



INTERNATIONAL JOURNAL OF
MODERN EDUCATION
(IJMOE)
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CONSTRUCTIVIST FOUNDATIONS FOR CULTIVATING ARTIFICIAL INTELLIGENCE LITERACY IN VOCATIONAL EDUCATION

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Article Info:

Article history:

Received date: 27.07.2026

Revised date: 19.08.2026

Accepted date: 20.09.2026

Published date: 28.09.2026

To cite this document:

Pei, L., & Musta'amal, A. H. (2026). Constructivist Foundations for Cultivating Artificial Intelligence Literacy in Vocational Education. *International Journal of Modern Education*, 8(31), 1482-1498.

Abstract:

Knowledge through prior experiences, authentic contexts, social interactions, and reflection. Grounded in Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism, constructivism provides important insights into how learners develop knowledge and competencies. With the growing integration of artificial intelligence (AI) into education and workplaces, AI literacy has become an essential competency. In this paper, AI literacy refers to the ability to understand AI concepts, apply AI appropriately in learning and occupational tasks, and critically evaluate AI technologies, outputs, and associated ethical issues. However, AI literacy education in higher vocational institutions continues to face challenges, including fragmented knowledge delivery, limited authentic learning experiences, and insufficient opportunities for practical application and reflection. Existing studies have largely focused on defining AI literacy competencies and identifying relevant knowledge and skills, while providing less explanation of how these competencies develop through learning processes, particularly in higher vocational contexts. This paper aims to integrate constructivist principles to develop a conceptual framework for explaining AI literacy development in higher vocational education. Through conceptual analysis, relevant literature on constructivism, AI literacy, and vocational education is examined by identifying key theoretical principles and analysing their relationships with the understanding, application, and evaluation of AI. The paper considers how situated learning, collaborative learning, anchored instruction, and experiential learning may support AI literacy development. It further conceptualises AI not only as an instructional tool but also as a cultural mediating artifact that may influence how

learners access information, engage in dialogue, solve problems, and construct knowledge. Based on the conceptual analysis, this paper proposes “understanding–application–reconstruction” as a constructivist learning process rather than an established stage model. Within this process, learners develop AI knowledge, apply AI technologies in authentic contexts, critically evaluate AI processes and outputs, and reconstruct their understanding through practice and reflection. The proposed framework provides a theoretical basis for AI curriculum design and learner-centred instructional practices in vocational education, while requiring further empirical validation.

DOI: 10.35631/IJMOE.831086

Keyword:

Constructivism; Knowledge Construction; Artificial Intelligence Literacy; Vocational Education; Learning Theory



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Introduction

Research Background

Artificial intelligence (AI) is reshaping industries, occupational practices, education, and everyday life. As interaction with AI becomes increasingly common, individuals need more than basic digital skills; they must be able to understand AI, use it appropriately, critically evaluate its outputs, and consider its ethical implications. Accordingly, AI literacy has been defined as a set of competencies that enables individuals to understand, communicate and collaborate with, and critically evaluate AI technologies (Long & Magerko, 2020). Subsequent reviews have further identified understanding, application, evaluation, creation, and ethical awareness as recurring components of AI literacy (Ng et al., 2021; Almatrafi et al., 2024).

AI literacy is particularly relevant to vocational education because vocational learning connects knowledge with practical competence and prepares students to participate in changing occupational practices (Billett, 2011). Higher vocational students therefore need not only to understand AI concepts and operate AI tools but also to select appropriate technologies, apply them to authentic tasks, verify generated outputs, and make responsible decisions in different professional contexts. AI literacy in vocational education should consequently be developed as a transferable capability rather than as specialised technical knowledge limited to computing-related disciplines.

Existing AI literacy research has made important progress in defining competencies, developing conceptual frameworks, and exploring teaching and assessment approaches. However, reviews of higher and adult education indicate that this field remains at an early stage and continues to focus heavily on defining AI literacy and determining what non-experts should learn (Laupichler et al., 2022). A broader systematic review similarly found that the literature

has primarily examined AI literacy constructs, implementation approaches, and assessment efforts (Almatrafi et al., 2024). These studies clarify what AI literacy includes but provide less explanation of how learners progressively develop AI understanding, practical application, critical evaluation, and ethical judgement through learning experiences.

The educational contexts examined in previous studies also reveal a gap. Major reviews have concentrated on K–12 education and general higher or adult education, while higher vocational education has received comparatively limited theoretical attention (Casal-Otero et al., 2023; Laupichler et al., 2022). Casal-Otero et al. (2023) found that many AI literacy learning experiences emphasised technical and applied skills within specific domains and called for more holistic, active, collaborative, and problem-oriented approaches. However, how such approaches can be systematically connected with AI literacy development in authentic vocational contexts remains insufficiently explained.

