An Australian-Ghanaian Comparison of STEM Education Contexts: Supporting STEM Reasoning

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This paper compares STEM contexts in two Australian and Ghanaian education studies to examine how they supported children's mathematical and scientific reasoning. Analysis was guided by a sociocultural perspective and Gilbert's (2006) attributes of context. Findings show that coherent, activity-focused contexts enabled children to engage with mathematical and scientific reasoning through shared inquiry. Across both settings, context mediated participation and shaped which forms of reasoning became visible and available for pedagogical response. This research highlights the importance of selecting meaningful STEM contexts that foreground explanation and justification.

STEM education can be siloed, integrated and multidisciplinary, and transdisciplinary. In a siloed approach for example, a teacher in a primary science lesson may rely upon their students' knowledge of mathematical concepts to measure temperature. In an early childhood setting, teachers may present a multidisciplinary approach through scientific exploration of crab colonies while making counting experiences explicit to support students to count crabs hiding on a leaf (English, 2025). Informed by a transdisciplinary approach, students may explore area as a measurement concept to better understand how plants generate sugars through the scientific process of photosynthesis (Fry & English, 2023). In each of these examples, choice of context is significant and frames the STEM teaching and learning experience. This paper explores STEM education contexts framing research in Australia and Ghana, to capture a comparative view of possibilities for promoting scientific and mathematical reasoning in early years settings (ages 4-8) and middle-years primary classrooms (ages 8-10).

Introduction

Selecting suitable contexts for STEM learning presents a persistent challenge for teachers as they plan meaningful mathematics and science classroom experiences. In Australia, STEM education has been criticised for frequently neglecting real-world contexts (ACARA, 2025). A large-scale study by Jones et al. (2025), examining STEM learning contexts across 47 Australian schools found that where the dominant vision of STEM was to promote general familiarity with the discipline, over half of the reported teaching–learning experiences relied on coding and robotics or were largely devoid of meaningful context. The authors called for a shift towards contexts that incorporate localised action and socially oriented or activist dimensions of STEM learning. Jones and colleagues (2025) further argued that engagement with authentic and sometimes controversial issues, such as climate change, may help address declining enrolments in STEM-related subjects. While the Australian Curriculum authority acknowledges the importance of purposeful connections across learning areas, it cautions that forced or superficial integration can diminish learning impact (ACARA, 2025). Consequently, careful attention is required when selecting STEM contexts to ensure that they authentically ground learning experiences and support students' engagement with disciplinary ideas involving mathematics and science.

In Ghana, attention to context is explicitly articulated at the level of curriculum policy through the Standards-Based Curriculum (SBC), which positions kindergarten and lower

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primary learning as inquiry-oriented, learner-centred, and grounded in children's everyday experiences (National Council for Curriculum and Assessment [NaCCA], 2019). The SBC encourages teachers to draw on familiar home, school, and community contexts to support conceptual understanding, problem-solving, and reasoning across subject areas, including mathematics and science. This orientation reflects a deliberate shift away from transmission-focused pedagogies towards constructivist and sociocultural approaches that conceptualise learning as socially mediated through interaction, language, and culturally situated activity. Drawing on Bourdieuian perspectives, Agbenyega (2018) further argued that transformational early childhood pedagogy in Ghana requires learning experiences embedded within children's social worlds and attentive to cultural capital, habitus, and power relations.

Despite these policy aspirations, research across both countries highlights challenges in teachers' capacities to enact integrated and transdisciplinary, context-rich STEM learning. In Australia, limited professional preparation in integrated STEM has contributed to teachers' lack of confidence in designing and implementing authentic STEM experiences (Ku et al., 2025). Ku and colleagues (2025) identified context as a critical stage within an integrated STEM instructional model, emphasising authentic, problem-based, and student-centred contexts grounded in learners' lived experiences. Parallel concerns are well documented in Ghanaian early childhood and basic education research. Empirical studies show that many kindergarten and early grade teachers feel insufficiently prepared to design and implement integrated, context-rich learning experiences, citing limited pre-service training and inadequate continuous professional development aligned with the Standards-Based Curriculum reforms (Agbosu, 2022; Ntumi et al., 2023). Ghanaian studies consistently report gaps between curriculum intentions and classroom enactment. Although learner-centred and inquiry-based pedagogies are emphasised in policy, classroom practices are often constrained by teacher preparedness, instructional routines, and limited professional learning opportunities (Agbosu, 2022; Cobbold, 2017; Ntumi et al., 2023; Sofo et al., 2019).

