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Reconceptualizing learning processes in vocational education: a bibliometric and conceptual synthesis

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ABSTRACT

This study examines how learning processes in vocational education can be understood as a structured and interconnected system rather than a set of isolated instructional activities. Although vocational education emphasizes practice-oriented competence, many learning designs still insufficiently connect cognitive activation, experiential engagement, knowledge construction, performance practice, and workplace transfer. A bibliometric analysis of 246 Scopus-indexed publications from 2021 to 2026 was conducted using VOSviewer-based keyword co-occurrence analysis, followed by conceptual synthesis. The findings identify six interrelated dimensions of vocational learning: cognitive activation, experiential engagement, knowledge integration, social knowledge construction, performance practice, and transfer and application. The study further interprets learning problems as process-based constraints that may accumulate across stages and affect competency formation. The resulting framework offers a basis for competency-based learning design, curriculum development, work-based learning integration, and student competency assessment in vocational education.

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1. INTRODUCTION

Vocational education is expected to prepare learners for occupational performance, adaptable problem solving, and continuous competence development. Recent studies in vocational learning, competence assessment, vocational teacher expertise, and project-based workplace learning show that competence formation depends on the integration of knowledge, practice, social interaction, and performance evidence [1]–[5]. This integration is especially important because fragmented learning processes can weaken graduate readiness, reduce the transfer of classroom learning to workplace tasks, and make it difficult for institutions to align curricula with changing industrial requirements.

A persistent problem in vocational education is that theory, practice, collaboration, and assessment are often organized as separate instructional events. When learners experience these elements without a coherent sequence, conceptual understanding may remain superficial, hands-on performance may be insufficiently scaffolded, and transfer to authentic tasks may be delayed [2], [6]–[9]. This problem suggests that the central challenge is not simply the selection of teaching techniques, but the design of a learning process that connects prior knowledge, authentic experience, knowledge integration, social construction, performance practice, and workplace application.

Learning theory provides useful foundations for addressing this challenge, but the relevant concepts are often discussed in separate bodies of literature. Bibliometric studies, including bibliometric work on dual vocational education and training (VET), can identify knowledge structures, keyword clusters, and research trends, while conceptual synthesis can interpret these patterns as relationships among learning problems, processes, and outcomes [10]–[18]. This body of evidence includes VET-focused bibliometric mapping that helps position the present study within the wider vocational education literature [12]. However, existing bibliometric work has more often described research landscapes than transformed keyword patterns into an explanatory model for vocational learning design.

The novelty of this study lies in its transformation of bibliometric keyword patterns into a process-oriented conceptual framework for vocational learning. Unlike previous bibliometric studies that mainly describe research trends, this study explains how learning problems, learning processes, and competency-oriented outcomes are sequentially connected. This contribution provides a structured basis for designing, implementing, and evaluating vocational learning activities that integrate cognitive activation, authentic experience, knowledge construction, performance practice, and workplace transfer.

Accordingly, this study aims to develop a conceptual framework of learning processes in vocational education through bibliometric analysis and systematic conceptual synthesis. The study analyzes keyword co-occurrence patterns, identifies thematic clusters, interprets learning challenges as process-based constraints, and links learning problems, process-oriented responses, and competency outcomes. The resulting framework is intended to support teachers, curriculum developers, institutions, and policymakers in designing more coherent vocational learning environments, while recognizing that future empirical validation is still required [3], [19]–[23].

2. METHOD

2.1. Research design

This study used a combined bibliometric and conceptual synthesis design to investigate how learning processes in vocational education are represented in recent scholarly literature. Bibliometric analysis was used to map keyword co-occurrence patterns and thematic relationships, while conceptual synthesis was used to interpret those patterns as learning dimensions and process roles [11], [13]. This design was appropriate because the study sought not only to describe publication trends, but also to translate the structure of the literature into a framework that can explain vocational learning as a staged and interconnected process.

The research design consisted of five linked stages: data source selection, systematic data collection, keyword co-occurrence analysis, thematic interpretation, and conceptual framework development. Each stage produced evidence for the next stage, so the framework was not built from theory alone. Instead, the framework was developed as a data-informed conceptual synthesis that combined bibliometric patterns with educational interpretation [14]–[16].