Constructivist learning theory provides a relevant perspective for addressing this gap. Piaget's cognitive constructivism explains how learners connect new experiences with prior knowledge and reconstruct their cognitive structures through assimilation and accommodation (Piaget, 1972). Vygotsky's sociocultural constructivism emphasises that learning is mediated by social interaction, cultural tools, and guidance within the learner's zone of proximal development (Vygotsky, 1978). These perspectives correspond with vocational learning, which commonly involves authentic tasks, practical experience, collaboration, problem-solving, and reflection. Constructivism may also help explain the role of AI in the learning process. AI can provide information, feedback, alternative explanations, and support for problem-solving, thereby influencing how learners interact with knowledge and revise their understanding. From a sociocultural perspective, AI may therefore be conceptualised as a cultural mediating artifact rather than merely as an instructional tool. However, its educational value depends on how learners interpret, verify, and act upon AI-generated information within carefully designed learning activities (Engeness & Gamlem, 2025).

In this paper, AI literacy comprises three interrelated dimensions: understanding AI, applying AI, and evaluating AI. Understanding AI includes knowledge of AI concepts, capabilities, limitations, application contexts, and ethical implications. Applying AI involves selecting and using AI appropriately in authentic learning and occupational tasks. Evaluating AI involves examining technological suitability, output reliability, practical value, bias, and ethical risks. Therefore, this paper integrates cognitive and sociocultural constructivist perspectives to develop a conceptual framework explaining how these dimensions may develop through authentic practice, social interaction, scaffolding, collaboration, and reflection in higher vocational education.

Research Questions

This study addresses the following research questions:

- RQ1: What are the fundamental principles and theoretical foundations of constructivist learning theory, particularly from the perspectives of cognitive constructivism and sociocultural constructivism, that are relevant to AI literacy development in higher vocational education?

- RQ2: How can constructivist learning principles, including authentic contexts, collaboration, dialogue, scaffolding, and reflective practice, support higher vocational students' development of the abilities to understand, apply, and evaluate AI?
- RQ3: How can constructivist theory be integrated into a conceptual framework for AI literacy development and provide implications for AI curriculum design, instructional strategies, assessment, and learning environments in vocational education?

Research Objectives and Significance

Theoretical Significance

This study contributes to theoretical development in three major ways.

First, it provides a systematic theoretical examination of constructivist learning theory by integrating Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism. Piaget's perspective explains how learners construct and revise knowledge through experience, assimilation, and accommodation, whereas Vygotsky's perspective emphasises the roles of social interaction, cultural tools, and scaffolding in cognitive development (Piaget, 1972; Vygotsky, 1978). By examining constructivist perspectives on knowledge, learning, and teaching, this study clarifies how cognitive processes, social interaction, and contextualised experiences may jointly contribute to the development of AI literacy among higher vocational students.

Second, this study extends existing AI literacy research by establishing a theoretical relationship between constructivism and AI literacy development. Previous studies have made important contributions by defining AI literacy competencies and identifying the knowledge, application, evaluation, and ethical capabilities required for engagement with AI (Long & Magerko, 2020; Ng et al., 2021; Almatrafi et al., 2024). Building on this work, the present study focuses on the learning processes through which these competencies may develop. From a constructivist perspective, AI literacy involves not only the acquisition of technological knowledge but also an iterative process of understanding AI, applying it in authentic contexts, evaluating its technologies and outputs, and reconstructing knowledge through practice and reflection. In this process, understanding, application, and evaluation represent the core dimensions of AI literacy, while reconstruction represents the learning process through which learners revise and deepen these competencies.

Third, this study extends the application of Vygotsky's sociocultural theory to contemporary AI-supported learning by conceptualising AI as a cultural mediating artifact. AI differs from many static learning resources in its capacity to interact with learners, generate information, provide feedback, and support dialogue and problem-solving. These functions may influence how learners access information, externalise their thinking, compare alternative perspectives, and revise their understanding. Recent research has similarly examined AI-generated feedback as a cultural tool that mediates learners' engagement with knowledge and learning activities (Engeness & Gamlem, 2025). This perspective therefore expands the understanding of how technological artifacts may participate in cognitive development and knowledge construction, while recognising that their educational value depends on learners' critical evaluation and on appropriate guidance from teachers and peers.

