



## Contextual Relevance of Pre-Tertiary Mathematics Self-Assessment Tasks in Ghanaian TVET: Evidence from the Building Construction Technology Programme

Akwasi Sakyi Denteh<sup>1</sup>, Francis Kwadwo Awuah<sup>2</sup>

<sup>1&2</sup>Kwame Nkrumah University of Science and Technology, Ghana

ORCID: Denteh 0009-0006-1380-5459; Awuah 0000-0001-6201-7703

Corresponding Author: [asdenteh@st.knust.edu.gh](mailto:asdenteh@st.knust.edu.gh)

### Abstract

Mathematics contextualisation is central to competency-based Technical and Vocational Education and Training (TVET), yet limited evidence exists on the contextual profile of Ghana's official NC II mathematics materials. This study examined 202 self-assessment tasks across the six units of the National Certificate II Mathematics Facilitating and Learning Materials (FLMs), with reference to Building Construction Technology (BCT). Quantitative content analysis used the contextual section of an adapted Skovsmose coding sheet validated by two TVET mathematics experts. A second coder independently classified a stratified sample of 40 tasks, producing substantial inter-rater agreement (Cohen's kappa = 0.78). Overall, 178 tasks (88.1%) were pure mathematics, 8 (4.0%) Semi-reality and 16 (7.9%) Real-life (Trade-specific, BCT). Contextual framing occurred in three units, while trade-specific tasks appeared only in PGC and MTR. Through Situated Learning Theory, this pattern indicates limited and uneven opportunities for learners to connect school mathematics with construction practice. The study recommends a unit-by-unit contextual redesign of FLM self-assessment tasks, guided by BCT Occupational Standards, together with facilitator development to support responsible adaptation.

**Keywords:** Building Construction Technology; competency-based TVET; contextualisation; mathematics tasks; situated learning

### Introduction

Mathematics in competency-based TVET is expected to serve vocational practice. At Ghana's National Certificate II (NC II) level, learners should be able to undertake complex and non-routine work with limited supervision (Commission for Technical and Vocational Education and Training [CTVET], 2023b). In Building Construction Technology (BCT), this work involves measurement, geometric layout, estimation, and calculations of lengths, areas and volumes. Foundational workplace studies documented these demands (Bessot, 2000; Eberhard, 2000), while recent TVET research continues to emphasise the need to connect mathematics to occupational practice (Acheampong & Awuah, 2025a; Adelabu & Pharamela, 2024). Such calculations inform material quantities, construction accuracy and, at times, safety (Hedidor & Bondinuba, 2017).

The NC II Mathematics Facilitating and Learning Materials (FLMs) are official resources through which these expectations are translated into routine learning and

self-assessment tasks (CTVET, 2023c). Curriculum materials do more than list content; they shape the problems learners are asked to notice and solve (Rezat et al., 2021). Where a construction context is integral to a task, learners can practise recognising mathematics within trade activity. Where tasks remain abstract, procedural fluency may develop without a clear sense of when the same mathematics is useful at a worksite (Acheampong & Awuah, 2025a).

This study was prompted by the limited trade-specific framing reported in vocational mathematics research and by the absence of a task-level account of Ghana's official NC II Mathematics FLMs for BCT. The study had two objectives. The first was to classify the overall contextual characteristics of the self-assessment tasks using the three reference contexts adapted from Skovsmose's framework, with specific reference to BCT. The second was to examine how these contextual characteristics were distributed across the six FLM units. Correspondingly, the study asked two

research questions. Research Question 1 examined the overall contextual characteristics of the self-assessment tasks, while Research Question 2 examined how these contextual characteristics were distributed across the six units.

### **Literature Review and Analytical Framework** **Empirical evidence on contextualisation in** **mathematics assessment**

Empirical studies across general and vocational mathematics point to a recurring separation between school tasks and the contexts in which mathematics is used. In Ghana, Dogbey and Dogbey (2018) reported that about 70% of WASSCE Core Mathematics items were framed within abstract contexts. Rejeki et al. (2021) similarly found that relevant and essential contexts appeared in only 10% of Grade 10 and 30% of Grade 11 vocational mathematics textbook tasks in Indonesia. Within Ghanaian TVET, Acheampong and Awuah (2025b) found that only 11.27% of application problems in welding and fabrication exercise books were connected to the trade. Related studies also show difficulty in recognising mathematics within vocational activity (Acheampong & Awuah, 2025a; Christidis et al., 2024). Although these studies differ in setting and source, together they indicate limited contextual alignment across examinations, textbooks, exercise books and workplace learning. However, limited studies have examined the unit-by-unit contextual profile of Ghana's official NC II Mathematics FLMs for BCT.