2.2. Data source and data collection

The Scopus database was selected as the primary data source because it provides broad coverage of peer-reviewed international publications and is frequently used in bibliometric research. The search focused on publications related to learning processes in vocational education and included terms such as “learning process”, “vocational education”, “experiential learning”, and “knowledge construction”. The final search string was TITLE-ABS-KEY (“learning process*” AND “vocational education” AND “experiential learning” AND “knowledge construction”), and the search was conducted on March 24, 2026.

The search was limited to research articles and review articles published in English between 2021 and 2026. Titles and abstracts were screened to remove records that were outside the scope of vocational learning processes, and irrelevant subject areas, particularly medical and health-only studies, were excluded where they did not contribute to the conceptual focus. After duplicate removal and manual relevance screening, 246 documents were retained and exported in CSV format for bibliometric analysis.

2.3. Bibliometric analysis

Keyword co-occurrence analysis was conducted using VOSviewer to examine conceptual relationships within the dataset. Author keywords and terms extracted from titles and abstracts were included to capture both author-defined concepts and recurring textual patterns. A full counting method was applied because the study aimed to identify the overall prominence of concepts across the dataset rather than weight individual documents differently.

A minimum occurrence threshold of five was used to balance inclusiveness with interpretability. From 1,571 identified keywords, 42 met the threshold and were included in the final network. Before visualization, keywords were normalized by merging singular and plural forms, removing demographic and generic methodological terms, and excluding concepts unrelated to vocational learning processes. The refined

keywords were used to construct a co-occurrence network in which nodes represented keywords and links represented co-occurrence relationships within documents. Node size indicated keyword frequency, and link strength indicated the intensity of association between concepts. The VOSviewer clustering algorithm was then used to identify groups of closely related keywords, which provided the empirical basis for thematic interpretation [11], [13], [24].

2.4. Thematic interpretation and conceptual synthesis

The thematic interpretation was conducted in three stages. First, keyword clusters generated by VOSviewer were examined according to dominant keywords, link patterns, and conceptual proximity. Second, cluster-level themes were compared across the network to identify common patterns related to engagement, knowledge development, interaction, practice, and application.

Third, the grouped themes were interpreted as functional dimensions of the learning process. This interpretation was guided by literature on learning pathways, knowledge integration, design learning, scaffolding, and systems-oriented educational frameworks [20], [25]–[28]. The purpose was not to claim that the keyword clusters directly prove learning stages, but to use the clusters as evidence for a careful conceptual synthesis.

2.5. Conceptual framework development procedure

The conceptual framework development procedure integrated bibliometric findings with interpretive process mapping. The procedure began with Scopus data collection, continued with VOSviewer keyword analysis, and then moved to cluster identification, problem interpretation, process mapping, and framework development. This sequence is illustrated in Figure 1, which summarizes the key stages of conceptual framework development.

The process mapping stage linked learning problems to process-oriented responses and expected learning outcomes. It drew on vocational learning literature that emphasizes co-construction at school-work boundaries, competence development, assessment, work-integrated learning, and learning environments that support transferable competencies [6], [9], [21], [23], [29], [30]. The final framework is therefore understood as a data-informed conceptual model rather than a causal empirical model.

