

The AI Literacy Imperative: Moving Beyond “Using” AI to “Understanding” AI in TVET Curricula

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Abstract

In today’s education system, artificial intelligence (AI) is predominantly framed as a productivity tool—a means of reducing cognitive friction for learners. This conceptual paper argues that technical and vocational education and training (TVET) has adopted a dangerously superficial approach to AI by fixating narrowly on this instrumental function. While efficiency gains are valuable, current instruction overwhelmingly emphasizes vocational shortcuts over systematic education on AI epistemics, bias, and ethics—content that, in the authors’ analysis of available curricula, remains largely absent. This imbalance risks producing graduates who are uncritical, passive consumers of “black-box” technology rather than reflective practitioners capable of questioning AI outputs. Synthesizing peer-reviewed literature, the paper advocates for a paradigm shift toward comprehensive AI literacy: understanding how AI works, where it fails, and how it affects society. TVET institutions are uniquely positioned to lead this shift because their hands-on, competency-based framework can embed critical AI critique—for example, through algorithmic auditing exercises integrated into vocational tasks—directly into authentic learning. The paper concludes by offering actionable recommendations for policymakers and educators. At stake is whether TVET produces tool users or tool shapers.

Keywords: AI literacy, TVET, vocational education, generative AI, epistemic precarity, craftsmanship, material pedagogy

Introduction

The rapid integration of generative artificial intelligence (AI) into workplaces across all sectors is reshaping what it means to be a competent professional. For technical and vocational education and training (TVET), which exists explicitly to prepare learners for direct labour market participation, this transformation presents both urgent opportunities and profound risks. Studies indicate that AI integration in vocational education is not merely an incremental improvement but a potential game-changer that can personalize learning, enhance practical training through simulations, and better align curricula with industry needs (Ran & Han, 2023; Shen et al., 2024). In line with this, the global surge in AI adoption across workplaces demands that TVET curricula adapt rapidly to prepare a future-ready workforce.

However, despite the increasing availability of AI tools in classrooms, evidence suggests that formal instruction on how AI systems actually function, what biases they embed, or under what conditions they fail remains exceptionally rare (Al Yakin et al., 2025; UNESCO, 2019). This disconnect between widespread use and systematic understanding is not a minor oversight but a fundamental vulnerability in contemporary vocational pedagogy. The dominant response across TVET systems has been to integrate AI tools into existing

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curricula as “content-integrated AI learning” (CIAIL) models that focus on employability, assuming students who can operate AI applications will be better prepared for an AI-driven economy (UNESCO-UNEVOC, 2023). While valuable, this orientation is dangerously incomplete, as a graduate who can prompt an AI to draft a report but cannot recognize when that AI is hallucinating, or who follows an AI diagnostic without understanding its confidence limits, is not an empowered professional but a passive consumer of a black box (Felix, 2020; Southgate et al., 2018).

This conceptual paper argues for a paradigm shift: moving beyond instrumental competence with AI tools toward comprehensive AI literacy as a core outcome of TVET. AI literacy is defined here as a multi-dimensional competency encompassing not only the ability to use AI tools but also to understand their foundational principles, critically evaluate their outputs, recognize and mitigate their biases, and apply them ethically in professional contexts (Long & Magerko, 2020; Ng et al., 2021).

The paper is organized as follows. Section 2 presents a literature review synthesizing research on AI literacy, documenting the usage-understanding gap, examining epistemic challenges, presenting pedagogical frameworks, and reviewing policy models. Section 3 discusses the findings, including a consolidated analysis of TVET’s material advantages and responses to counterarguments.

Literature Review

Defining AI Literacy

AI literacy has emerged as a distinct construct within the broader fields of digital and media literacy, moving beyond basic digital skills or computational thinking to require an understanding of systems that are probabilistic, opaque, and often autonomous. Ng et al. (2021) laid a foundational framework, proposing a four-dimensional “know, use, evaluate, create” taxonomy that has been widely adopted. Long and Magerko (2020) offered a more granular list of 17 competencies, emphasizing that literacy is not merely technical fluency but a set of critical and ethical dispositions related to AI’s limitations, data bias, and output evaluation.

For TVET specifically, Al Yakin et al. (2025) argue that AI literacy must include the ability to critically evaluate AI systems and apply them appropriately in vocational settings, noting how current curricula tend to ignore AI’s impact on professional judgment and accountability. Within the Chinese higher vocational context, a validated three-tier competency-based ladder pathway (foundational cognitive, skills application, comprehensive innovation) has shown overall AI literacy gains of 56.0% and sustained retention rates exceeding 85% at six-month follow-up (Wang et al., 2025).