### **Situated Learning Theory and the contextual coding** **lens**

The basic tenet of Situated Learning Theory (SLT) is that knowledge is inseparable from the social and material setting in which it is developed and used (Lave & Wenger, 1991). Thus, learners build competence through participation in authentic practice. In BCT, tools, procedures and standards give mathematical ideas vocational meaning. SLT therefore provides a basis for asking whether written mathematics tasks position learners to connect procedures with construction activity. In this study, the theory is used to interpret opportunities represented by the tasks, not to infer learner achievement or classroom behaviour.

Skovsmose's (2001) framework combines two forms of classroom activity with three types of contextual reference: Pure mathematics, Semi-reality and Real-life situations. This study adapted only the contextual-reference dimension. Pure mathematics tasks contain no situation outside mathematics; Semi-reality tasks use generic, hypothetical or contrived settings; and Real-life tasks draw on situations relevant to practice. For the present study, the final category was operationalised as Real-life (Trade-specific, BCT). The analysis therefore concerns contextual reference rather than the full set of Skovsmose's six learning milieus.

## **Methodology**

### **Research design, corpus and analytical sample**

Quantitative content analysis is a systematic and replicable approach for coding documentary material into predefined categories and summarising the resulting patterns numerically (Krippendorff, 2018). This analysis of a single was adopted because the study sought to classify a complete corpus of written self-assessment tasks and compare contextual distributions across units. The corpus comprised the official NC II Mathematics FLM organised into Plane Geometry and Construction (PGC), Mensuration and Trigonometry (MTR), Surds, Indices and Logarithms (SIL), Statistics and Probability (STP), Series and Sequence (SAS), and Matrices and Calculus (MAC). The analytical sample comprised all 202 eligible self-assessment tasks: PGC (21), MTR (39), SIL (33), STP (52), SAS (20) and MAC (37). The study used a census of all eligible tasks rather than sampling the units because every eligible task across the six FLM units was included. A whole question was treated as one task; a subpart was counted separately when it required a distinct response. Worked examples were excluded, and each task received a unique identifier for traceability.

### **Data collection instrument and coding procedure**

The Content Analysis Coding Sheet served as the instrument for data collection and task classification. Adapted from Skovsmose's reference contexts, the instrument contained operational definitions, decision cues, consistency rules and task examples for the three categories. Tasks stated entirely in mathematical terms were coded Pure mathematics. Generic everyday, school-based or hypothetical situations without a specific BCT connection were coded Semi-reality. A task was coded Real-life (Trade-specific, BCT) when its wording, diagram or required procedure was directly linked to construction practice and the context informed what had to be calculated. The BCT Occupational Standards (CTVET, 2023a) were used as a supporting document to verify trade-specific terminology and functional relevance in borderline cases.

### **Validity, reliability and data analysis**

Two TVET mathematics experts with doctoral qualifications independently validated the instrument for clarity, relevance and contextual appropriateness. Their feedback led to a clearer boundary between Semi-reality and Real-life tasks. After revision, a second coder independently coded a stratified sample of 40 tasks, approximately 20% of the corpus: PGC 4, MTR 8, SIL 7, STP 10, SAS 4 and MAC 7. Cohen's kappa was calculated before consensus discussion and yielded 0.78, indicating substantial agreement (Cohen, 1960; Landis & Koch, 1977). Disagreements were then resolved using the operational rules. Microsoft Excel was used to organise the task-level classifications and calculate frequencies and

percentages for the complete corpus, both overall and by unit. No inferential analysis was required because the full eligible corpus was analysed.