Against this backdrop, we examined how STEM context choices supported young children in sharing their mathematical and scientific reasoning in Australian and Ghanaian classrooms. We saw the role of context in STEM educational experiences as an entry point into better understanding how young children can be supported to reason, with the view that context frames the educational experience. In the research presented below, STEM contexts are conceptualised as transdisciplinary and integrated learning settings in early to middle primary years classrooms in which mathematical reasoning (e.g., measurement, comparison, statistics), scientific reasoning (e.g., observation, prediction), and engineering reasoning (e.g., design, testing) are simultaneously elicited. Adopting a sociocultural perspective that foregrounds context as a mediator of learning opportunities, this paper explores how two STEM education experiences were framed in both countries to support reasoning. By analysing how contexts are represented and mobilised across the two settings, the study seeks to identify focal characteristics of STEM contexts that can inform teachers' planning, noticing, and pedagogical responses to children's emerging STEM ideas, thereby contributing to comparative and classroom-based STEM education research.

Context

Context is defined in this study as an event or setting that weaves together and gives meaning to words, actions, and concepts, providing a frame for teaching and learning. In classroom practice, teachers commonly use context to support meaningful exploration, guide discourse, and shape representations, positioning context as a potential leverage point for reasoning. Early work by Sullivan, Zevenbergen, and Mousley (2002) highlighted the importance of relevant and realistic contexts in mathematics education, while also cautioning that context selection is complex. They argued that teachers must consider mathematical suitability, relevance to learners, motivational impact, and the risk of exclusion when choosing problem-solving contexts.

In Ghanaian early years classrooms, STEM education contexts that foreground mathematics and science are typically drawn from children's everyday social and cultural experiences, including market activities, household routines, environmental exploration, and the use of locally available materials (Agbenyega, 2018). Such contexts provide opportunities for children to engage in counting, measuring, comparing quantities, observing change, and explaining outcomes, supporting the integration of mathematical and scientific reasoning within shared activity (Fleer, 2019). Within the Ghanaian Kindergarten Curriculum, learning is organised around integrated thematic strands rather than discrete STEM subjects (NaCCA, 2019). However, research indicates that the educational potential of context depends on how it is pedagogically mobilised; when contexts are used merely to organise activity rather than to support sustained inquiry and dialogue, opportunities for deeper reasoning may be limited (Cobbold, 2017; Ntumi et al., 2023; Sofo et al., 2019).

Conceptual bridge via Gilbert's (2006) attributes of context

Building on Gilbert's (2006) conceptualisation of context as a focal event that gives coherence and meaning to learning, four attributes of context were adapted in this study to support analysis of STEM education contexts. Rather than serving as a passive backdrop, context is positioned as an active mediator of participation, meaning-making, and disciplinary sense-making within STEM learning experiences (Gilbert, 2006). Collectively, these attributes provide a lens for examining how mathematical and scientific reasoning is enabled, constrained, and made visible through classroom activity. Significantly, Gilbert (2006) frames the four attributes of a context by relevance (for students) and supporting meaning-making. We have adapted to add a specific STEM emphasis. The first attribute (a), the value of the setting as a social, spatial, and temporal framework, highlights how contexts organise participation and shape which ideas are taken up during STEM tasks. The context becomes the setting for a community of practice that values student participation. Socioculturally, these settings shape interaction patterns and the social distribution of knowledge, influencing learners' opportunities to reason and what teachers can notice during instruction (Mousley, 2003; Robbins, 2005). The second attribute (b) refers to the behavioural environment of the activities that take place, emphasising the kinds of tasks or encounters that would take place and framing the talk that students need to use. The third attribute (attribute c), the promotion of mathematical and scientific language and reasoning, aligns directly with the focus of this paper. Contexts that foreground reasoning as a shared classroom practice support the articulation of relationships, testing of ideas, and interpretation of evidence, shaping how reasoning becomes visible through talk, representation, and action (Mousley, 2003). Tasks requiring explanation, justification, comparison, or interpretation create opportunities for reasoning to emerge and moments for teachers to notice learner's thinking and respond instructionally (Gilbert, 2006; Sullivan et al., 2002). The fourth attribute (d) highlights how contexts build on learners' existing experiences as resources for sense-making. When contexts resonate with learners' lived experiences, they support richer explanation and justification, while providing teachers with entry points for noticing emerging reasoning and scaffolding movement toward more disciplinary forms of understanding (Gilbert, 2006; Robbins, 2005).

