

From Recall to Reasoning: A Systematic Review of Cognitive Demand in Technical and Vocational Mathematics Assessment

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Abstract

Technical and Vocational Education and Training (TVET) must prepare graduates to solve complex work-related problems in the era of Industry 5.0. This function of TVET is consistent with Sustainable Development Goal (SDG) 4 on inclusive education. However, the mathematics curriculum in TVET centres leans mainly towards procedures rather than critical thinking and problem-solving. This systematic review consolidates studies on how cognitive demands in TVET Mathematics assessment have been investigated to identify salient findings and gaps. In accordance with the PRISMA protocol, this review was conducted using an exploratory design. The databases used comprise Google Scholar, Scopus, SAGE Online and Emerald. We searched for English-language peer-reviewed articles published between January 2015 and July 2025. Of the 813 identified records, 37 studies were included that examined cognitive demands through lenses such as Bloom's Taxonomy or Webb's DOK. The findings were grouped into four question groups. Most cognitive demands were expressed through classical taxonomies (32.5%), applied/contextual practices (29.7%), and Higher-Order thinking skills (HOTS) categories (24.3%). Regarding methodology, reviewed/synthesised designs (37.8%) and quantitative designs (27.0%) predominated among the findings. The majority of the research contributions were from Asia-Pacific (43.3%) and Africa (24.3%). Findings from primary studies relevant to implementation show that interventions such as inquiry-based and technology-enhanced learning support higher-order skills. Despite that, there are obstacles such as teacher under-preparation, a mismatch in the curriculum, and the dominance of low-level assessment items. The review indicated that to build 21st-century cognitive skills for life in the contemporary workplace, assessment should be fashioned as a context product. Nevertheless, systemic obstacles prevent widespread adoption in other states. TVET systems should invest in teacher professional development in HOTS pedagogies, an industry-driven curriculum, and the integration of technology into pedagogy.

Keywords: Cognitive Demand; Higher-Order Thinking Skills; Mathematics Assessment; Systematic Review; Technical and Vocational Education and Training

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Introduction

Mathematics plays a foundational and critical role in Technical and Vocational Education and Training (TVET). Garraway (2022) and Yusop et al. (2022) revealed that mathematics is a fundamental pillar of technical problem-solving, innovation, and critical thinking across diverse fields, including engineering, advanced manufacturing, and information technology. Additionally, mathematics serves not only as a set of procedural tools but also as a unique vehicle for cultivating the abstraction, logical analysis, and decision-making needed for today's competent occupational practice (Acheampong & Awuah, 2025; Maharani et al., 2025). In view of this, mathematical assessment and competence in TVET must move beyond procedural fluency to encompass the higher-order cognitive demands required to solve complex, authentic problems in the current era (Garraway, 2022; Korotaj & Buchberger, 2025).

The importance of TVET is widely recognised as nations transition from the Fourth Industrial Revolution into the emerging Industry 5.0 era (Ye et al., 2024; Yusop et al., 2022). According to Ye et al. (2024), this era is characterised by intelligent automation, artificial intelligence, and robotics. To meet the demands of this era and broader 21st-century requirements, TVET systems are expected to cultivate the highly skilled talent necessary to drive this transformation. This role of TVET aligns with the United Nations Sustainable Development Goals (SDGs), especially SDG 4. TVET contributes to this role by promoting inclusive, equitable, quality education and lifelong learning opportunities through high-quality skills training (Yusop et al., 2022; Ye et al., 2024). The concept of cognitive demand can provide a lens for examining mathematics assessments. This is sometimes analysed using frameworks such as Bloom's Taxonomy and Webb's Depth of Knowledge (DOK) (Folson & Awuah, 2025). The taxonomy framework classifies tasks from lower-order skills and creation. Likewise, by applying the Depth of Knowledge framework in TVET contexts, it helps to identify whether the assessments merely verify routine procedures or require learners to engage in strategic thinking and extended reasoning (Mhlungu et al., 2025; Folsom & Awuah, 2025).

Despite the importance of higher-order skills noted above, a significant challenge may persist. For instance, Garraway (2022) noted that numerous TVET college assessments in mathematics (and in related technical fields such as engineering, advanced manufacturing, and information technology) were inadequately moderated and exhibited limited cognitive challenge. Thus, these assessments frequently failed to measure the higher-order competencies required for the authentic workplace.

Although there are several systematic reviews on TVET assessment, a gap may exist in domain-specific synthesis that focuses on mathematics. Some existing reviews, for example, Yusop et al. (2022), provide important insights into the general assessment approaches. Nevertheless, in their discussions, they offer a limited understanding of how cognitive demands are specifically framed, studied and implemented in TVET mathematics. So, the global research landscape on this specific issue remains unclear, with evidence potentially concentrated in particular regions, such as parts of Asia and Africa. This concentration limits the generalisation of findings.

To address these gaps, this systematic review synthesises existing literature on cognitive demands in mathematics assessment within TVET. The review is guided by the following research questions:

1. How have cognitive demands in mathematics assessment been framed in the Technical and Vocational Education and Training literature?

2. What types of research methods and designs have been used to study cognitive demands in mathematics assessment within Technical and Vocational Education and Training?
3. Which regions have contributed to the literature on cognitive demands in mathematics assessment within Technical and Vocational Education and Training?
4. What are the key findings on the implementation of cognitive demands in mathematics assessment within Technical and Vocational Education and Training?

Methodology

This systematic review adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines in order to ensure comprehensive and transparent reporting (Page et al., 2021). The exploratory design was used to map and synthesise literature on cognitive demands in TVET mathematics assessment (Peters et al., 2020). This suited the research questions better than frameworks like Population, Intervention, Comparison, Outcome (PICO). Figure 1 illustrates the PRISMA process, in which 813 records were identified, 737 screened, 49 full texts assessed, and 37 included. This ensures transparency in selection.