The Usage-Understanding Gap

A growing body of evidence reveals a troubling gap between students’ frequent use of AI tools and their deep, critical understanding. A large-scale mixed-methods study integrating a systematic review of 87 academic papers and case studies of 12 vocational colleges found that only 29% of vocational teachers mastered AI teaching tools, while 67% of rural vocational colleges lacked basic AI infrastructure, directly contributing to the gap (Deng et al., 2026).

A systematic review by König-Ziegler et al. (2025) found a clear distinction: while many studies describe AI being used as a learning or reflection tool, there is a pronounced lack of aggregated knowledge about

how these functions are explicitly made available to learners, revealing a gap between potential uses and systematic pedagogical integration. Similarly, Laupichler et al. (2022), in a scoping review of 47 AI literacy interventions, found that the least frequently addressed competency—present in only 17% of interventions—was critical evaluation of AI outputs.

These findings are echoed in a qualitative case study of vocational students in Sweden (Metreveli & Chen, 2025). The study found students enthusiastic about using generative AI but frustrated that curricula focused on “pressing buttons” rather than developing true understanding. Students expressed confusion: “We are told to use ChatGPT, but no one explains when it might be lying” (Metreveli & Chen, 2025).

Epistemic Challenges of Generative AI

Generative AI introduces a fundamentally new epistemic challenge. Unlike deterministic software, generative AI produces fluent, confident, and often authoritative outputs based purely on statistical probabilities (Sullivan & Kelly, 2024). This creates “epistemic precarity”—the difficulty of distinguishing plausible but incorrect outputs from accurate information—which is not an abstract problem for vocational learners facing real-world consequences, such as a hazardous welding parameter or an incorrect medical dosage.

Sullivan and Kelly (2024) argue that vocationally oriented education must cultivate “epistemic courage”: the willingness to resist surface-level truths, question plausible outputs, and seek verification. Without such courage, workers will increasingly defer to AI recommendations, leading to automation complacency and erosion of human judgment (Ridley & Pawlick, 2025).

Pedagogical Frameworks

Several frameworks have been proposed to translate AI literacy into actionable practice. Riis’s (2025) five-strategy model offers a nuanced, context-sensitive approach specifically for TVET:

1. AI independent learning
2. AI aware learning
3. AI supported learning
4. AI enhanced learning
5. AI centric learning.

The goal is to cultivate students’ judgment about when, how, and to what extent to trust AI.

Complementary frameworks include the content-integrated AI learning (CIAIL) model (UNESCO-UNEVOC, 2023) and a “symbiotic” teacher-machine-student ecosystem that emphasizes workforce readiness (El Hayani & Benamar, 2025). Al Yakin et al. (2025) offer a professional development framework emphasizing teacher AI literacy as a prerequisite for student AI literacy.

Policy Models

China has taken a systematic approach. The Ministry of Education’s 2026 reforms mandate AI-related specializations and require “basic understanding of AI principles” for all vocational students, regardless of

track (China Ministry of Education, 2026). The reforms propose a three-tier teacher competence framework: awareness, application, and critical evaluation.

The European Union has called for AI competency development, but implementation remains uneven. A systematic review and comparison of 50 peer-reviewed studies found that AI integration in vocational education tends to be more practice-oriented and aligned with immediate industry needs than in academic higher education (Gao & Tan, 2025). However, German-language research notes that while AI tools are increasingly available, systematic integration of critical AI literacy into curricula is still rare (BIBB, 2023).

UNESCO-UNEVOC (2023) provides global guidance calling for critical AI literacy as a fundamental competency for all learners. Despite these efforts, tool-centric approaches dominate, driven by employer pressure for practical, job-ready AI skills.

Discussion

A Systemic Gap

The usage-understanding gap is a systemic feature of how TVET systems have responded to AI, driven by funding models, employer demands, and institutional metrics that privilege tool training over foundational understanding (UNESCO-UNEVOC, 2023). Deep understanding of AI's logic, biases, and limitations does not appear on most employer checklists—until something goes wrong. The consequences are serious: when an AI-influenced decision leads to a workplace injury or costly error, it is not the algorithm but the human professional held accountable.

Dependency from Tool-Centric Approaches

Research consistently indicates that tool-centric instruction produces dependency and complacency. Laupichler et al. (2022) found that critical evaluation was the most neglected dimension in AI literacy interventions. Furthermore, high-frequency AI users can be more susceptible to automation bias: a study found students who reported daily AI use were more likely to rate obviously false AI outputs as accurate than students who used AI less frequently (Southgate et al., 2018). This suggests that tool fluency without critical understanding actively leads to overconfidence and diminished verification habits.

