	Disciplinary integration	Community context	Integrative assessment
NRC Integrated STEM (2014)	Explicit	Explicit	Not explicit	Partial
Boix Mansilla (2005)	Partial	Explicit	Not explicit	Explicit
NASEM STEM transformation (2025)	Explicit	Explicit	Partial	Not explicit

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Source	Authentic problem	Disciplinary integration	Community context	Integrative assessment
UNESCO ESD roadmap (2020)	Explicit	Partial	Explicit	Not explicit
Bringle & Hatcher (1996)	Explicit	Not explicit	Explicit	Not explicit

Across-source counts are authentic problem: 5 of 5; disciplinary integration: 4 of 5; community context: 3 of 5; integrative assessment: 2 of 5. The pattern identifies emphasis within the selected documents; it does not measure classroom prevalence or learner benefit.

Figure 1. Descriptive source counts by analytic dimension



Note. Counts are derived from the bounded corpus and codebook described in Materials and Methods; dimensions can co-occur.

Extended analytical implications

A local problem becomes educationally authentic when learners encounter evidence and constraints that matter to people beyond the classroom. The label "local" alone is insufficient. A project may refer to a nearby river or neighborhood while relying on generic assumptions and leaving residents without voice. Authenticity therefore involves a defensible relationship between the question, available evidence, affected groups, and the scope of student action. Instructors should ask whose problem is being framed, which data are trustworthy, and what the class can responsibly promise. These questions are part of disciplinary learning because they shape what counts as a valid solution. Integration also depends on sequencing. If students are asked to synthesize before they understand disciplinary concepts, the task can produce shallow analogies. If they work in separate subject teams until the final week, they may never reconcile incompatible assumptions. The design should alternate disciplinary depth and integrative checkpoints: introduce a shared question, teach or review the necessary tools, gather evidence in defined groups, then compare how methods complement or challenge each other. The teacher's role is to make the connection explicit without turning every subject contribution into the same method. In the urban heat example, a temperature map is not a complete account of risk. Students need to consider time of day, shade, building materials, sensor placement, and who can access cooling. Water-saving proposals may reduce irrigation but affect tree health or public use. Engineering models can estimate material performance, while community interviews can identify maintenance concerns; neither evidence type should be treated as sufficient by itself. The example shows why interdisciplinary decisions involve values as well as technical calculations, and why uncertainty should appear in the final recommendation.

A strong integrative assessment asks students to explain relationships among methods. A concept map can show that they know relevant terms, but a short written justification can reveal whether they understand why a data source changes the design decision. Individual reflection is useful because group products may conceal unequal participation. Peer assessment can help describe collaboration but should not substitute for evaluating disciplinary understanding. The rubric should reward a justified connection and identify incorrect synthesis, even if the prototype is attractive or the presentation is polished.

Partnership with a community organization should be designed with reciprocity and realistic scope. Before inviting participants, the course team should agree on time commitments, data handling, attribution, and how results will be returned. Students should not collect identifiable information without appropriate review and consent. A class may be able to produce options or a small prototype but not deliver infrastructure or public policy. Communicating those boundaries protects community trust and helps learners understand the difference between a classroom exercise and professional engineering practice.

The source analysis points to three levels of success that should be kept distinct. At the first level, students learn the disciplinary concepts and tools. At the second, they make valid connections across methods and explain limitations. At the third, they produce a useful public-facing recommendation. A project may succeed at one level and not another. For example, a team can show strong cross-disciplinary reasoning even when its proposed intervention is not adopted. Evaluations should therefore report learning outcomes separately from partner satisfaction or implementation.

Local relevance should be balanced with transfer. Students need to recognize that a method used in one place may not work under different climate, infrastructure, or governance conditions. Comparing two localities or testing one changed assumption can help students identify which findings generalize and which remain context-bound. This move strengthens applied learning because professional decisions often require adaptation rather than simple replication. It also prevents a successful class project from being misrepresented as a universal solution.

A future pilot can use a mixed evidence package: pre/post concept explanations, scored project rationales, individual reflections, artifact versions, and stakeholder feedback. Two raters can independently score a sample of work using the integrative rubric and discuss disagreements before full scoring. The evaluation should record which disciplines were taught, instructional time, student roles, partner involvement, and data limitations. Such documentation would make findings comparable across courses and help determine whether the framework is practical for different institution sizes and applied-science fields.

Discussion

The analysis supports a distinction between interdisciplinary breadth and integration quality. Breadth concerns the number of disciplines involved; quality concerns whether learners understand relationships among their concepts and methods. Adding subjects without a shared epistemic question can increase workload without improving learning. Conversely, a carefully bounded problem may require only two or three disciplines yet still demand substantial integration. Local relevance should be established through evidence and consultation, not assumed because a problem occurs nearby.

A practical rubric can assess (1) accuracy within each discipline, (2) explicit links among evidence types, (3) handling of uncertainty and conflicting priorities, (4) feasibility and ethical consequences, and (5) clarity for a non-specialist audience. Instructors can use a concept map, evidence log, prototype record, and individual reflection as complementary traces. Partnerships with local organizations require clear expectations, consent where people are studied, and safeguards against promising solutions that a class cannot deliver. The framework is suitable for pilot design, but its effects require evaluation.