Theoretical background

Using a sociocultural perspective, a comparative lens offers the chance to examine the researchers' selections of STEM contexts to frame their work in Australia and Ghana, to generate characteristics of STEM contexts that could shape children's mathematical and scientific sense-making, as well as to consider pre-emptively how STEM contexts may support teachers to notice and respond to children's emerging STEM ideas. Through a sociocultural perspective, the social and the person are inextricably interwoven, and we argue, the context contributes and shapes the social distribution of knowledge. Social activity seemed to have the strongest bearing on what mathematical ideas were made available to children in Mousley's (2003) study grounded in Situated Cognition. With a knowledge focus, Mousley (2003) discussed the important role of the social in raising mathematical concepts to a level of consciousness. Resnick and Stieff (2024) examined the theoretical roles of cognition and context in mathematics education research, arguing that these roles are intertwined by positioning context as a mediator of cognition—even in the learning of abstract mathematics. They note that qualitative studies must provide rich description in order to identify "the kinds of relevant contexts which exist and why they are functionally meaningful" (Resnick & Stieff, 2024, p.282). Similarly, we consider the selection of STEM contexts important for framing social activity and mediating discussion, and for emphasising the teaching and learning of scientific and mathematical knowledge.

Research Design

The research question guiding this exploratory study is: *how are young children's STEM education experiences framed in Australia and Ghana to support scientific and mathematical reasoning?* This research explores Australian and Ghanaian early- and middle-years STEM education contexts within the researchers' bodies of work (science- and mathematics-focused). Selected cases were relevant to addressing the research question. Both studies were conducted in classrooms, generating rich and diverse data including video recordings and detailed field notes. Qualitative meta-analysis (Ulloa & Schwerer, 2024) supported a cross-study interpretation of these data and research experiences, and existing research, to generate new findings focused specifically on the contexts framing each study. We conducted a deductive, framework-guided analysis, using the attributes of Gilbert's (2006) framework as coding categories in one study by each of the first two authors. Braun and colleagues (2018) refer to such an approach as *codebook Thematic Analysis*. Findings can support teachers in planning, noticing, and scaffolding both mathematical and scientific reasoning simultaneously, supporting teachers to respond to children's emerging STEM ideas during inquiry-based tasks.

Results

Australia: Context-Mediated Mathematical Reasoning in Agricultural Science Activity

Fry's (2025) study examined STEM exploration in a Year 4 Australian classroom using a sociocultural approach, focusing on how shared mathematical practices emerged within a scientific context of plant growth (Table 1, column 2). The classroom activity centred on data collection and interpretation, with students engaging with mathematical ideas embedded in a YouTube clip depicting the growth (time lapse) of a capsicum plant (see Fry, 2025). Students were challenged to graph plant growth, requiring them to encode and represent multivariate features of growth.

The shared scientific context structured collective engagement and supported the coordinated use of cultural tools, including language, representations, and classroom routines. The teacher framed the task around the meaningful challenge of representing plant growth in agricultural science, which supported sustained engagement and sense-making in science (attribute a). Students' activity mirrored practices used by agricultural scientists and data scientists, as they made decisions about which growth features to attend to and how to represent them graphically (attribute b). The context supported the use of both mathematical and scientific language, with students relationally describing plant height, growth patterns, leaves, and life-cycle stages, while also attending to statistical graphing conventions such as axes, scaling, and appropriate conventions for displaying statistical information (attribute c). Without explicit instruction, students produced graphs on A3 paper and incorporated visual features inspired by infographics to encode salient aspects of plant growth. Extra-situational background knowledge was drawn from concurrent science studies on plant life cycles and energy transfer within food chains, situating the activity within broader understandings of agricultural science (attribute d).