## Results

### Overall contextual characteristics (RQ1)

Across the 202 self-assessment tasks, 178 (88.1%) were classified as Pure mathematics, 8 (4.0%) as Semi-reality and 16 (7.9%) as Real-life (Trade-specific, BCT). Thus, 24 tasks (11.9%) contained any contextual framing, of which 16 were trade-specific. Table 1 presents the distribution by unit.

**Table 1**

*Contextual Distribution of Self-Assessment Tasks by Unit (N = 202)*

| Unit         | N          | Pure mathematics, n (%) | Semi-reality, n (%) | Real-life BCT, n (%) |
|--------------|------------|-------------------------|---------------------|----------------------|
| PGC          | 21         | 11 (52.4)               | 0 (0.0)             | 10 (47.6)            |
| MTR          | 39         | 29 (74.4)               | 4 (10.3)            | 6 (15.4)             |
| SIL          | 33         | 33 (100.0)              | 0 (0.0)             | 0 (0.0)              |
| STP          | 52         | 48 (92.3)               | 4 (7.7)             | 0 (0.0)              |
| SAS          | 20         | 20 (100.0)              | 0 (0.0)             | 0 (0.0)              |
| MAC          | 37         | 37 (100.0)              | 0 (0.0)             | 0 (0.0)              |
| <b>Total</b> | <b>202</b> | <b>178 (88.1)</b>       | <b>8 (4.0)</b>      | <b>16 (7.9)</b>      |

Note. Percentages are calculated within each unit; totals are calculated across all 202 tasks.

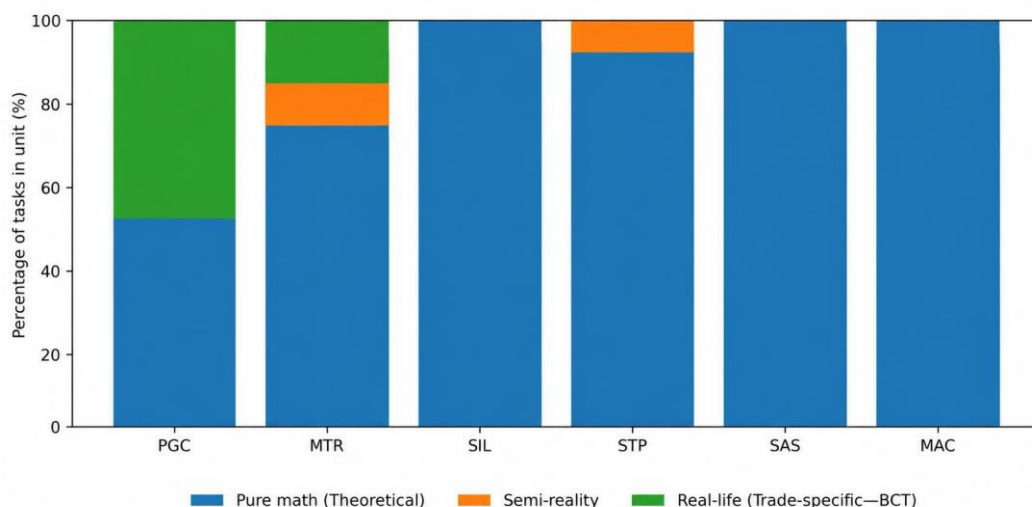
### Contextual characteristics across units (RQ2)

Contextual framing appeared in PGC, MTR and STP, but trade-specific BCT tasks appeared only in PGC and MTR. PGC contained 10 Real-life tasks (47.6%). MTR contained 6 Real-life tasks (15.4%) and 4 Semi-reality tasks

(10.3%). STP contributed 4 Semi-reality tasks (7.7%) but no trade-specific task, while SIL, SAS and MAC were entirely Pure mathematics. Figure 1 provides a visual comparison of the within-unit distributions.

**Figure 1**

*Contextual Distribution of Self-Assessment Tasks Across the Six NC II Mathematics FLM Units*



Note. Figure 1 shows a stacked bar chart of contextual categories by unit to make unit-level differences easier to compare visually.