Practical Significance

From a practical perspective, this study provides implications for curriculum design, instructional practice, assessment, and learning environment development in higher vocational education.

First, constructivist learning theory provides a theoretical basis for connecting AI curricula with authentic vocational contexts. AI curricula can combine conceptual knowledge and tool operation with realistic workplace problems and project-based activities. Vocational learning is closely connected with participation in occupational practices and the development of knowledge and competence for work (Billett, 2011). Similarly, AI literacy education may benefit from active and collaborative learning activities organised around real-world problems (Casal-Otero et al., 2023). Integrating AI into authentic occupational tasks may therefore help students connect conceptual understanding with practical experience and apply their learning across different professional situations.

Second, this study highlights the importance of learner-centred instructional practices in AI education. From a constructivist perspective, teachers can facilitate learning by designing meaningful tasks, providing appropriate scaffolding, and encouraging inquiry, collaboration, verification, and reflection. AI technologies may be used to provide information, feedback, and alternative solutions, while teachers and peers remain important in guiding students to examine the accuracy, suitability, and ethical implications of AI-generated content. The educational value of AI-mediated feedback depends on how it is incorporated into structured learning activities and how learners interpret and act upon it (Engeness & Gamlem, 2025).

Third, the findings suggest that AI literacy assessment should consider both learning outcomes and the processes through which students complete AI-supported tasks. In addition to evaluating final products, assessment may examine students' task analysis, selection and use of AI tools, verification of outputs, collaborative participation, ethical judgement, reflection, and revision. Methods such as project documentation, learning portfolios, reflective journals, presentations, and peer feedback may provide evidence of these processes. Such approaches are consistent with authentic assessment, which connects assessment tasks, contexts, criteria, and expected performance with professional practice (Gulikers et al., 2004).

Finally, constructivist principles provide guidance for creating AI-supported learning environments that integrate technology, authentic tasks, and social interaction. These environments can provide opportunities for students to explore AI applications, compare alternative solutions, discuss different perspectives, and reflect on the consequences of AI use. By combining occupational contexts, technological resources, teacher guidance, and peer collaboration, higher vocational institutions may support the development of practical problem-solving, critical evaluation, independent learning, and responsible AI use.

Structure of the Paper

The remainder of this paper is organized as follows. The first section reviews the development of constructivist learning theory, distinguishing between cognitive constructivism and sociocultural constructivism while examining constructivist perspectives on knowledge, learning, and teaching. The second section discusses the application of constructivism in vocational education, focusing on Anchored Instruction, situated workplace learning, tacit

knowledge development, and learner agency. The third section explores the theoretical implications of constructivism for AI education by comparing the strengths and limitations of its two major theoretical perspectives and examining the educational role of AI as a cultural mediating tool. The fourth section proposes a constructivist framework for AI education centered on the integrated learning process of constructing, experimenting, and reflecting. Finally, the paper concludes by summarizing the major findings, discussing implications for curriculum reform and instructional practice in vocational education, and outlining the study's limitations and directions for future research.

Development and Theoretical Foundations of Constructivist Learning Theory

Since the 1980s, constructivist learning theory has become increasingly influential in educational research. Existing literature generally describes constructivism as a perspective that shifts attention from the transmission of knowledge to learners' active construction of meaning (Palincsar, 1998). From this perspective, learning involves interpreting new information through prior knowledge and continuously revising understanding through experience, interaction, and reflection.

The modern theoretical foundations of constructivism are commonly associated with Piaget's theory of cognitive development, Bruner's discovery learning, and Vygotsky's sociocultural theory. Although these perspectives differ in emphasis, they share the view that learners actively participate in the learning process rather than simply receiving knowledge. Knowledge is constructed and reconstructed as learners interact with their environment, other individuals, and meaningful learning contexts (Bruner, 1961; Piaget, 1972; Vygotsky, 1978).

According to the literature, constructivism can generally be discussed from two major perspectives: cognitive constructivism and sociocultural constructivism. Cognitive constructivism, represented by Piaget, views learning as a process in which individuals develop and adapt their cognitive structures through assimilation and accommodation. Sociocultural constructivism, associated with Vygotsky, places greater emphasis on the roles of language, culture, social interaction, and cultural tools in cognitive development. Vygotsky's concept of the Zone of Proximal Development further suggests that learners may achieve a higher level of performance through appropriate guidance or collaboration with more capable others (Vygotsky, 1978).