Ghana: Context-Mediated Mathematical Reasoning in Engineering Construction Activity

Amo-Darko's (2025) study examined STEM activity in early and primary years classrooms in Ghana through a sociocultural lens, focusing on how children's mathematical reasoning emerged within engineering construction contexts (Table 1, column 3). Classroom activities centred on constructing houses, household items (e.g. tables and chairs), and wheeled artefacts using manipulatives. Through these activities, children engaged with mathematical ideas embedded in the selection, arrangement, and testing of materials.

Engineering construction tasks functioned as shared, time-bound classroom events that elicited mathematical reasoning (attribute a). While building and material use were familiar to children through everyday experiences, the classroom focus was on designing stable structures and objects capable of movement, providing a purposeful setting for exploring mathematical ideas. Children's engagement mirrored engineering design practices, requiring them to construct, measure, compare, and test structures as they worked toward design goals (attribute b). Decisions about the number of blocks, placement of wheels, and relative size and length of components supported sustained reasoning related to quantity, measurement, comparison, and spatial arrangement. The construction context also supported the use of specific mathematical and scientific language during interaction, with children using mathematical language related to quantity, measurement, and spatial relations (e.g., more, less, longer, same size, next to), alongside scientific language used to explain stability, movement, and cause-and-effect relationships (e.g., balance, fall, move, stay up) (attribute c). Teachers' prompts drew attention to these forms of reasoning as constructions were tested and revised. Children's reasoning was further supported by connections to extra-situational background knowledge drawn from everyday experiences with building, balance, and movement (attribute d). Teacher interviews indicated that these familiar experiences were intentionally leveraged to support learning. In this way, engineering construction functioned as a STEM education context that mediated mathematical reasoning, with science providing explanatory meaning and engineering activity structuring opportunities for engagement.

Table 1 summarises the key attributes of the STEM education contexts identified in the Australian and Ghanaian studies, drawing on Gilbert's (2006) framework to highlight how context mediated mathematical and scientific reasoning across both settings.

Table 1

Attributes of STEM education contexts used in the researchers' studies in Australia and Ghana

Attributes of context (Gilbert, 2006), framed by relevance and meaning-making	**Australian Study (Author, 2025)**	**Ghanaian Study (Author, 2025)**
a) Value of the setting as a social, spatial, and temporal framework	YouTube clip depicting plant growth	Classroom engineering construction tasks using manipulatives as shared, time-bound building and testing events
b) Behavioural environment of the activity	Mirroring the work of agricultural scientists and data scientists in agriculture	Mirroring engineering design practices through constructing, measuring, comparing, and testing
c) Use of specific language (supporting mathematical and scientific reasoning)	Encoding multivariate features depicting plant growth	Mathematical language of quantity, measurement, comparison, and spatial

		relations, with scientific language of stability and motion
d) Relationship to extra-situational background knowledge	Life and living studies in science, life stages of a plant	Everyday experiences with building, balance, and movement support informal measurement and engineering concepts

Cross-Context Patterns in Reasoning and Noticing

Across the Australian and Ghanaian studies, the findings highlight how STEM contexts functioned as mediating structures that shaped the visibility of both mathematical and scientific reasoning within classroom activity. In both settings, student reasoning emerged through participation in coherent, activity-focused contexts; in data representation within a scientific inquiry in Australia; and in engineering construction activity in Ghana, rather than as isolated individual responses. These contexts enabled learners to engage with mathematical ideas (e.g., representation, measurement, comparison) and scientific ideas (e.g., growth, stability, cause–and–effect) through shared interaction, representation, and talk, replicating professional STEM professions in an informal manner. In both cases, the STEM context influenced which forms of mathematical and scientific reasoning became observable and available for pedagogical response. Context supported shared engagement, and clear purposes enabled teachers (and the researchers) to more readily notice, interpret, and extend learners' reasoning (Amo-Darko, 2025; Fry, 2025).