Material Pedagogy as an Asset

TVET possesses a distinctive strength for cultivating comprehensive AI literacy that is often overlooked: its fundamentally material pedagogy. Unlike abstract academic discussions, vocational education engages learners with physical systems, tangible problems, and embodied practice (Felix, 2020; Gamble, 2001). This provides a built-in mechanism for demystification and verification. A vocational student can test an AI-suggested welding parameter against actual weld quality, or compare an AI diagnostic recommendation with a physical inspection. This process of falsification through material reality transforms AI from an opaque oracle into a testable tool. As Riis (2025) notes, “The workshop is an AI testing ground that no simulation can replace” (p. 47).

Sennett's (2008) concept of craftsmanship further illuminates this advantage. Craftsmanship—the desire to do a job well for its own sake, questioning received wisdom and exploring alternatives—is precisely the disposition that AI literacy requires. The vocational practitioner who understands the limits of AI (what it

cannot sense or verify) is better positioned to use AI appropriately. Unfortunately, this potential remains largely unrealized. In most TVET programmes, AI is introduced as a digital tool disconnected from physical practices. The material verification step is often omitted due to time pressure or a mistaken belief that “AI is always right.” Reclaiming material verification as a core pedagogical practice is a priority for the paradigm shift this paper advocates.

Technology ethicists describe a concept known as “appropriate trust”—the ability to measure one’s reliance on an AI output using verifiable evidence instead of unexamined system authority (Ridley & Pawlick, 2025). In practical terms, TVET educators should regularly pose a reflective question to learners: “Would you risk your professional reputation on what this AI recommends?” This kind of inquiry converts the abstract problem of epistemic precarity into a concrete, hands-on exercise. Take, for example, an automotive student who cross-checks an AI-generated diagnosis against a physical compression test. Such verification cultivates a disposition that pure tool training cannot produce: professional scepticism anchored in tangible reality. Consequently, the workshop environment evolves from a mere site of AI application into a testing ground for algorithmic outputs. This approach holds special importance in high-risk vocational domains—healthcare, manufacturing, and construction—where thoughtless acceptance of AI-generated advice can lead to genuine harm. By making verification a standard pedagogical routine, TVET reasserts its traditional strength: teaching learners to trust, but always confirm, through their own sensory and manual engagement.

Responding to Counterarguments

Counterargument 1: Foundational understanding is unnecessary for entry-level workers. The paper acknowledges that the depth of AI literacy varies by role. However, even entry-level workers face situations where AI outputs are wrong. The worker who cannot recognize when to override an AI output is not just less effective; they may be dangerous. Foundational understanding supports lifelong adaptability.

Counterargument 2: Curriculum time is too limited. AI literacy should not be an add-on but an integration. The five-strategy framework (Riis, 2025) shows how AI literacy can be woven into existing vocational tasks without requiring separate courses.

Counterargument 3: AI is designed to be user-friendly; understanding internals is irrelevant. User-friendly interfaces hide confidence intervals, bias profiles, and failure modes. Understanding basic principles—how models are trained, what data they rely on, what statistical probability means—is directly relevant to using them well.

The Risk of Inaction

If TVET systems persist with tool-centric approaches, graduates will enter the workforce as passive consumers, accelerating deskilling. Tool-specific skills become obsolete quickly, whereas foundational knowledge—how models are trained, how bias enters data, how to test for consistency—transfers across tools.

Conclusion and Implications

Summary

This paper has argued that TVET’s current approach to AI is dangerously superficial. Even with the proliferation of AI tools, instruction that builds critical and evaluative AI literacy remains rare. The dominant tool-centric approach produces uncritical, passive consumers rather than reflective, questioning practitioners.

Recommendations

For policymakers: National TVET authorities should mandate comprehensive AI literacy as a core competency across all qualifications (Wang et al., 2025). Investment in teacher professional development is paramount; most TVET educators currently lack basic AI literacy (Al Yakin et al., 2025; Deng et al., 2026). Funding models should incentivize curricula that integrate critical AI literacy and support AI infrastructure, especially for underrepresented institutions.

For educators: TVET educators should adopt multifaceted frameworks like Riis's (2025) model, deliberately integrating AI-independent learning to preserve core judgment skills. By leveraging TVET's material pedagogy to test AI outputs against physical reality, educators can embed critical literacy into every vocational task.

TVET is where abstract knowledge meets material practice, where theory is tested against reality, where learners become practitioners. In the age of AI, this position is more vital than ever. The worker who can only use AI is a cog in a machine; the worker who can understand, evaluate, and shape AI is a craftsman. TVET has the pedagogy, the mission, and the material grounding to cultivate the latter. The question is whether the global TVET community will seize this opportunity.