Further analytical interpretation

A problem is educationally authentic when its evidence and constraints matter beyond the classroom. Calling a topic local is insufficient if residents have no voice and generic assumptions drive the solution. Authenticity requires a defensible relationship between the question, available evidence, affected groups, and scope of student action. Instructors should ask whose problem is framed, which data are trustworthy, and what the class can responsibly promise. These questions shape the epistemic and ethical quality of the project.

Integration depends on sequence. Asking learners to synthesize before they understand disciplinary concepts can produce shallow analogies; separating teams until the final week can prevent meaningful synthesis. A design should alternate disciplinary depth with integrative checkpoints: introduce a shared question, teach relevant tools, gather evidence, and compare how methods complement or challenge each other. The teacher makes connections explicit without making every disciplinary contribution use the same method.

A temperature map is not a complete account of heat risk. Students need to consider time, shade, sensor placement, building materials, and who can access cooling. Water-saving proposals can affect tree health or public use. Engineering models estimate performance while community interviews reveal maintenance concerns; neither evidence type is sufficient alone. The example shows that interdisciplinary decisions involve values as well as calculation, and that uncertainty should be visible in recommendations.

Assessment should ask learners to explain relationships among methods. A concept map may show relevant terms, while a written rationale reveals whether they understand why a data source changes a design decision. Individual reflection can expose contribution hidden by a group product. The rubric should reward justified connections and identify incorrect synthesis, even when the prototype or presentation is polished.

Partnership with a community organization requires reciprocity and realistic scope. Before inviting participants, the course team should agree on time commitments, data handling, attribution, and how findings will be returned. Students should not collect identifiable data without appropriate review and consent. A class may develop options but not deliver infrastructure or policy. Stating these boundaries protects trust and helps learners distinguish an academic project from professional practice.

Future pilots should distinguish disciplinary learning, integration quality, and public usefulness. A course may succeed at one level and not another. Evaluation could score concept explanations and project rationales separately, document partner involvement, and report stakeholder feedback as a distinct outcome. This would test whether integrative checkpoints improve student explanations, rather than relying only on satisfaction or prototype completion.

Table 3. Evidence trace supporting the coding decisions

Source or scene	Evidence anchor	Reason for interpretation	Analytic use
NRC Integrated STEM	Integration principles and research agenda	Connects disciplines around learning aims	Integration
Boix Mansilla	Interdisciplinary understanding	Supports assessment of synthesis	Assessment
NASEM 2025	Undergraduate STEM principles	Connects contexts and student learning	Higher education
UNESCO ESD	Sustainability roadmap	Supports place-based problem framing	Local context
Bringle & Hatcher	Service-learning model	Supports partnership design	Reciprocity

Reproducibility and operational codebook

To replicate the comparison, analysts should retain each source's purpose and unit of evidence. Reports, theory papers, and implementation studies do not offer equivalent evidence. The coding asks whether a concept or procedure is present, not whether a source proves that a teaching method works. A reviewer should record the relevant section, distinguish explicit from implied support, and preserve an explanatory memo when a source contributes to multiple dimensions.

A broader review could add applied-science curricula and local partner agreements from Uzbek institutions, subject to institutional access and appropriate approvals. It should analyze assessment artifacts separately from policy statements. Before scoring student work, raters need examples that distinguish a valid interdisciplinary connection from a list of subject contributions. Reliability should be reported together with how disagreements were resolved; a single numerical coefficient cannot explain why a rubric was misunderstood.

The codebook below operationalizes the source comparison and points to boundary cases. The dimensions are non-exclusive, and explicit/partial judgments are source-level. Counts indicate the presence of textual support only. They do not establish that an institution has adopted the principle, that a project is authentic, or that students learned more.

Table 4. Operational definitions and boundary cases

Dimension	Operational rule	Boundary / exclusion
Authentic problem	Source supports open-ended problems with consequential real-world constraints.	A themed exercise without evidence or decision stakes is partial.
Disciplinary integration	Source requires learners to connect concepts/methods across fields.	Several subjects listed side-by-side do not qualify.
Community context	Source includes place, stakeholders, or public relevance.	A local label without stakeholder or place evidence is partial.
Integrative assessment	Source evaluates quality of cross-disciplinary reasoning.	A product score alone does not establish integration.

Limitations and future research

The source set is purposive and combines reports with conceptual scholarship. The scoring summarizes textual emphasis and cannot rank programs or predict learning outcomes. The urban heat example is a design illustration; no temperature or cost dataset was collected for this article. Local problems vary in political sensitivity, available data, and partner capacity. Future studies should test the rubric with student work from multiple applied-science courses and report inter-rater agreement, disciplinary learning, and stakeholder feedback.

Conclusion

Local problems can connect applied sciences when students must use disciplinary tools, compare evidence, and explain trade-offs in a shared decision. The comparative analysis identifies assessment of integration as the least explicit element in the selected sources and turns that gap into a five-stage design cycle with observable checkpoints. The framework is a reasoned proposal, not evidence of improved achievement. Its value should be assessed through carefully documented course pilots in different Uzbek contexts.

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Conflict of interest

The author should confirm whether any competing interests exist before submission.

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