Search strategy

The search was conducted in four databases: Google Scholar, Scopus, SAGE Online, and Emerald. Google Scholar captured diverse sources, such as grey literature and proceedings (Halevi et al., 2017). Furthermore, Scopus and Emerald added peer-reviewed and education-focused content, and SAGE emphasised vocational research. The search covered January 2015 to July 2025 to capture recent developments. Boolean terms, adapted per database, were:

("Technical and Vocational Education and Training" OR "TVET" OR "Vocational Education" OR "Technical Education") AND ("Math*") AND ("Cognitive demand*" OR "Cognitive level*" OR "Cognitive skill*" OR "Higher-order thinking" OR "Higher order cognition") AND ("Assessment" OR "Evaluation" OR "Examination" OR "Test item*" OR "Task design")

The initial search of the selected databases and other sources yielded 813 records: Google Scholar (n=639), Scopus (n=71), SAGE Online (n=59), Emerald (n=19), and a hand search of 25. After removing 76 records (67 duplicates, 9 irrelevant), 737 records underwent title and abstract screening. Afterwards, 663 studies did not meet the predefined inclusion criteria and were excluded. The full texts of 49 studies were reviewed for their eligibility. Finally, 37 studies met the inclusion criteria and were included in the review synthesis. The complete search and selection process is illustrated in the PRISMA flow diagram (Figure 1).

Selection criteria

The selection criteria were peer-reviewed English articles from 2015 to 2025. These articles addressed cognitive demands in TVET mathematics assessment using frameworks such as Bloom's Taxonomy and Webb's DOK (Higgins et al., 2019; Nussbaumer-Streit et al., 2020; Gough et al., 2017). The studies covered contexts such as engineering and the trades, as well as cognitive aspects. Studies excluded were conference papers, theses, grey literature, non-TVET or general education studies. This was to ensure quality and replicability (Bearman et al., 2016).

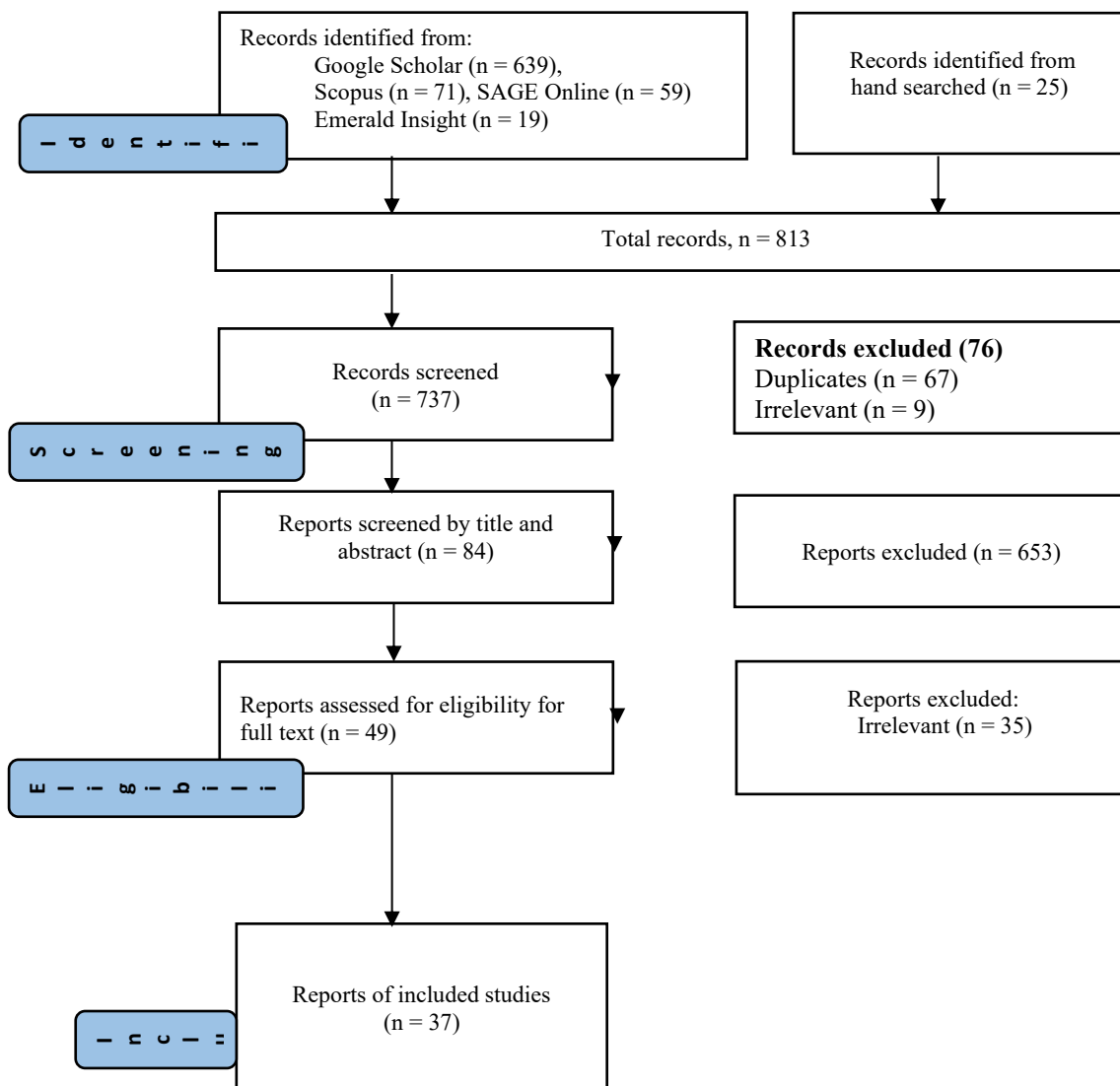


Fig. 1: Flow Diagram of Studies’ Screening and Selection (based on PRISMA)

Source: Authors Construct

Results

The thorough review of 37 studies revealed important trends in how cognitive demands are conceptualised, studied, and applied in mathematics assessments within Technical and Vocational Education and Training (TVET). This detailed review organises the findings based on the specific research questions in the studies, providing a clearer view of how cognitive requirements are defined, examined in research, and applied in practice in assessment.