## Discussion

### Dominance of abstract contextual framing

The predominance of Pure mathematics indicates that NC II self-assessment positions BCT learners mainly to practise mathematical procedures apart from the situations in which those procedures acquire occupational meaning. From an SLT perspective, this matters because participation in authentic activity helps learners recognise what knowledge is for and when it is useful (Lave & Wenger, 1991). The present pattern converges with the literature reviewed. Dogbey and Dogbey (2018) found a strong abstract orientation in Ghanaian school mathematics assessment. Similarly, Rejeki et al. (2021) reported limited essential contexts in vocational textbooks while Acheampong and Awuah (2025b) found little trade-specific framing in welding and fabrication exercise books. The current study extends this evidence to Ghana's official NC II Mathematics FLMS. The study also helps explain why vocational learners may experience a gap between school mathematics and mathematics-in-use, as reported by Acheampong and Awuah (2025a) and Christidis et al. (2024). The document analysis, however, cannot establish what learners ultimately transfer.

### Uneven distribution and implications for BCT

The unit-level pattern suggests that contextualisation is treated as topic-dependent rather than as a programme-wide design principle. Geometry and mensuration are readily connected with visible construction situations, but the absence of trade-specific framing in other units is not an inherent mathematical limitation. Vocational modelling research shows that occupational activities can support meaningful mathematical use across different content areas (Frejd, 2025). According to Legesse et al. (2020), mathematical discourse-based instruction in probability and statistics can strengthen both procedural and conceptual understanding. In BCT, for example, statistics could examine variation in material measurements, sequences could model work schedules, and matrices could organise quantities from estimates or construction drawings. The implication is that unit-specific task-writing choices, rather than the mathematics itself, may account for much of the unevenness.

The distinction between Semi-reality and trade-specific context is also important. A task can contain a familiar story without requiring the learner to reason through a construction condition. In that case, the context is present but does little vocational work. This finding supports Skovsmose's distinction between forms of contextual reference and reinforces the competency-based expectation that the situation should shape what is interpreted, calculated or verified. At the same time, the findings describe the written curriculum rather than classroom enactment. Facilitators may adapt, replace or discuss tasks as they work with curriculum resources

(Remillard, 2005; Rezat et al., 2021). The limitation identified here is therefore a design-level issue in the documented task set, not evidence of facilitator failure or weak learner performance.

## Conclusion

The study concludes that the contextual profile of the NC II Mathematics FLM self-assessment tasks is heavily abstract and only partially aligned with BCT practice. Trade-specific tasks are few and unevenly distributed, so opportunities to encounter mathematics as part of construction activity depend strongly on the unit being studied. The substantial inter-rater agreement supports confidence in the classification, but the conclusion remains limited to the written tasks and should not be extended to classroom enactment or learner competence without further evidence.

## Recommendations

In relation to the first objective, CTVET and FLM developers could consider increasing the proportion of tasks in which BCT context genuinely determines what learners must interpret, calculate or verify. The BCT Occupational Standards can support authenticity checks, while facilitator development can help teachers adapt remaining abstract exercises without reducing their mathematical intent.

In relation to the second objective, revision could proceed unit by unit, with particular attention to SIL, STP, SAS and MAC, where trade-specific tasks were absent. Contextual alignment may also be included as an explicit FLM quality-assurance criterion. Further research should examine how facilitators enact these tasks and whether stronger contextualisation improves learners' recognition and transfer of mathematics in BCT practice.

## Declarations

**Ethics:** The study analysed documents and did not involve human participants.

**Data availability:** The coding data and full coding guide are available from the corresponding author on reasonable request.

**Conflict of interest:** The authors declare no conflict of interest.

## References

- Acheampong, P. A., & Awuah, F. K. (2025a). Application of mathematics concepts in welding and fabrication among high school graduates in Ghana. *African Journal of Science, Technology and Mathematics Education*, 11(1), 178-182. [https://www.ajstme.com.ng/admin/img/paper/AJSTME11\\_1\\_041.pdf](https://www.ajstme.com.ng/admin/img/paper/AJSTME11_1_041.pdf)
- Acheampong, P. A., & Awuah, F. K. (2025b). Examining the real-life application problems in welding and fabrication students' mathematics exercise books.