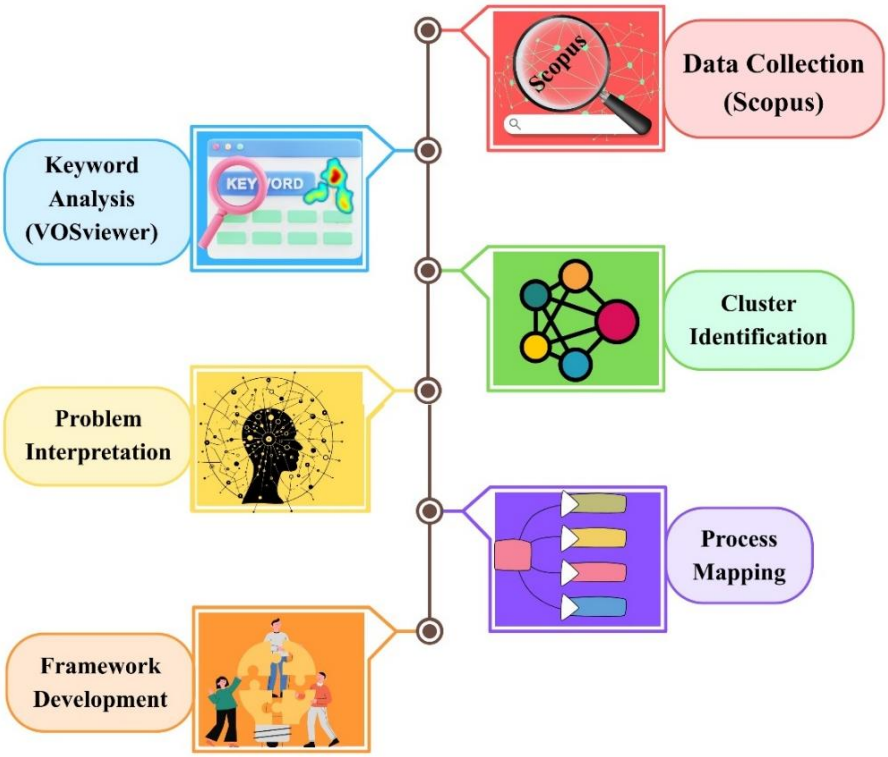


Figure 1. Conceptual framework development process based on bibliometric analysis and systematic conceptual synthesis

3. RESULTS AND DISCUSSION

3.1. Keyword co-occurrence network analysis

The keyword co-occurrence network provides a structured representation of the knowledge landscape related to learning processes in vocational education. As shown in Figure 2, central terms such as students, learning, teaching, engineering education, e-learning, and experiential learning occupy prominent positions in the network. These terms indicate that learner-centered instruction, technology-enhanced learning, and practice-based experience form major areas of connection in the recent literature.

The network also shows that concepts related to educational technology, virtual reality, gamification, collaborative learning, workplace learning, and professional development are connected rather than isolated. These links suggest that vocational learning research increasingly treats digital tools, authentic practice, social interaction, and competence development as mutually related themes [15]–[17], [19], [29], [31]. The structure of the network therefore provides an empirical basis for interpreting learning as a sequence of interconnected processes.

Importantly, the network does not directly establish causal relationships among learning stages. It does, however, reveal recurring conceptual associations that can be interpreted through educational theory and vocational learning research [12], [13], [24]. This interpretation supports the next stage of analysis, in which keyword clusters are reorganized into learning dimensions and process roles.

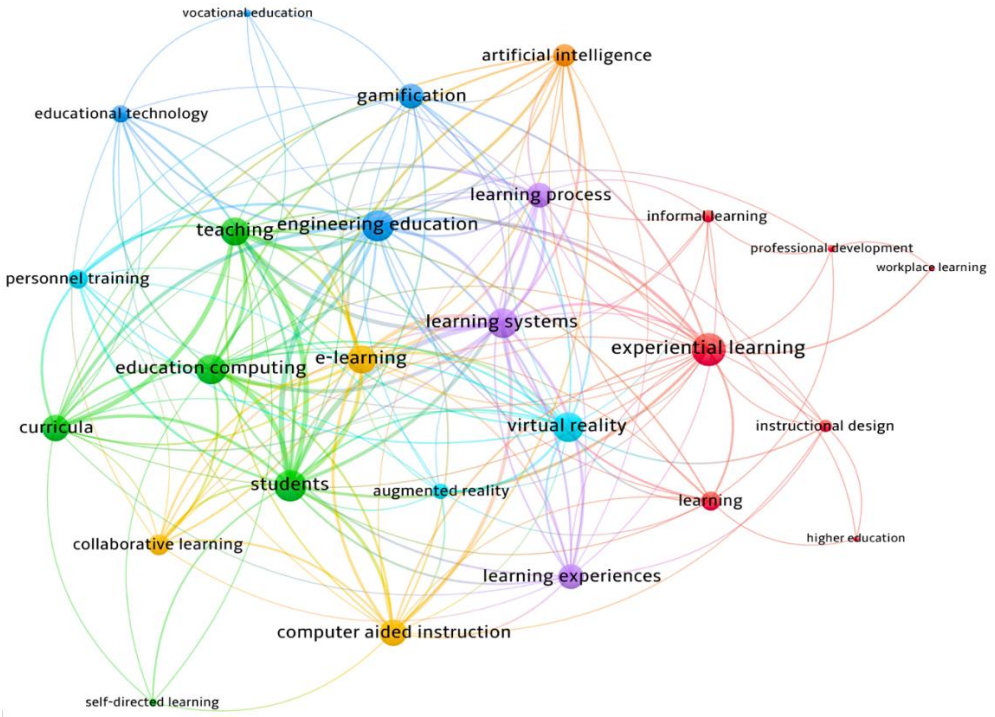


Figure 2. Keyword co-occurrence network of learning processes in vocational education based on bibliometric analysis using VOSviewer

3.2. Synthesis of learning dimensions and process roles

The keyword clusters were synthesized into six interrelated learning dimensions: cognitive activation, experiential engagement, knowledge integration, social knowledge construction, performance practice, and transfer and application. These dimensions represent functional roles in a learning process rather than isolated categories. Table 1 summarizes how cluster-derived themes were interpreted as learning dimensions and process roles.