Framing of Cognitive Demands in Mathematics Assessment in Technical and Vocational Education and Training Literature

Cognitive demands were examined through five distinct approaches, each offering a unique perspective on their complexity. These approaches collectively highlight the multifaceted nature of cognitive challenges encountered in various contexts. In Table 1, we provide a comprehensive breakdown of how the studies are categorised across the five approaches, illustrating the distribution and emphasis of research within each framework. Additionally, Figure 2 offers a visual representation of these distributions, allowing a clearer understanding of how the different perspectives converge and diverge in their examination of cognitive demands.

Table 1: Framework Categories

Framework Type	% (n)	Studies
Classical Taxonomic	32.5% (12)	Basori et al. (2023); Duong (2018); Folson & Awuah (2025); Garraway (2022); Korotaj & Buchberger (2025); Lin (2025); López et al. (2023); Mhlungu et al. (2025); Mohd Jamil et al. (2023); Ngoveni & Machaba (2024); Parker & Roumell (2020); Ramaila et al. (2019)
HOTS Focus	24.3% (9)	Abdurrahman et al. (2021); Ali et al. (2024); Hidayat et al. (2025); Liu (2019); Maharani et al. (2025); Mazibuko & Maharaj (2024); Novyanti et al. (2021); Sumandya et al. (2020); Wakid et al. (2024)
Contextual/Applied	29.7% (11)	Christidis et al. (2024); Dalby & Noyes (2022); Guo et al. (2021); Jatisunda et al. (2024); Kotsifakos et al. (2024); Matu & Paik (2021); Motseki & Jojo (2022); Putri & Juandi (2025); St Omer et al. (2025); Suominen et al. (2024); Ye et al. (2024)
Metacognitive/Process	10.8% (4)	Muda et al. (2019); Oktaviyanthi & Lestari (2023); Raharjo et al. (2025); Vimbelo & Bayaga (2024)
Specialised Models	2.7% (1)	De Andrade et al. (2022)

The largest proportion of the studies used classical taxonomies (32.5%, $n = 12$). This category drew from Bloom's Taxonomy or revisions (e.g., Ngoveni & Machaba, 2024; Ramaila et al., 2019; Garraway, 2022). Others used similar models, such as Buchberger's critical thinking (Korotaj & Buchberger, 2025) or Webb's DOK (Folson & Awuah, 2025; Mhlungu et al., 2024). These provided standardised measures for assessment levels.

The higher-order thinking skills (HOTS) framed 24.3% ($n=9$), emphasised critical thinking, analysis, and creation for vocational problem-solving (e.g., Abdurrahman et al., 2021; Ali et al., 2024; Wakid et al., 2024). Contextual and applied frameworks also accounted for 29.7% ($n=11$), which integrated cognition with real-world vocational relevance, such as competency-based training (Suominen et al., 2024), functional mathematics (Dalby & Noyes, 2024), or project-based learning (Jatisunda et al., 2024).

Metacognitive and process frameworks appeared in 10.8% ($n=4$) of studies, focusing on self-regulation and reflection, for example, cognitive apprenticeship in Oktaviyanthi and Lestari (2023) and monitoring in Muda et al. (2019). One specialised model (2.7%, $n=1$) used the MATH taxonomy for recall, application, and justification (De Andrade et al., 2022). Studies with multiple frameworks were categorised by their primary focus.

