Qualitatively Integrating Mathematics Within STEM

Context and Rationale

Although integrated STEM education is increasingly emphasized worldwide, research consistently shows that mathematics often remains underrepresented or superficially embedded within STEM learning activities. Several reviews note that mathematics tends to be overshadowed by science and engineering, despite being foundational for authentic interdisciplinary problem-solving and conceptual understanding (Kristensen et al., 2024). Moreover, empirical studies indicate that when mathematics is included, it frequently involves tasks of low cognitive demand, highlighting the need for more intentional, rigorous integration of mathematical thinking (Forde et al., 2023).

This workshop responds to these gaps by introducing and collaboratively exploring a qualitative rubric designed to analyze and promote meaningful mathematical integration within STEM projects.

Target Group

This workshop is designed for:

- iSTEM researchers
- Pre- and in-service elementary STEM teachers
- Pre and in-service secondary STEM teachers

Workshop Objectives and Intended Outcomes

By the end of the session, participants will:

1. **Understand the role of mathematics in integrated STEM** based on existing research frameworks and current challenges.
2. **Learn to use a qualitative rubric** for identifying, characterizing, and strengthening mathematical components in STEM project designs.
3. **Apply the rubric to sample STEM projects**, reflecting on depth, authenticity, and cognitive demand of mathematical tasks.
4. **Cocreate an Inspiration List** of mathematics topics, concepts, and practices that can be meaningfully embedded within STEM learning activities for different grade levels.
5. **Develop actionable ideas** for improving mathematics integration in their own instructional or research contexts.

Instructional Strategies

The workshop is grounded in collaborative, research informed professional learning. Activities include:

- **Interactive MiniLecture** introducing key findings from recent STEM integration literature (e.g., consensus principles of integration, inquiry, design, and teamwork from Portillo Blanco et al., 2024) and concerns of mathematics integration.
- **Guided Rubric Exploration**, where participants examine the categories and indicators of a research-based, qualitative mathematics in STEM rubric.
- **Small Group Case Analysis**, applying the rubric to sample STEM units to evaluate mathematical rigor and authenticity.
- **Collaborative Brainstorming**, using structured facilitation protocols to assemble a shared Inspiration List of mathematics concepts and practices for different grade levels suitable for STEM projects.
- **Whole Group Reflection and Synthesis** to consolidate insights and identify next steps for classroom practice or research.

- ★ Although the other STEM disciplines might be foregrounding the STEM initiatives, could this workshop also relate to the other disciplines?
- ★ How does Mathematical modelling, mathematical representations like equations and graphs, translate into analysing/interpreting complex, real-world problems, or predict real-world scenarios to provide insights and inform decision-making in fields like engineering, physics, biology, and finance etc.

Programme: ***Qualitatively Integrating Mathematics Within STEM Projects(3.5h)***

Copilot proposal – still need to edit

0. Before the session — Setup for Heterogeneous Groups

Facilitator prep:

- Create intentionally mixed groups (researchers + teachers + pre-service teachers).
- Prepare three STEM units at different grade levels (primary, lower secondary, upper secondary).
- Use colorcoded materials so participants can easily find tasks aligned with their experience level, while still collaborating crosslevel.

Optional presurvey:

Helps reveal participants' backgrounds, confidence levels, and classroom experience, allowing strategic grouping.

1. Welcome & Goals (0:00–0:15 — 15 min)

Objectives:

- Build group cohesion across varied backgrounds.
- Establish norms for sharing expertise respectfully.

Activities:

- Quick "experience spectrum" activity: participants line up by teaching/research experience and then pair with someone from the opposite end.
- Overview of workshop: improve recognition, evaluation, and intentional design of mathematics within STEM contexts.

2. MiniLecture: Why Mathematics Is Often Underused in STEM (0:15–0:45 — 30 min)

Tailored to mixed audience:

- Make research accessible: avoid jargon but highlight key findings.
- Provide concrete classroom examples for teachers and conceptual insights for researchers.

Interactive element:

- Think–pair–share: "Where do *you* see math being overlooked or underused in STEM projects?"

3. Introducing the Rubric (0:45–1:15 — 30 min)

Approach for mixed audience:

- Present rubric dimensions with examples from *both* primary and secondary contexts.
- Show how researchers might use the rubric for analysis, while teachers use it for planning.

Guided practice:

- Analyze one short STEM task together; allow voices from different educational settings to comment on feasibility.

4. Application Round 1: Evaluating STEM Units (1:15–2:00 — 45 min)

Participants form mixedexperience groups and choose from three sample STEM units (primary, lower secondary, upper secondary).

Each group must include:

- At least one person familiar with the chosen grade band,
- At least one person external to it (to bring fresh perspective).

Tasks:

- Use the rubric to evaluate mathematics presence, authenticity, and cognitive demand.
- Discuss the practical constraints of the context (young learners vs abstract reasoning, etc.).

Outcome:

A rich, multi-perspective evaluation that respects classroom realities while aiming for strong integration.

— Short break (2:00–2:10 — 10 min)

5. Gallery Walk & CrossLevel Insights (2:10–2:35 — 25 min)

Why this is excellent for mixed audiences:

- Primary teachers learn from secondary contexts (e.g., modelling, data analysis).
- Secondary teachers learn from primary contexts (e.g., concrete representations, embodied learning).
- Researchers see pattern diversity across levels.

Activity:

- Groups post their evaluations.
- Participants walk around, adding stickynote comments:
    - "How this idea could be adapted for younger learners…"
    - "How this could become more mathematically rigorous…"
    - "Research suggests you could strengthen this by…"

6. Application Round 2: Redesigning the Unit (2:35–3:05 — 30 min)

Task:

Each group redesigns a portion of the unit to improve math integration.

Encourage differentiation through:

- Extensions for more advanced learners
- Scaffolding for younger learners
- Alternative representations (tables, manipulatives, simulations)
- Authentic contexts appropriate to age level

Mixedaudience strength:

- Secondary teachers help identify mathematical depth.
- Primary teachers suggest realistic pedagogy and entry points.
- Researchers contribute frameworks and theoretical grounding.

Output:

A redesigned, more mathematically robust STEM activity.

7. CoCreation: Mathematics Inspiration List (3:05–3:30 — 25 min)

Process adapted for mixed background:

Each group contributes items at three levels:

1. Early Learners (ages ~6–10)
    - patterns, simple measurement, comparing quantities, interpreting visuals
2. Middle Learners (ages ~10–14)
    - proportionality, data handling, geometric reasoning, simple modelling
3. Older Learners (ages 14+)
    - functions, optimization, statistics, computational modelling, systems thinking

Why this works well:

- Teachers map content to curriculum expectations.
- Researchers map ideas to disciplinary integration frameworks.
- Preservice teachers learn crossgrade possibilities.

All ideas collected on a shared digital board → becomes a conference takeaway resource.

8. Reflection & Closing (3:30–3:45 — 15 min)

Prompts tailored to mixed audience:

- "What is one idea you will implement in your own context?"
- "What is one insight you gained from a participant with a different background?"
- "Where do you see the rubric informing your future practice or research?"

Final action:

Participants receive a link to:

- Digital rubric
- Revised units created in the workshop
- Inspiration List
- Optional followup community for sharing STEM tasks