The first dimension, cognitive activation, represents the starting point of learning because learners need to connect prior knowledge with new occupational concepts. Experiential engagement then provides authentic or simulated contexts in which learners can make sense of these concepts through activity. Knowledge integration and social knowledge construction support deeper understanding by organizing concepts and enabling collaborative meaning-making [7], [25], [26], [32].

The final two dimensions emphasize performance practice and transfer. Performance practice supports the development of observable skills through repeated action, feedback, and assessment, while transfer and application concern the movement of learning into workplace or workplace-like contexts [8], [33]–[35]. Together, the six dimensions show that vocational learning is best understood as a developmental process that connects understanding, experience, interaction, practice, and application.

Table 1. Thematic clusters and implied learning progression

Cluster-derived theme	Representative keywords	Interpreted learning dimension	Implied process role
Cognitive activation	Students; teaching; artificial intelligence	Cognitive activation and initiation of learning	Initiating understanding
Experiential engagement	Experiential learning; virtual reality; workplace learning	Learning through authentic or simulated experience	Engaging through experience
Knowledge integration	Learning systems; learning process; learning experiences	Organization and connection of concepts	Structuring knowledge
Social knowledge construction	Collaborative learning; e-learning; teaching	Co-construction of knowledge through interaction	Constructing shared understanding
Performance practice	Gamification; computer-aided instruction; educational technology	Skill development through guided practice and tools	Developing competency
Transfer and application	Workplace learning; professional development	Application of learning in real contexts	Applying learning in context

3.3. Process-based synthesis of learning problems

The synthesis further indicates that learning problems in vocational education are distributed across different stages of the learning process. These problems include insufficient cognitive activation, experiential gaps, cognitive disconnection, limited social engagement, lack of hands-on practice, and poor transfer. Table 2 presents these problems as process-based constraints rather than unrelated instructional weaknesses.

Table 2. Process-based learning problems across learning stages

Learning dimension	Learning problem	Process stage	Process function
Cognitive activation	Lack of cognitive activation	Early cognitive stage	Initiating understanding
Experiential engagement	Experiential gap	Experiential stage	Engaging through experience
Knowledge integration	Cognitive disconnection	Integration stage	Structuring knowledge
Social construction	Limited social engagement	Social interaction stage	Co-constructing knowledge
Performance practice	Lack of hands-on practice	Practice stage	Developing competency
Transfer and application	Poor transfer	Application stage	Applying learning in context

At the initial stage, weak cognitive activation can prevent learners from connecting prior knowledge with new vocational concepts. In the experiential stage, limited access to authentic tasks or simulations can create a gap between theory and practice [8], [36], [37]. These early constraints may reduce later engagement and make it harder for learners to organize knowledge into a coherent structure.

At the knowledge integration and social construction stages, learners may struggle to connect ideas, explain decisions, and learn through interaction. These constraints are important because vocational competence often depends on collaborative problem solving, team learning, and the ability to justify performance decisions [4], [7], [26], [38]. If these processes remain weak, performance practice may become mechanical rather than conceptually grounded.

At the performance and transfer stages, insufficient guided practice can limit competency formation and reduce the likelihood that students can apply learning in new situations. Studies on hands-on learning, experiential learning, employability, assessment, work-based learning, and boundary-crossing social learning support the importance of structured practice and transfer opportunities [33]–[35], [39]–[44]. This evidence reinforces the need to treat learning problems as connected constraints that can accumulate across stages.

3.4. Linking learning problems, processes and outcomes

The process-based interpretation enables the development of an integrated framework linking learning problems, process-oriented responses, and expected outcomes. The framework positions learning processes as mechanisms through which constraints are transformed into competency-oriented outcomes. Table 3 summarizes these relationships across the six learning stages.