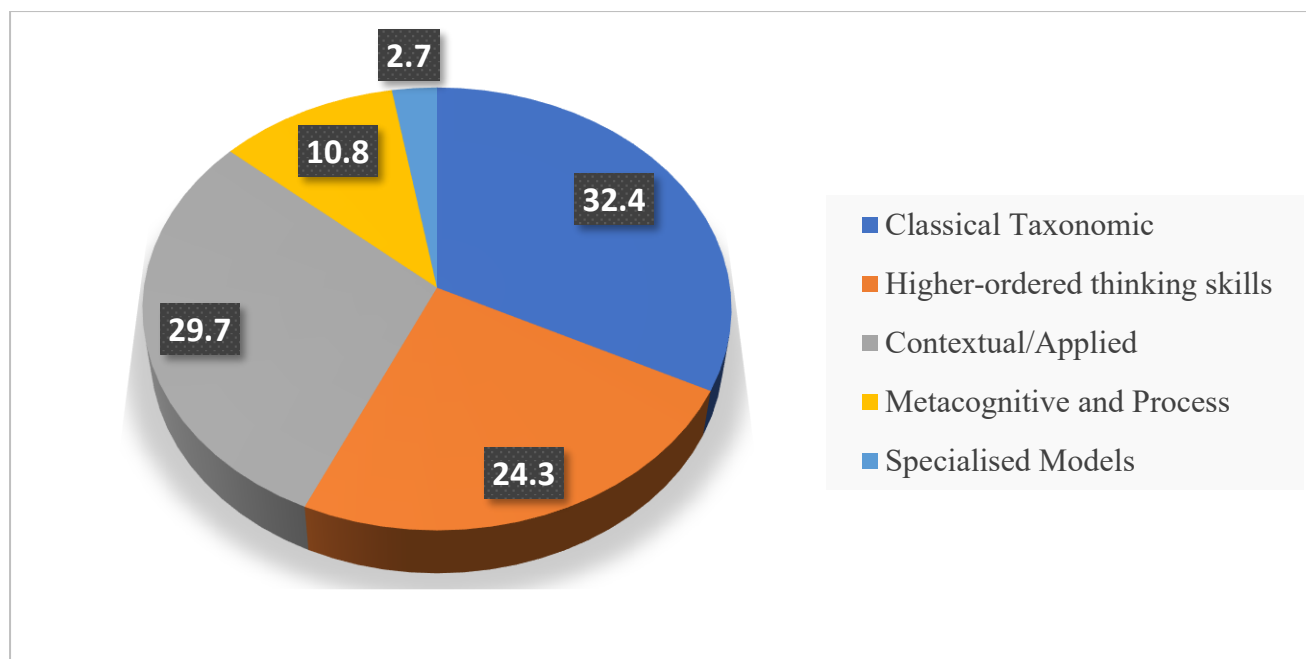


Figure 2: Framework categories

Types of Research Methods and Designs that Have Been Used to Study Cognitive Demands of Mathematics Assessment Within Technical and Vocational Education and Training

Four distinct methodological approaches were identified, highlighting the diversity of ways in which cognitive demands are explored. These approaches provide a comprehensive view of the ways researchers analyse and understand cognitive processes. Detailed information about each method is presented in Table 2, and a visual representation is shown in Figure 3.

Table 2: Methodological Categories

Method Type	% (n)	Key Studies Examples
Review/Synthesis	37.8% (14)	Ali et al. (2024); Basori et al. (2023); Garraway (2022); Guo et al. (2021); Hidayat et al. (2025); Liu (2019); Maharani et al. (2025); Matu & Paik (2021); Parker & Roumell (2020); Putri & Juandi (2025); Raharjo et al. (2025); St Omer et al. (2025); Wakid et al. (2024); Ye et al. (2024)
Quantitative	27.0% (10)	Abdurrahman et al. (2021); Jatisunda et al. (2024); Mhlungu et al. (2025); Mohd Jamil et al. (2023); Motseki & Jojo (2022); Muda et al. (2019); Novyanti et al. (2021); Ramaila et al. (2019); Sumandya et al. (2020); Suominen et al. (2024)
Qualitative	21.6% (8)	Christidis et al. (2024); De Andrade et al. (2022); Korotaj & Buchberger (2025); Kotsifakos et al. (2024); Mazibuko & Maharaj (2024); Ngoveni & Machaba (2024); Oktaviyanthi & Lestari (2023); Vimbelo & Bayaga (2024)
Mixed-Methods	13.5% (5)	Dalby & Noyes (2022); Duong (2018); Folsom & Awuah (2025); Lin (2025); López et al. (2023)

The review and synthesis studies comprised 37.8% (n=14). These included systematic reviews and literature analyses to identify patterns and gaps (e.g., Ali et al., 2024; Garraway, 2022; St Omer et al., 2025). Also, the quantitative methods covered 27.0% (n=10). These studies used quasi-experimental designs, surveys, and content analyses for empirical evidence (e.g., Abdurrahman et al., 2021; Motseki & Jojo, 2022). Furthermore, qualitative methods accounted for 21.6% (n=8), offering contextual insights through case studies, observations, and content analyses (e.g., Christidis et al., 2024; Vimbelo & Bayaga, 2024).

Mixed-methods approaches accounted for 13.5% (n=5), in which studies combined data types to achieve a comprehensive understanding (e.g., Dalby & Noyes, 2022; Folson & Awuah, 2025; López et al., 2023).