Piaget's theory of cognitive development provides an important foundation for cognitive constructivism. Piaget (1972) proposed that learners actively organise experience through cognitive structures or schemas. Assimilation occurs when new information is incorporated into existing cognitive structures, whereas accommodation involves modifying those structures in response to experiences that cannot be adequately explained by existing understanding. The interaction between assimilation and accommodation enables learners to establish, revise, and refine their knowledge continuously.

Vygotsky's sociocultural perspective further highlights that cognitive development is situated within social and cultural contexts. Learners possess both an actual developmental level and a potential developmental level, and appropriate guidance may enable them to perform beyond what they can achieve independently. Language, cultural tools, teachers, and peers can mediate this developmental process. Learning is therefore understood not only as an individual

cognitive activity but also as a socially mediated process involving participation, communication, and guidance (Vygotsky, 1978).

Taken together, cognitive and sociocultural constructivism provide complementary explanations of knowledge construction. Cognitive constructivism focuses primarily on how learners process experience and reorganise their internal cognitive structures. Sociocultural constructivism explains how this process is influenced by social interaction, cultural contexts, and mediating tools. Through collaboration, dialogue, negotiation, and shared inquiry, learners may compare different perspectives and continuously refine their understanding (Palincsar, 1998).

The constructivist literature also reconsiders the roles of teachers and learners. Learners are viewed as active participants in knowledge construction, while teachers facilitate learning by designing meaningful activities, providing appropriate guidance, and supporting inquiry, collaboration, and reflection. This does not eliminate the teacher's responsibility for providing knowledge and structure; instead, it emphasises that teaching should create conditions in which learners can connect new information with prior knowledge and participate actively in the development of understanding.

Overall, constructivist learning theory places learners at the centre of the learning process and emphasises the importance of prior knowledge, meaningful contexts, active engagement, social interaction, and reflection. From an epistemological perspective, learners' understanding is continuously interpreted, refined, and reconstructed through experience and interaction. These theoretical principles provide the foundation for the following discussion of how knowledge, learning, and teaching are conceptualised within constructivism and how these principles may subsequently be applied to AI literacy development in higher vocational education.

Constructivist Perspectives on Knowledge, Learning, and Teaching

From the perspective of knowledge, constructivism holds that knowledge is not simply received as a fixed body of information but is interpreted and constructed by learners based on their prior knowledge and experiences within particular contexts. As learners encounter new information and experiences, their understanding may be continuously refined and reconstructed. Differences in prior knowledge, life experience, and cultural background may therefore lead learners to interpret the same information in different ways. This perspective does not necessarily deny the existence of disciplinary knowledge; rather, it emphasises that learners develop their understanding of such knowledge through active interpretation, experience, and interaction with their environments (Piaget, 1972; Vygotsky, 1978).

Based on this epistemological perspective, constructivism argues that the acquisition of new knowledge cannot be fully explained as a one-way transmission from teachers to learners. Learners connect and integrate new information with their existing knowledge, modifying their cognitive structures when new experiences cannot be adequately explained by their previous understanding. Because the meaning and application of knowledge are influenced by context, meaningful learning is supported when learners have opportunities to apply knowledge to authentic situations and problems. Prior knowledge therefore provides an important foundation for understanding, applying, and transferring new knowledge.

From the perspective of learning, constructivism views learning as an active process in which learners interpret information through their existing knowledge and experiences within particular social and cultural contexts. Learning involves knowledge acquisition as well as reflection, interpretation, negotiation, and the reorganisation of relationships between prior and new knowledge. The literature therefore associates constructivist learning with problem-solving, collaboration, authentic tasks, inquiry, and dialogue. These activities may enable learners to compare perspectives, examine their understanding, and construct meaning through active exploration and social interaction (Palincsar, 1998).

From the perspective of teaching, constructivism emphasises that teachers act not only as providers of knowledge but also as designers, organisers, and facilitators of learning activities. Instructional design should consider learners' prior knowledge and provide meaningful and appropriately challenging learning experiences. Through explanation, questioning, collaboration, inquiry, and reflective practice, teachers can provide the guidance and scaffolding needed for learners to construct understanding. Learners are consequently positioned as active participants who interpret experience, collaborate with others, and refine their knowledge through interaction with teachers, peers, and the learning environment. This perspective does not exclude direct instruction but situates it within a broader process of guided knowledge construction.

Constructivism has influenced contemporary curriculum and instructional theory and is particularly relevant to vocational education. Vocational education emphasises the relationship between conceptual knowledge, occupational practice, workplace contexts, and the development of professional competence (Billett, 2011). These characteristics correspond with constructivist principles such as contextualised learning, active participation, collaboration, and reflection. Examining vocational education from a constructivist perspective may therefore provide a theoretical basis for understanding how vocational students develop competencies through the integration of knowledge and practice and, subsequently, how these principles may inform the development of an AI literacy framework for higher vocational students.