As shown in Figure 3, the framework suggests that vocational learning should be designed as a coherent progression from learning problems to structured processes and competency-oriented outcomes, rather than as a set of disconnected activities. Insufficient activation at the beginning of learning may reduce

engagement, weak engagement may limit knowledge integration, and poor integration may weaken performance practice and transfer [6], [9], [21], [45]. This sequential interpretation explains why local improvements in a single activity may be insufficient when other learning stages remain misaligned.

Figure 3 also illustrates the conceptual contribution of the framework by positioning learning processes as mediating mechanisms that connect constructivist, experiential, practice-based, and systems-oriented perspectives. The framework does not claim that these stages operate in a rigid linear order in every context, because vocational learning can be recursive and context-dependent [27], [29], [46]. Nevertheless, it provides a structured basis for diagnosing where learning processes break down and for designing interventions that preserve continuity across stages.

Table 3. Synthesis of problem-process-outcome across learning stages

Learning stage	Learning problem	Process-oriented response	Expected outcome
Cognitive activation	Lack of cognitive activation	Activate prior knowledge and cognitive engagement	Conceptual understanding
Experiential engagement	Experiential gap	Provide authentic and simulated learning experiences	Active engagement
Knowledge integration	Cognitive disconnection	Structure and connect knowledge systematically	Deep understanding
Social construction	Limited social engagement	Facilitate collaborative and interactive learning	Shared understanding
Performance practice	Lack of hands-on practice	Enable practice-based and performance-oriented activities	Skill development
Transfer and application	Poor transfer	Support real-world application and contextual learning	Real-world competency

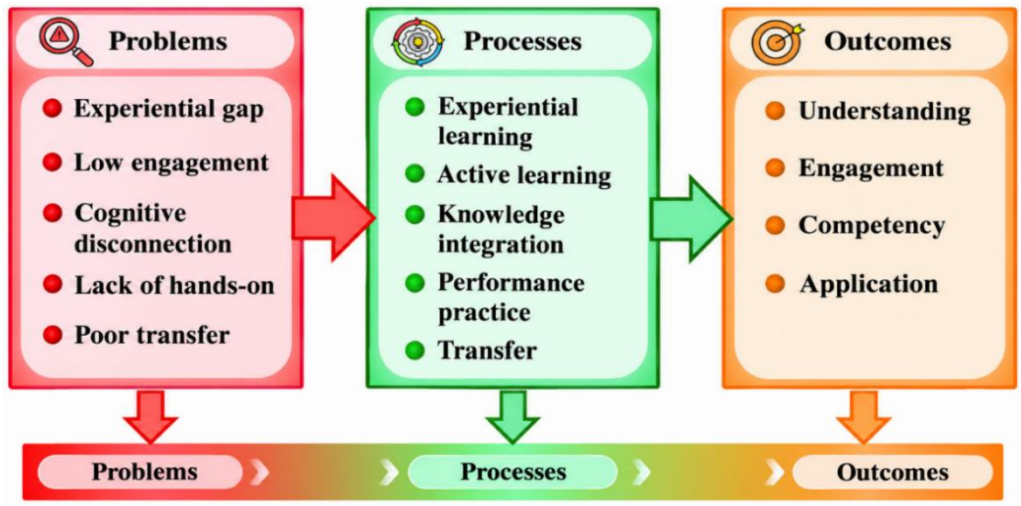


Figure 3. Process-oriented conceptual framework linking learning problems, learning processes, and learning outcomes

3.5. Operational applications of the proposed framework in vocational education

The framework can be operationalized by teachers as a design sequence for project-based and practice-based learning. A teacher may begin with prior-knowledge activation, introduce an authentic occupational problem, organize collaborative interpretation, guide performance practice, and end with a transfer task or portfolio artifact. This sequence is consistent with the literature on modularized vocational education, school-work boundary learning, team learning, design thinking, experiential learning, work-integrated education, and domain-general competence development [6]–[8], [23], [30], [47], [48]. Recent work on enactive design-based research, vocational identity, tacit occupational knowledge, and work-placement assignments further supports treating vocational learning design as an activity-centered and boundary-sensitive process [49]–[52].

Curriculum developers and institutions can use the framework to align course outcomes, learning activities, and assessment evidence. Instead of evaluating students only through final tests, the framework encourages assessment of staged evidence, including conceptual explanation, process logs, collaborative problem solving, practical performance, workplace feedback, and transfer tasks [3], [21], [39], [40], [53].

Table 4 provides operational examples showing how the framework can be applied across common vocational education practices.