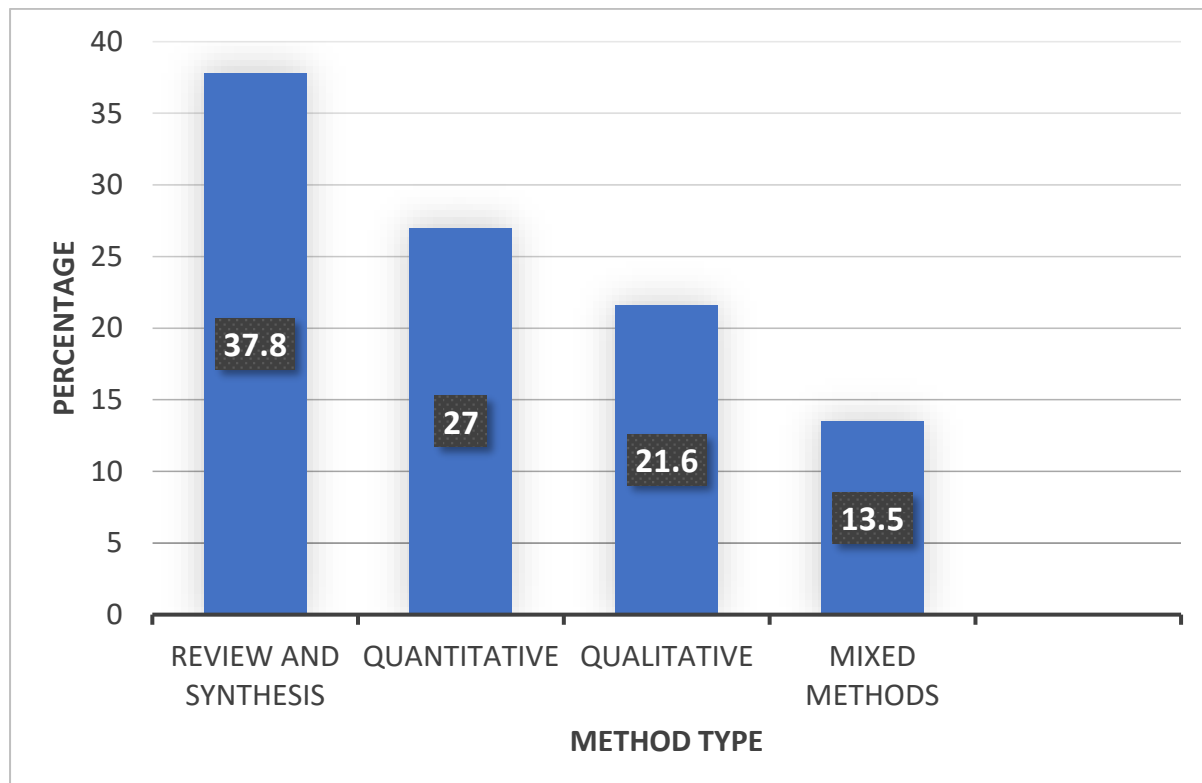


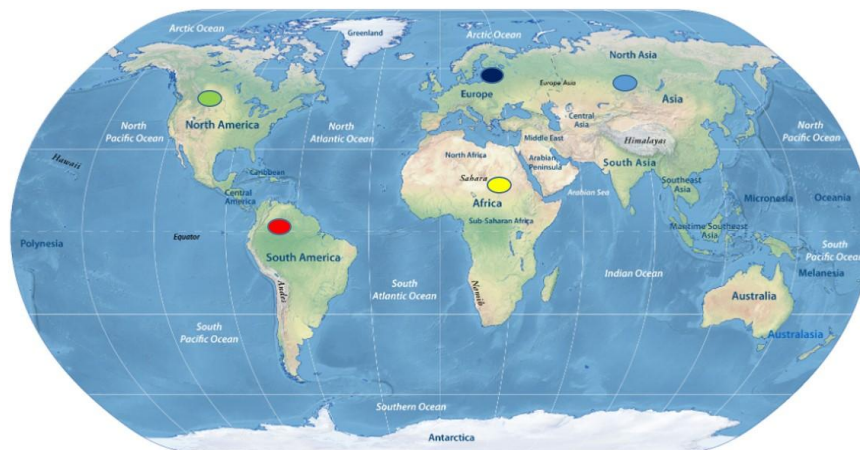
Figure 3: Method types

Regions that have Contributed to the Literature on Cognitive Demands in Mathematics Assessment Within Technical and Vocational Education and Training

Contributions revealed the four main continents, with geographic imbalances. The virtual view of the distribution is shown in Figure 4. Asia-Pacific dominated the research landscape, accounting for 43.3% (n = 16) of the studies. This was driven more by Indonesia (n = 7) as Basori et al. (2023); Jatisunda et al. (2024); Maharani et al. (2025); Novyanti et al. (2021); Oktaviyanthi & Lestari (2023); Raharjo et al. (2025) and Sumandya et al. (2020). This is followed by China (n = 4) as Guo et al. (2021), Lin (2025), Liu (2019), and Ye et al. (2024). And then, Malaysia (n = 3), as Ali et al. (2024), Mohd Jamil et al. (2023) and Muda et al. (2019). Finally, single contributions in Asia-Pacific came from Vietnam (n = 1), as Duong (2018) and the Gulf region (n = 1), as Matu & Paik (2021).

Africa contributed 24.3% (n = 9) to the corpus, mainly from South Africa (n = 6), namely Mazibuko & Maharaj (2024); Motseki & Jojo (2022); Mhlungu et al. (2025); Ngoveni &

Machaba (2024); Ramaila et al. (2019); Vimbelo & Bayaga (2024), and Garraway (2022), with one each from Ghana (Folson & Awuah, 2025) and Nigeria (Abdurrahman et al., 2021). Europe added 13.5% (n=5), from Finland (Suominen et al., 2024), England (Dalby & Noyes, 2024), Sweden (Christidis et al., 2024), Greece (Kotsifakos et al., 2024), and broader perspectives (Korotaj & Buchberger, 2025). South America had 2.7% (n=1), from Chile (López et al., 2023). Multi-regional studies (16.2%, n=6) comprised global or cross-regional reviews: De Andrade et al. (2022); Hidayat et al. (2025); Parker & Roumell (2020); Putri & Juandi (2025); St Omer et al. (2025); Wakid et al. (2024).



● Asia-Pacific Region (n=16, 43.3%)

● Africa (n=9, 24.3%)

● Europe (n=5, 13.5%)

● South America (n=1, 2.7%)

● ● ● Multi-Regional and Global Studies (n=6, 16.2%)

Key Findings on the Implementation of Cognitive Demands in Mathematics Assessment Within Technical and Vocational Education and Training

The findings highlighted positive impacts, barriers, facilitators and the emerging patterns in the implementation process.

Implementation and Impact

The studies demonstrated that well-designed interventions improved outcomes. Some of these examples include the following:

- Inquiry-based learning showed large effects on HOTS (Abdurrahman et al., 2021).
- Technology-enhanced methods yielded a significantly positive and robust effect on students' math achievement ($g = 1.090$; $p < 0.05$) as revealed by Putri and Juandi (2024).
- Modelling activities increased problem-solving skills with an effect size (ES) from 0.78 to 0.97 (Hidayat et al., 2025).
- Project-based approaches outperformed traditional ones (Jatisunda et al., 2024), and apprenticeship models raised decision-making scores (Oktaviyanthi & Lestari, 2023).