Discussion

Context, Task Framing, and the Social Organisation of Reasoning

This study examined how STEM education contexts, in the researchers' own studies, mediated mathematical and scientific reasoning in Australian and Ghanaian classrooms, drawing on a sociocultural perspective to interpret how participation, interaction, and pedagogical action were organised within activity. We draw on Resnick and Stieff's (2024) work to substantiate our finding that the contexts framing the STEM research across both nations, curricula, and learning settings, functioned to support mathematics learning. Across both studies, the findings show that context functioned not merely as a backdrop for learning, but as a mediating structure that shaped which forms of reasoning became visible, attainable, and pedagogically supportable.

The STEM contexts organised the social conditions in each classroom, shaping patterns of interaction and access to disciplinary practices. In the Australian study, the scientific focus on plant growth provided a coherent frame for collective engagement, enabling students to appropriate mathematical practices related to data representation through dialogue, representation, and negotiated meaning. Similarly, in the Ghanaian study, engineering construction activities structured classroom interaction around shared material activity, with reasoning related to measurement, comparison, stability, and movement emerging through talk, gesture, and action. Across both cases, context functioned as a mediating structure that shaped participation and made reasoning available for pedagogical response, consistent with sociocultural perspectives on learning (Mousley, 2003). Contexts supported clear purposes, sustained interaction, and appropriate cultural tools enabled reasoning to emerge through talk, action, and representation rather than through isolated task completion. The findings suggest that, despite differences in curricular structures and classroom conditions, principles related to context coherence, interactional organisation, and the integration of mathematics and science within STEM activity were relevant across diverse early years and primary middle-years settings.

Task framing further influenced the visibility of reasoning. When activities were framed as shared inquiry tasks requiring interpretation, justification, or testing of ideas, mathematical and scientific reasoning became observable through collective interaction and representation. In contrast, procedurally framed or time-constrained tasks can limit learners' opportunities to articulate and extend their thinking. These findings suggest that meaningful reasoning depends on the alignment of context and task design rather than context alone (Gilbert, 2006; Sullivan et al., 2002).

In the Australian study, Fry (2025) demonstrated that mathematical reasoning related to data representation emerged through collective engagement in a scientifically framed inquiry on plant growth. The use of a time-lapse video as a shared artefact structured students' attention to multivariate features of growth and supported the coordinated use of mathematical and scientific language. Through graphing and discussion, students appropriated statistical conventions and life science concepts via interaction, representation, and negotiated meaning, illustrating how a coherent scientific context organised shared participation and supported the social construction of mathematical reasoning.

Similarly, in the Ghanaian context, Amo-Darko (2025) showed that engineering construction activities functioned as focal STEM contexts through which children's mathematical reasoning became visible as children interacted with shared materials during construction. Mathematical ideas related to quantity, measurement, comparison, and spatial arrangement were enacted as children selected materials, tested constructions, and revised designs, while scientific reasoning supported explanations of stability, movement, and cause–and–effect. As in the Australian study, reasoning was mediated through socially organised activity, with context shaping opportunities for noticing, discussion, and pedagogical response.

The findings highlight the importance of positioning context as a core pedagogical resource in early years and middle-primary years STEM education rather than as a motivational add-on. Teachers should be supported in selecting socially meaningful contexts and in framing tasks that foreground explanation, comparison, prediction, and justification, thereby increasing the visibility of children's mathematical and scientific reasoning. These findings suggest that strengthening teachers' capacity to design and adapt STEM contexts that foreground reasoning may be a productive pathway for supporting noticing and responsive pedagogy in early years and primary years STEM classrooms. The findings also demonstrate the value of examining STEM contexts as units of analysis. Future research could investigate how attributes of context interact with task framing and teacher noticing over time, particularly through classroom-based and video-supported methodologies. Comparative studies across diverse settings would further clarify which principles of context-based STEM learning are transferable and which require local adaptation.

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