Application of Constructivism in Vocational Education

From the perspective of vocational education, constructivism is not only a learning theory but also an important theoretical foundation for curriculum reform and instructional practice. Wu (2018) identified Anchored Instruction and Situated Learning as two important constructivist approaches to vocational teaching and learning. Anchored Instruction organises learning around authentic and representative problems, referred to as “anchors,” which serve as the central focus of instructional activities (Cognition and Technology Group at Vanderbilt, 1990). Through analysing, exploring, and solving these problems, learners are encouraged to integrate theoretical knowledge with practical application. In AI literacy education, an anchor may take the form of an occupational task that requires students to analyse task requirements, select appropriate AI tools, evaluate AI-generated outputs, and refine the final solution.

Situated Learning emphasises that knowledge and competence develop through participation in meaningful social practices (Lave & Wenger, 1991). In vocational education, knowledge acquisition provides an important foundation for developing technical skills and professional competencies. Practical experience in authentic or simulated occupational contexts may help students connect conceptual understanding with professional application. In AI literacy

education, situated learning may also help students recognise that the suitability, reliability, and ethical consequences of AI use depend on particular tasks and occupational contexts.

Based on these principles, constructivism views knowledge as meaning actively constructed by learners through interaction with their environments, other individuals, and practical activities within particular contexts. Context, collaboration, conversation, and meaning construction provide important conditions for this process. Learning develops through communication, collaboration, problem-solving, and the sharing of experiences within authentic contexts. Accordingly, constructivist vocational education emphasises active exploration, workplace practice, collaborative interaction, and reflective learning (Wu, 2018). Within this process, conversation and collaboration play important roles. Through questioning, discussion, demonstration, interviews, and presentations, learners can share experiences, compare perspectives, and refine their understanding. In AI-supported vocational learning, collaborative activities may enable students to compare AI-generated outputs, examine alternative solutions, identify limitations or risks, and negotiate responsibility for the final outcome. Meaning construction is reflected in learners' continuous refinement of prior understanding through practice, dialogue, and reflection.

From the perspective of cognitive development, learning involves continuous interaction with the environment and the revision of cognitive structures. Wang (2022) noted that Piaget identified assimilation and accommodation as two fundamental mechanisms of cognitive development. Assimilation refers to integrating new information into existing cognitive structures, whereas accommodation involves modifying those structures in response to new experiences. In AI literacy development, learners may connect new AI concepts with their existing technological and professional knowledge. When they encounter inaccurate, biased, or unsuitable AI outputs, they may need to revise their previous assumptions about AI capabilities and limitations.

Constructivist vocational education also places importance on cultivating learner agency. Ai (2007) argued that vocational curricula should help students acquire disciplinary knowledge and professional skills while supporting creativity, knowledge construction, and professional ethics. In the context of AI literacy, learner agency may involve deciding whether and how AI should be used, monitoring its contribution to a task, verifying its outputs, and accepting responsibility for the final decision. These abilities are relevant to autonomous learning, technological understanding, and responsible AI use.

Authentic learning environments include physical, cognitive, and social dimensions. Well-designed environments may stimulate learners' interest, support collaboration, and provide opportunities to integrate theoretical knowledge with practical skills. For AI literacy development, these environments may include realistic workplace problems, simulated professional scenarios, collaborative projects, and opportunities to evaluate and revise AI-supported solutions. However, their educational value depends on task design, teacher guidance, learner participation, and opportunities for reflection.

Furthermore, constructivist vocational curricula emphasise learners' active participation in developing technical and practical experience. Xu (2014) argued that exploration, creativity, and autonomous knowledge construction are important principles of vocational curriculum implementation. In addition to factual and procedural knowledge, vocational curricula may support the development of tacit and contextual knowledge through activities related to

production, operation, management, and service. Integrating authentic tasks, guided practice, collaboration, and reflection may therefore provide a theoretical foundation for developing higher vocational students' abilities to understand, apply, and evaluate AI in professional contexts.