Persistent Implementation Barriers

Despite these positive outcomes, the review identified some barriers that constrain the implementation of cognitive demands. These challenges included:

- Teacher under-preparation in HOTS pedagogies (Liu, 2019; Maharani et al., 2024).
- Curriculum misalignment, with alignment coefficients of 0.594-0.819 (Folson & Awuah, 2025).
- Student performance gaps under higher demands (Ramaila et al., 2019).
- Dominance of low-level tasks (66.6% recall; Mhlungu et al., 2024).
- High costs for technology (Guo et al., 2021).

Facilitators for Successful Implementation

However, the review identified some facilitators that can enable the implementation of cognitive demand. Some of these enablers featured:

- Real-world contextualization, achieving >80% competency (Lin, 2025).
- Educator training, shifting to student-centred methods (Vimbelo & Bayaga, 2024).
- Industry collaboration in design (Garraway, 2022).
- Technology with pedagogy, like inquiry-based software (St Omer et al., 2025).

Emerging Implementation Patterns

Notwithstanding, the findings from the review showed emerging patterns in the implementation of cognitive demand, reflecting the field's maturity. Some of these patterns showed that formative assessments enhanced critical thinking (Wakid et al., 2024). Also, culturally responsive teaching boosted students' engagement (Vimbelo & Bayaga, 2024).

Furthermore, there were aspects of metacognitive gaps and policy constraints. Muda et al. (2019) identified high metacognitive capabilities among students but noted deficiencies in their solutions and strategies. Also, although policy issues constrain implementation, there is relevance to the vocational context of functional mathematics approaches (Dalby & Noyes, 2024).

Implementation Quality and Sustainability Concerns

Some studies showed concerns about implementation quality and long-term sustainability. For instance, Mazibuko & Maharaj (2024) noted low post-intervention levels (77% lower cognition) and Maharani et al. (2024) found inconsistent assessments.

In summary, the findings indicated that implementing cognitive demands in TVET mathematics assessment required attention to teacher preparation, curriculum alignment, authentic contextualization, and sustained institutional support.

Discussion

This systematic review focuses on the cognitive demands of TVET mathematics assessment. The review paints a picture of a field in flux. So, as a field that is trying to prepare students for the increased complexity of today's workplaces, it is densely layering them with ongoing hits, making real change difficult to implement. The discourse interprets key findings in light of skills development and the workforce, yielding implications for theory, practice and policy.

Theoretical Frameworks and the Evolution of Cognitive Assessment

As shown in the results, taxonomic frameworks (32.5%), such as Bloom's Taxonomy, provide the structure for cognitive hierarchies in assessment design. However, these frameworks may fall short in capturing what is required in the modern workplace. The rise of HOTS frameworks (24.3%) signals a shift towards adaptive competencies, such as critical thinking and problem-solving, that are vital for Industry 5.0 (Mazibuko & Maharaj, 2024; Abdurrahman et al., 2021). This approach aligns with SDG 4.4, which stresses relevant skills for employment.

Webb's DOK framework, applied in fewer studies, emphasises depth over difficulty. This framework aids in the transfer of mathematical knowledge to vocational problems (Folson & Awuah, 2025; Mhlungu et al., 2024). However, the limited use of contextual frameworks (29.7%) highlights a gap in situated cognition. In this framework, the concepts of vocational knowing integrate mathematics into real-world tasks (Christidis et al., 2024). Therefore, future research could develop culturally responsive frameworks and validate them longitudinally for vocational success.

Methodological Diversity and Research Maturation

There is a methodological balance with reviews (37.8%), quantitative (27.0%), qualitative (21.6%), and mixed (13.5%) methods. This balance indicates that the field is reaching maturity. The study also showed that the review studies consolidated knowledge, while experiments tested interventions which strengthened the evidence for cognitive practices. Nevertheless, there was an uneven geographical distribution. The evidence from Asia-Pacific (43.2%) and Africa (24.3%) reflects regional differences and limits the generalisation of the findings. Furthermore, the scarce input from Europe and South America shows different priorities. This constrains SDG 4's inclusive educational goals. However, cross-cultural studies could bridge these constraints and gaps identified in this review.

Implementation Effectiveness and Contemporary Skills Development

The findings affirmed that targeted interventions may transform assessments. Evidence of large effects from inquiry-based (Abdurrahman et al., 2021) and technology-enhanced methods (Putri & Juandi, 2024) builds 21st-century skills such as collaboration and digital literacy. These support SDG 8.6 by reducing youth underemployment through adaptive problem-

solving. Similarly, blended approaches enhance reasoning, which in turn encourages the integration of tools such as GeoGebra into pedagogy (St Omer et al., 2025).

Persistent Barriers and Systemic Challenges

Despite the positive intervention outcomes, some implementation barriers remain. These barriers include teacher under-preparation in HOTS (Liu, 2019) and misalignment, with alignment coefficients ranging from 0.594 to 0.819 (Folson & Awuah, 2025). Also, there was a dominance of low-level tasks (66.6% recall) (Mhlungu et al., 2024). These barriers are misaligned with workplace demands and also hinder progress on SDG 4.4.

Contextual Integration and Workplace Relevance

On the other hand, there was evidence of how contextual integration and workplace-oriented practice may enhance mathematics learning in TVET settings. For instance, Lin (2025) showed that real-world links boost competency and metacognitive focus and also aid lifelong learning (Muda et al., 2019). Additionally, Extended Reality (XR) technologies offer immersive assessments for decision-making (Guo et al., 2021) that align with automation-driven work.

Implications for Policy and Practice

In all these respects, it was evident that policymakers must prioritise teacher development, curriculum alignment, and access to technology for equitable implementation. There was also a need for industry partnerships to ensure relevance (Garraway, 2022). This practice fosters SDG 8's economic growth, which reveals that international collaborations can adapt practices across regions to enhance inclusive TVET.