- East African Journal of Arts and Social Sciences*, 8(1), 247-256. <https://doi.org/10.37284/eajass.8.1.2730>
- Adelabu, F. M., & Pharamela, S. (2024). Teaching relevant mathematics topics to prepare Technical and Vocational Education Training college students for workforce: Lecturers' perspective. In X. Liu (Ed.), *Innovation and evolution in higher education*. IntechOpen. <https://doi.org/10.5772/intechopen.1005459>
- Bessot, A. (2000). Geometry at work. In A. Bessot & J. Ridgway (Eds.), *Education for mathematics in the workplace* (pp. 137-149). Springer. [https://doi.org/10.1007/0-306-47226-0\\_13](https://doi.org/10.1007/0-306-47226-0_13)
- Billett, S. (2001). Knowing in practice: Re-conceptualising vocational expertise. *Learning and Instruction*, 11(6), 431-452. [https://doi.org/10.1016/S0959-4752\(00\)00040-2](https://doi.org/10.1016/S0959-4752(00)00040-2)
- Christidis, M., Hemingstam, A., & Lindberg, V. (2024). Mathematics as an aspect of vocational knowing in animal caregiving, from a student perspective. *Learning, Culture and Social Interaction*, 45, 100804. <https://doi.org/10.1016/j.lcsi.2024.100804>
- Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1), 37-46. <https://doi.org/10.1177/001316446002000104>
- Commission for Technical and Vocational Education and Training. (2023a). *Building construction technology occupational standards* [Occupational standards].
- Commission for Technical and Vocational Education and Training. (2023b). *National TVET qualifications framework implementation guide*. <https://ctvet.gov.gh/qualifications-framework/>
- Commission for Technical and Vocational Education and Training. (2023c). *NC II mathematics facilitating and learning materials*.
- Dogbey, J., & Dogbey, J. (2018). Depth of knowledge and context characteristics of the West African Examination Council's Core Mathematics assessment: The case of Ghana from 1993-2013. *Assessment in Education: Principles, Policy & Practice*, 25(4), 376-398. <https://doi.org/10.1080/0969594X.2016.1192524>
- Eberhard, M. (2000). Forms of mathematical knowledge relating to measurement in vocational training for the building industry. In A. Bessot & J. Ridgway (Eds.), *Education for mathematics in the workplace* (pp. 41-52). Springer. [https://doi.org/10.1007/0-306-47226-0\\_4](https://doi.org/10.1007/0-306-47226-0_4)
- Frejd, P. (2025). Fostering the spirit of mathematical modelling in vocational education. *Nordic Studies in Mathematics Education*, 30(4), 117-140. <https://doi.org/10.7146/nomad.v30i4.164193>
- Hedidor, D., & Bondinuba, F. K. (2017). Exploring concrete materials batching behaviour of artisans in Ghana's informal construction sector. *Journal of Civil Engineering and Construction Technology*, 8(4), 35-52. <https://doi.org/10.5897/JCECT2017.0439>
- Krippendorff, K. (2018). *Content analysis: An introduction to its methodology* (4th ed.). SAGE.
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159-174. <https://doi.org/10.2307/2529310>
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>
- Legesse, M., Luneta, K., & Ejigu, T. (2020). Analysing the effects of mathematical discourse-based instruction on eleventh-grade students' procedural and conceptual understanding of probability and statistics. *Studies in Educational Evaluation*, 67, 100918. <https://doi.org/10.1016/j.stueduc.2020.100918>
- Rejeki, S., Meidina, R. A., Hapsari, M. P., Setyaningsih, R., & Azura, R. N. F. (2021). Context-based tasks in mathematics textbooks for vocational high school students. *Journal of Physics: Conference Series*, 1776(1), 012030. <https://doi.org/10.1088/1742-6596/1776/1/012030>
- Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, 75(2), 211-246. <https://doi.org/10.3102/00346543075002211>
- Rezat, S., Fan, L., & Pepin, B. (2021). Mathematics textbooks and curriculum resources as instruments for change. *ZDM-Mathematics Education*, 53, 1189-1206. <https://doi.org/10.1007/s11858-021-01309-3>
- Skovsmose, O. (2001). Landscapes of investigation. *ZDM-Mathematics Education*, 33(4), 123-132. <https://doi.org/10.1007/BF02652747>