Theoretical Implications of Constructivism for Artificial Intelligence Education

As discussed earlier, constructivist learning theory has gained increasing prominence in educational research since the 1980s (Slavin et al., 2003; Chen & Liu, 1997). Its two major perspectives are commonly associated with Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism. Piaget argued that learners continuously construct and reorganise their cognitive structures through interactions with the environment and through the processes of assimilation and accommodation (Piaget, 1967, 1972; Kamii & Ewing, 1996). Vygotsky emphasised the role of sociocultural contexts, language, and social interaction in cognitive development. His concept of the Zone of Proximal Development suggests that learning and development may be supported through guidance and collaboration with others (Vygotsky, 1978). Although these perspectives differ in emphasis, they provide complementary explanations of learning: Piaget focuses primarily on the internal reconstruction of knowledge, whereas Vygotsky explains how this process is socially and culturally mediated.

These complementary perspectives are relevant to different aspects of AI literacy development. Piaget's cognitive constructivism may explain how learners connect new AI knowledge with their existing cognitive structures and revise their understanding when they encounter inaccurate, biased, or unsuitable AI outputs. However, individual cognitive processes alone do not fully explain learners' interactions with technological tools and sociocultural environments (Piaget, 1977; Wegerif, 2002). Vygotsky's theory of mediation provides an additional perspective by explaining how social interaction and cultural tools participate in learning. From this perspective, AI may be conceptualised as a contemporary cultural mediating artifact that influences how learners' access and organise information, formulate questions, receive feedback, compare alternatives, and solve problems (Wertsch, 2003; Kozulin, 2003). Technology can therefore function not only as a medium through which learning takes place but also as an artifact that shapes learners' activities and thinking processes (Cole & Derry, 2005). Recent research has similarly examined AI-generated feedback as a cultural tool that mediates learners' engagement with knowledge and learning activities (Engeness & Gamlem, 2025). Nevertheless, AI does not automatically support cognitive development; its educational value depends on how learners interpret, verify, and apply its outputs and on the guidance provided by teachers and peers. This perspective may provide a theoretical basis for an AI literacy framework that connects cognitive development, practical application, critical evaluation, and social interaction (Yim, 2024).

Furthermore, constructivism regards learners as active constructors of meaning, while teachers provide knowledge, design learning activities, and offer appropriate scaffolding (Piaget, 1972; Vygotsky, 1978). This perspective corresponds with the interactive and feedback-generating characteristics of generative AI technologies. For example, when using tools such as ChatGPT, learners can ask questions, examine alternative explanations, verify information, revise their responses, and reflect on their learning experiences. These iterative interactions may support learners in developing their understanding of AI concepts and application logic within authentic contexts (Grubaugh et al., 2023). At the same time, teacher guidance and peer

interaction remain necessary to help learners identify inaccurate information, evaluate the appropriateness of AI-generated responses, and consider related ethical implications.

Constructivism further explains learning as a dynamic process in which learners connect conceptual understanding with practical competence through exploration, social interaction, and reflection within meaningful contexts (Piaget, 1972; Vygotsky, 1978; Fosnot, 1996). This perspective is applicable to AI literacy development. Learners need to acquire fundamental AI concepts and understand supporting elements such as data, data quality, and data diversity (Halagatti et al., 2023). They also need opportunities to apply AI in authentic tasks, compare alternative solutions, evaluate the reliability and suitability of AI outputs, and adjust their application strategies. Based on this conceptual analysis, the present paper uses “understanding–application–reconstruction” to describe an iterative constructivist learning process rather than an established stage model. Within this process, understanding and application are accompanied by the continuous evaluation of AI technologies and outputs, while reconstruction occurs when learners revise their knowledge and application strategies through practice and reflection. Thus, understanding, application, and evaluation represent core dimensions of AI literacy, whereas reconstruction describes the learning process through which these competencies may be further developed.

Artificial Intelligence Education from a Constructivist Perspective

Constructivist learning theory is highly compatible with artificial intelligence (AI) education and continues to shape the development of AI literacy education (Kahn & Winters, 2021). From a constructivist perspective, learners are expected not only to understand AI-related knowledge but also to actively construct knowledge through practice, creation, and reflection. Accordingly, contemporary AI education encourages students to produce authentic and creative computational artifacts (Touretzky et al., 2019), develop technical competence through programming and AI application activities (Casal-Otero et al., 2023), and cultivate computational thinking by solving authentic, real-world problems (Van Brummelen et al., 2019; Williams et al., 2019).