Limitations

This review has some limitations. This includes reliance on peer-reviewed English articles, which may overlook grey literature and non-English sources. Also, the geographic concentration in Asia-Pacific and Africa may bias the findings, reducing generalizability. Furthermore, exclusion of non-empirical studies and a ten-year timeframe might miss other broader trends.

Therefore, future research should pursue longitudinal studies of the impacts of interventions on career outcomes. Similarly, further research on cross-cultural validation of frameworks, explorations of AI in assessment, and cost-effectiveness analyses of scalable models would help address these existing gaps. Thus, such efforts can ensure TVET prepares graduates for a dynamic global economy.

Conclusions

This systematic review highlights the evolving landscape of cognitive demands in TVET mathematics assessment. The well-designed interventions, such as inquiry-based and technology-enhanced approaches, show promise that building higher-order skills is essential for modern workplaces. However, persistent barriers like teacher under-preparation and curriculum misalignment hinder progress.

In summary, taxonomic frameworks provide a foundation, but HOTS and contextual approaches better capture the complexities of vocational contexts. Also, the different methods employed strengthen the evidence base of the cognitive demand. However, the geographic biases limit global insights and generalisation. Notwithstanding implementation successes, the need for authentic, integrated assessments to foster adaptive competencies remains.

Recommendations

To advance TVET systems, policymakers should invest in teacher professional development, focused on HOTS pedagogies and assessment design. Institutions must prioritise curriculum alignment with workplace demands by incorporating industry partnerships for real-world relevance. Technology integration, paired with frameworks like DOK, can enhance cognitive depth. These steps support SDG 4's quality education goals and SDG 8's emphasis on decent work and economic growth.

Declarations

Ethical Approval and Consent

This study is a systematic review of published literature and did not involve human participants; therefore, ethical clearance was not required.

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Authors' Contributions

Akwasi Sakyi Denteh: Conceptualisation, Literature review, Systematic review protocol, Writing — original draft, Project administration.

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Competing Interest

The authors declare no financial, personal, or other interests that could be considered a potential conflict of interest regarding the publication of this article.

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References

- Abdurrahman, M. S., Halim, A. A., & Sharifah, O. (2021). Improving polytechnic students' high-order-thinking-skills through inquiry-based learning in the mathematics classroom. *International Journal of Evaluation and Research in Education*, 10(3), 976–983.
- Acheampong, P. A., & Awuah, F. K. (2025). The study of mathematics content in the context of vocational education: A systematic review. *Physical and Mathematical Education*, 40(4), 6-12.
- Basori, B., Sajidan, S., Akhyar, M., & Wiranto, W. (2023). Blended learning model towards vocational students' learning outcomes: A scoping review. *International Journal of Evaluation and Research in Education*, 12(1), 205-215.
- Bearman, M., Dawson, P., Boud, D., Bennett, S., Hall, M., & Molloy, E. (2016). Support for assessment practice: Developing the assessment design decisions framework. *Teaching in Higher Education*, 21(5), 545-556.
- 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, 100-109.
- Dalby, D., & Noyes, A. (2022). The waxing and waning of functional skills in mathematics. *Journal of Vocational Education & Training*, 74(3), 434-453.
- De Andrade, M. O., Nyamapfene, A., Zurita, M., & Burova, I. (2022). Assessing higher levels of learning through real-life problems in engineering mathematics. *Engineering Education Review*, 18(3), 156-171.
- Folson, D., & Awuah, F. K. (2025). Assessing cognitive alignment in pre-tertiary TVET core mathematics: A Ghanaian case study of curriculum and exit examinations. *East African Journal of Education Studies*, 8(2), 176-188.
- Garraway, J. (2022). Designing complex, challenging and creative assessments for work preparedness: A review of competency-based assessment. *Assessment in Education: Principles, Policy and Practice*, 29(4), 445-462.
- Gough, D., Oliver, S., & Thomas, J. (2017). *An introduction to systematic reviews* (2nd ed.). Sage.
- Guo, X., Guo, Y., & Liu, Y. (2021). The development of extended reality in education: Inspiration from the research literature. *Sustainability*, 13(24), 13-36.
- Halevi, G., Moed, H., & Bar-Ilan, J. (2017). Suitability of Google Scholar as a source of scientific information and as a source of data for scientific evaluation: Review of the literature. *Journal of Informetrics*, 11(3), 823-834.
- Hidayat, R., Ayub, A. F. M., bin Bahurudin Setambah, M. A., & Mazlan, N. H. (2025). A meta-analysis of the effect of modelling activities on learning outcomes in mathematics. *STEM Education*, 5(3), 401-424.
- Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (Eds.). (2019). *Cochrane handbook for systematic reviews of interventions* (2nd ed.). John Wiley & Sons.
- Mohd Jamil, M. R., Mat Noh, N., Idris, N., Othman, M. S., & Md Zalli, M. M. (2023). Enhancing higher-order thinking skills among TVET students: HyperDocs as a tool for TVET teachers. *Jurnal Kejuruteraan*, 6(2), 31-43.
- Motseki, P., & Jojo, Z. (2022). The effectiveness of using the geometer's sketchpad to enhance TVET college level 4 students' understanding of circle geometry. *Progressio*, 43(1), 1-17.