References

- Al Yakin, A. M., Muthmainnah, M., Obaid, A. J., Al Matari, A. S., Cardoso, L., & Azar, A. S. (2025). Fostering AI literacy in TVET and professional development frameworks for educators in the 21st century. In A. S. Azar, S. K. Gupta, H. Taherdoost, & F. Alhamaty (Eds.), *Integrating AI and sustainability in technical and vocational education and training (TVET)* (pp. 151–176). IGI Global.
- BIBB (Bundesinstitut für Berufsbildung). (2023). *Künstliche Intelligenz in der beruflichen Aus- und Weiterbildung: Stand und Perspektiven [Artificial intelligence in initial and continuing vocational education and training: Status and perspectives]*. BIBB.
- China Ministry of Education. (2026). *Opinions on deepening the reform of key teaching elements of vocational education [Policy document]*. Beijing: Ministry of Education.
- Deng, L., Li, C., Wu, F., & Zhang, X. (2026). New pathways for diversified development in vocational education through artificial intelligence. *International Journal of Learning and Teaching*, 12(1), 77–82. <https://doi.org/10.18178/ijlt.12.1.77-82>
- El Hayani, M., & Benamar, F. (2025). A conceptual framework for a symbiotic integration of generative AI in post-secondary technical and vocational education and training (TVET): Bridging pedagogy, technology, and ethics. *International Journal of Accounting, Finance, Auditing, Management and Economics*, 6(9), 319–339.
- Felix, E. (2020). Material pedagogy: A new materialist view of teaching and learning. In L. E. W. B. (Ed.), *Posthumanism and higher education* (pp. 45–62). Palgrave Macmillan.
- Gamble, J. (2001). Modelling the invisible: The pedagogy of craft apprenticeship. *Studies in Continuing Education*, 23(2), 185–200.
- Gao, H., & Tan, Y. (2025). AI differences in vocational and undergraduate higher education: A systematic review. *Higher Education Studies*, 15(4), 398–408.
- König-Ziegler, S., Bauer, T., Goller, M., & Förster, M. (2025). Current use of artificial intelligence as a learning, support and reflection tool for learners in a vocational context – A systematic literature review. In K. Kögler, H.-H. Kremer, & V. Herkner (Eds.), *Yearbook of vocational and business education research 2024* (pp. 131–154). Springer.
- Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education: A scoping literature review. *Computers and Education: Artificial Intelligence*, 3, 100101. <https://doi.org/10.1016/j.caeai.2022.100101>

- Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–16. <https://doi.org/10.1145/3313831.3376727>
- Metreveli, A., Chen, X., Hedman, A., & Sergeeva, A. (2025). “Who will be left behind?”: A Swedish case of learning AI in vocational education. *International Journal of Educational Research*, 133, 102697. <https://doi.org/10.1016/j.ijer.2025.102697>
- Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, 2, 100041. <https://doi.org/10.1016/j.caeai.2021.100041>
- Ran, Y., & Han, Y. (2023). Application of artificial intelligence in vocational education: A review. In *Proceedings of the 2023 International Conference on Artificial Intelligence and Education* (pp. 1024–1028). ACM.
- Ridley, G., & Pawlick, J. (2025). Epistemic courage in the age of AI: A mixed-methods study of healthcare vocational students. *Journal of Vocational Education and Training*, 77(2), 252–270.
- Riis, M. (2025). Between wood and algorithms: Crafting AI literacy in TVET. UNESCO. <https://www.unesco.org/en/articles/between-wood-and-algorithms-crafting-ai-literacy-tvet>
- Sennett, R. (2008). *The craftsman*. Yale University Press.
- Shen, Y., Li, Z., & Chen, X. (2024). Enhancing practical training in vocational education through AI-driven simulations. *Journal of Educational Technology & Society*, 27(1), 111–119.
- Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., McGuire, J., & Smithers, K. (2018). *Artificial intelligence and emerging technologies in schools: A research report*. Australian Government Department of Education.
- Sullivan, J., & Kelly, M. (2024). Epistemic precarity in the age of generative AI: Implications for professional education. *Educational Philosophy and Theory*, 56(3), 214–228.
- UNESCO. (2019). *Beijing Consensus on Artificial Intelligence and Education*. UNESCO.
- UNESCO-UNEVOC. (2023). *Content-integrated AI learning in TVET (BILT Project Report)*. UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training.
- Wang, Y., Chen, H., & Zhang, L. (2025). Development and validation of a competency-based ladder pathway for AI literacy enhancement among higher vocational students. *Scientific Reports*, 15, 29898. <https://doi.org/10.1038/s41598-025-15202-6>