Biagini et al. (2024) further argued that constructivism has shifted AI literacy education from merely understanding AI toward experiencing AI. This shift is captured by the principle of “Learning AI through constructing, experimenting, and reflecting,” which emphasizes that AI learning should occur through active construction, experimentation, and reflection. This perspective highlights learners’ active inquiry using digital tools, media, and authentic learning environments, such as AI technologies to create meaningful learning artifacts and continuously transform personal experiences into new knowledge construction (Ackermann, 2001; Papert, 1980). Early constructivist practices primarily relied on digital tools such as simulators, mobile applications, and educational robots to support learning (Ng et al., 2021). More recently, with the emergence of generative artificial intelligence, new learning activities such as digital storytelling have increasingly been incorporated into constructivist instructional practices, providing learners with more open, authentic, and diverse environments for knowledge construction (Hafner & Miller, 2011).

Discussion and conclusion

Constructivist learning theory provides a valuable theoretical foundation for understanding AI literacy development in higher vocational education. The conceptual analysis suggests that AI

literacy involves not only the acquisition of technical knowledge and operational skills but also an ongoing process in which learners connect knowledge with experience, apply AI in authentic contexts, evaluate its technologies and outputs, and revise their understanding through reflection. Conceptual knowledge and tool operation provide necessary foundations, while authentic practice, social interaction, and reflective evaluation may help learners apply and adapt these foundations across different tasks and professional situations.

Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism provide complementary explanations of this process. Piaget's perspective explains how learners connect new AI knowledge with existing cognitive structures and revise their understanding through assimilation and accommodation. This process is relevant to students' understanding of AI concepts, technical principles, capabilities, and limitations. Vygotsky's sociocultural perspective explains how this individual cognitive development is mediated by teachers, peers, cultural contexts, and technological tools. It is particularly relevant to the application and evaluation of AI through scaffolding, collaboration, dialogue, and participation in meaningful vocational activities. AI may also be conceptualised as a contemporary cultural mediating artifact because it can influence how learners access information, formulate questions, receive feedback, compare alternatives, and solve problems. However, this mediating role depends on learners' ability to interpret and verify AI-generated information and on the guidance provided within the learning environment (Engeness & Gamlem, 2025).

The principal theoretical contribution of this study lies in integrating these constructivist principles into a structured explanation of AI literacy development in higher vocational education. Previous studies have primarily identified the competencies required to understand, use, and critically evaluate AI (Long & Magerko, 2020; Almatrafi et al., 2024). Building on this work, the present study focuses on how these competencies may develop through prior experience, cognitive reconstruction, authentic practice, social interaction, scaffolding, collaboration, and reflection. It therefore connects the individual cognitive processes emphasised by Piaget with the socially and technologically mediated processes emphasised by Vygotsky. It also extends the application of sociocultural theory by considering how interactive AI technologies may participate in, but not independently determine, learners' knowledge construction.

The analysis further suggests that constructivist principles may provide a coherent learning process for connecting the three dimensions of AI literacy: understanding AI, applying AI, and evaluating AI. Understanding provides the conceptual and technical basis for selecting and using AI. Application enables learners to test this knowledge in authentic tasks, while evaluation requires them to examine technological suitability, output reliability, practical value, and ethical implications. In the conceptual framework proposed in this paper, "understanding–application–reconstruction" describes an iterative learning process rather than an established or strictly linear stage model. Evaluation operates throughout application and reflection, enabling learners to identify limitations, compare alternatives, and reconstruct their knowledge and application strategies. Thus, understanding, application, and evaluation represent the core dimensions of AI literacy, whereas reconstruction describes the process through which these competencies may be refined.

These theoretical relationships also have implications for AI education in vocational contexts. Anchored instruction, situated learning, experiential learning, and collaborative learning may provide opportunities for students to connect AI concepts and tool operation with workplace

problems, professional standards, and ethical responsibilities. Vocational curricula can therefore combine systematic instruction in AI knowledge and technical skills with project-based activities and authentic occupational tasks. This connection is consistent with the emphasis of vocational education on integrating conceptual knowledge with participation in occupational practice (Billett, 2011).

From a pedagogical perspective, teachers remain responsible for explaining foundational knowledge and establishing appropriate learning goals while also designing meaningful tasks, providing scaffolding, guiding inquiry, and supporting collaboration and reflection. Assessment can similarly consider both students' final outcomes and the processes through which they analyse tasks, select AI tools, verify outputs, justify decisions, collaborate with others, and revise their work. These practices may provide a broader representation of AI literacy than assessment based only on conceptual knowledge or completed products. However, because this paper is conceptual, these implications should be understood as theoretically derived propositions rather than empirically established effects.