- Nussbaumer-Streit, B., Klerings, I., Dobrescu, A. I., Persad, E., Stevens, A., Garritty, C., Kamel, C., Affengruber, L., Meerpohl, J. J., & Gartlehner, G. (2020). Excluding non-English publications from evidence syntheses did not change conclusions: A meta-epidemiological study. *Journal of Clinical Epidemiology*, *118*, 42-54.
- Jatisunda, M. G., Suryadi, D., & Prabawanto, S. (2024). Enhancing mathematical problem-solving ability through project-based learning: A study of vocational high school students. *Jurnal Elemen*, *10*(3), 711-727.
- Kotsifakos, D., Kiriakos, D., Kalovrektis, K., Psaromiligkos, Y., & Douligeris, C. (2024). Research and analysis in the cognitive principles of vocational education and training in Greece at the beginning of the 21st Century. *Applied System Innovation*, *7*(5), 98-107.
- Lin, Q. (2025). Constructing a vocational mathematics teaching model aligned with industry needs. *World Journal of Education and Humanities*, *7*(3), 1-17.
- López, F., Contreras, M., Nussbaum, M., Paredes, R., Gelerstein, D., Alvares, D., & Chiuminatto, P. (2023). Developing critical thinking in technical and vocational education and training. *Education Sciences*, *13*(6), 590-599.
- Maharani, S., Arthur, R., & Soeprijanto, S. (2025). Standardised higher-order thinking skills assessment in engineering mechanics: A traditional literature review and future research directions. *Jurnal Eduscience*, *12*(4), 1088-1097.
- Matu, J. B., & Paik, E. J. (2021). Generic skills development in the Gulf Cooperation Council countries and graduate outcomes: A systematic review of the literature. *Gulf Education and Social Policy Review*, *2*(1), 69-90.
- Mazibuko, G. N., & Maharaj, A. (2024). An explorative study of developing a mathematical model for evaluating HOTS in the Mathematics curriculum operating in the KZN TVET Colleges. *Education Sciences*, *14*(3), 279-292.
- Mhlongu, X., Ramaila, S. M., & Ramnarain, U. (2025). The cognitive complexity of technical sciences: An analysis using the depth-of-knowledge level scheme. *International Journal of Learning, Teaching and Educational Research*, *24*(2), 613-635.
- Muda, W. H. N. W., Ab Halim, F., Ismail, N., & Jimas, M. N. M. (2019). metacognitive skills among technical students through mathematical problem solving: Technical students' perceptions. *Online Journal for TVET Practitioners*, *4*(2), 93-98.
- Ngoveni, M. A., & Machaba, M. F. (2024). Effectiveness of questioning techniques in mathematics: An analysis of lecturers' practices at TVET colleges. *Journal of Pedagogical Sociology and Psychology*, *6*(3), 21-33.
- Novyanti, Y., Rahmayanti, H., Azwar, S. A., Ichsan, I. Z., Singh, C. K. S., Rahman, M. M., & Ali, A. (2021). An overview of students' HOTS to develop an instructional kit for disaster mitigation based on vocational education. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *6*(1), 117-124.
- Oktaviyanthi, R., & Lestari, I. (2023). Cognitive apprenticeship in vocational students' mathematical decision-making skills. *Jurnal Pendidikan Vokasi*, *13*(1), 80-97.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89-100.
- Parker, D. A., & Roumell, E. A. (2020). A functional contextualist approach to mastery learning in vocational education and training. *Frontiers in Psychology*, *11*, 14-39.
- Peters, M. D. J., Marnie, C., Tricco, A. C., Pollock, D., Munn, Z., Alexander, L., McInerney, P., Godfrey, C. M., & Khalil, H. (2020). Updated methodological guidance for the conduct of scoping reviews. *JBIEvidence Synthesis*, *18*(10), 2119-2126.

- Putri, A. D., & Juandi, D. (2025). Blended learning and math achievement: A meta-analytic review highlighting the effectiveness and heterogeneity. *Electronic Journal of E-Learning*, 23(1), 113-128.
- Raharjo, E. Y., Putri, P. A., Danim, S., & Risdianto, E. (2025). How do students' cognitive style influence their mathematical problem-solving thinking processes: A systematic literature review. *Journal of Mathematics Science and Education*, 8-15.
- St Omer, S. M., Evers, K., Wang, C. Y., & Chen, S. (2025). Technology-enhanced mathematics learning: review of the interactions between technological attributes and aspects of mathematics education from 2013 to 2022. *Humanities and Social Sciences Communications*, 12(1), 1-13.
- Sumandya, I. W., Suarni, N. M., Mahendra, I. W. E., & Panglipur, I. R. (2020). Developing an assessment of vocation-based tests on mathematics subject for the X class of vocational school. *International Journal of Scientific and Technology Research*, 9(2), 2900-2903.
- Suominen, S., Ikonen, K., Leinonen, R., Viholainen, A., & Asikainen, M. A. (2024). Vocational school students' use and opinions of voluntary-based online learning solutions presented in a mathematics course. *European Journal of Science and Mathematics Education*, 12(3), 394-410.
- Vimbelo, S., & Bayaga, A. (2024). Transforming mathematics education in TVET Colleges through humanising pedagogy: An exploration of teaching approaches, student engagement, and real-life examples. *Journal of Education*, 65(2), 139-154.
- Wakid, M., Sofyan, H., Widowati, A., & Zaida Ilma, A. (2024). Learning-oriented assessment: a systematic literature network analysis. *Cogent Education*, 11(1), 23-56.
- Ye, J. H., He, Z., Bai, B., & Wu, Y. F. (2024). Sustainability of technical and vocational education and training (TVET) along with vocational psychology. *Behavioural Sciences*, 14(10), 859-890.
- Yusop, S. R. M., Rasul, M. S., Mohamad Yasin, R., Hashim, H. U., & Jalaludin, N. A. (2022). An assessment approaches and learning outcomes in technical and vocational education: A systematic review using PRISMA. *Sustainability*, 14(9), 25-52.