Several limitations should therefore be acknowledged. First, the proposed relationships among constructivist principles, AI literacy dimensions, and knowledge reconstruction have not been empirically validated through classroom interventions or large-scale investigations. Future studies may use case studies, experiments, longitudinal research, or mixed methods designs to examine whether and how these relationships operate in different vocational contexts. Second, the framework does not fully account for differences among vocational disciplines, institutional resources, teachers' AI competence, students' prior experience, or access to workplace collaboration. Future research may examine how these contextual factors influence the implementation and outcomes of constructivist AI literacy education. Third, because the framework was developed through conceptual analysis, its interpretation is influenced by the literature selected and the theoretical perspectives adopted. Further reviews and empirical studies may refine, extend, or challenge the proposed relationships.

In conclusion, constructivism offers an important theoretical lens for explaining how AI literacy may develop in higher vocational education. By integrating cognitive construction, social mediation, authentic practice, scaffolding, collaboration, and reflection, the proposed framework extends AI literacy research from identifying required competencies to explaining the learning processes through which these competencies may be developed. It also conceptualises AI as a cultural mediating artifact whose educational value depends on human interpretation, critical evaluation, and appropriate pedagogical guidance. Although further empirical validation is required, the framework provides a theoretical basis for connecting AI understanding, application, and evaluation with curriculum design, instructional practice, assessment, and learning environments in vocational education.

Practical Implications

This study provides practical implications for AI literacy education in higher vocational institutions. As these implications are theoretically derived, they require adaptation and empirical examination in specific contexts.

First, AI curricula may be connected with authentic workplace tasks and project-based learning. AI concepts and skills, such as data awareness, tool selection, prompt formulation, output verification, and AI-assisted decision-making, can be integrated into occupational

scenarios. Anchored Instruction and Situated Learning may help students connect conceptual knowledge with practical application across professional contexts (Billett, 2011).

Second, generative AI may serve as a learning scaffold in collaborative and inquiry-based activities. It can support questioning, information analysis, feedback, revision, and reflection. However, AI-generated information should not replace teacher guidance, peer interaction, or independent judgement. Structured discussion and reflection are needed to help students verify AI outputs and reconstruct their understanding (Engeness & Gamlem, 2025).

Third, instruction may combine explicit teaching of AI concepts and technical skills with inquiry, problem-solving, experiential learning, and reflective practice. Teachers can guide students to compare AI-generated solutions, verify information, and examine ethical implications. These activities may support technical competence, critical thinking, creativity, problem-solving, and ethical reasoning (Casal-Otero et al., 2023).

Fourth, AI literacy assessment may consider both learning outcomes and learning processes. Written examinations can assess conceptual knowledge, while authentic tasks, portfolios, reflective journals, presentations, and project documentation can evaluate students' application and evaluation abilities. Assessment criteria may include task analysis, tool selection, output verification, ethical judgement, decision justification, and responsible AI use (Gulikers et al., 2004).

Finally, vocational institutions may strengthen teacher professional development and cooperation with industry. Teachers need support in designing authentic tasks, integrating AI tools, providing scaffolding, and evaluating AI-supported learning. Industry collaboration can also provide workplace projects, simulations, and enterprise-based learning opportunities. The effectiveness of these practices will depend on institutional resources, disciplinary requirements, teacher competence, industry participation, and the quality of task design.

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- Acknowledgements:** The authors would like to acknowledge the Faculty of Educational Sciences and Technology, Universiti Teknologi Malaysia, for the academic support provided during the preparation of this manuscript. The authors also appreciate the constructive comments provided by the editor and anonymous reviewer(s), which helped improve the manuscript.
- Funding Statement:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
- Conflict of Interest Statement:** The authors declare that they have no known financial or personal conflicts of interest that could have influenced the work reported in this paper.
- Ethics Statement:** This study is conceptual in nature and is based exclusively on the analysis of previously published literature. It did not involve human participants, animals, personal data, or the collection of primary empirical data. Therefore, ethical approval and informed consent were not applicable.
- Author Contribution Statement:** Both authors contributed significantly to the development of this manuscript. Pei Liu was responsible for conceptualization, methodology, data collection, analysis, interpretation of results, literature review, and drafting the manuscript. Aede Hatib Bin Musta'amal provided methodological guidance, overall supervision, and critical revision of the manuscript. Both authors read and approved the final version prior to submission.
- Declaration on the Use of Artificial Intelligence (AI)** The authors declare that generative AI or AI-assisted technologies were used during the preparation of this manuscript. The following tool was used: ChatGPT (OpenAI). It was used to assist with language editing, grammar improvement, translation, enhancement of clarity and coherence, and revision of selected passages. It was not used to generate or analyse empirical data. All AI-assisted content, theoretical claims, and references were reviewed and verified by the authors, who take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.
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