For policymakers, the framework provides a language for connecting vocational curriculum reform with graduate readiness. Policies that require workplace exposure, competency-based curriculum alignment, digital learning tools, and performance-based assessment can be evaluated according to whether they support all stages of the learning process rather than one isolated intervention [19], [22], [31], [54], [55]. Thus, the framework has practical value for classroom design, institutional quality assurance, and system-level planning.

Table 4. Operational applications of the process-oriented framework in vocational education

Practice area	Framework-based implementation	Operational example	Evidence or assessment method
Project-based learning design	Sequence learning from cognitive activation to authentic project tasks, collaborative problem solving, performance practice, and workplace transfer.	Students analyze an authentic construction, manufacturing, hospitality, or technical-service problem; connect prior knowledge to design decisions; build or simulate a solution; and present performance evidence.	Project report; prototype or product; process log; performance rubric; peer assessment; reflective journal.
Work-based learning	Connect classroom preparation with workplace observation, guided practice, supervisor feedback, and reflection.	Learners complete a pre-task briefing, perform workplace-based or simulated tasks, document difficulties, receive mentor feedback, and revise their performance strategy.	Workplace logbook; mentor or supervisor assessment; competency checklist; portfolio evidence; reflective report.
Competency-based curriculum development	Map course outcomes to the six learning-process dimensions: cognitive activation, experiential engagement, knowledge integration, social knowledge construction, performance practice, and transfer/application.	Each module specifies prior-knowledge activation, authentic tasks, collaborative activities, guided practice, and transfer tasks linked to occupational standards.	Curriculum map; competency matrix; module outcomes; performance indicators; alignment checklist.
Student competency assessment	Assess both learning process and competency outcome rather than relying only on final tests.	Students are evaluated through staged evidence: conceptual explanation, collaborative problem solving, hands-on performance, and real-world application.	Analytic rubric; performance test; e-portfolio; structured observation; self/peer assessment; transfer task evaluation.

3.6. Limitations and future research

This study has several limitations that should be considered when interpreting the framework. First, the bibliometric analysis used Scopus as the only database, so it may not capture all relevant literature from Web of Science, ERIC, Google Scholar, regional databases, or practitioner-oriented sources. This limitation means that the keyword network should be treated as a structured representation of the selected dataset rather than a complete map of all vocational education research.

Second, the search strategy focused on terms such as learning process, vocational education, experiential learning, and knowledge construction. Relevant studies that use different terminology, such as occupational pedagogy, professional learning, workplace learning design, or competence formation, may have been missed. Future bibliometric studies should compare multiple search strings and databases to test whether the same learning dimensions appear across broader evidence sources.

Third, keyword clusters reveal patterns of co-occurrence, but they do not directly prove causal relationships among learning stages. The proposed model is therefore a data-informed conceptual synthesis, not a causal empirical model. Future research should validate the framework through classroom implementation, work-based learning cases, competency assessment design, teacher interviews, student performance evidence, and cross-database bibliometric comparison.

4. CONCLUSION

This study synthesized bibliometric evidence and conceptual interpretation to explain vocational learning as a structured, process-oriented system. The findings show that vocational learning can be organized through six connected dimensions: cognitive activation, experiential engagement, knowledge integration, social knowledge construction, performance practice, and transfer and application. These dimensions clarify how learning develops from initial engagement with knowledge toward competency-oriented performance.

The main contribution of the study is the development of a conceptual framework that links learning problems, learning processes, and learning outcomes. Rather than viewing fragmented learning, low engagement, limited practice, and poor transfer as separate issues, the framework positions them as process-based constraints that can affect later stages of competency formation. This interpretation extends bibliometric mapping into a more explanatory model of vocational learning.

The framework has practical implications for teachers, curriculum developers, vocational institutions, and policymakers. It can guide project-based learning design, work-based learning, competency-based curriculum development, and student competency assessment by ensuring that learning activities move coherently from understanding to authentic practice and workplace transfer. Future research should empirically validate the framework in real vocational education settings and examine how it supports graduate readiness and industry-aligned competencies.

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AUTHOR CONTRIBUTIONS STATEMENT

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Surawut Saekram		✓		✓						✓		✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

Informed consent is not applicable to this study because it used bibliometric analysis and conceptual synthesis methods. The study did not involve identifiable human participants, interviews, questionnaires, classroom intervention, or personal data collection. Therefore, no individual consent documentation was required for the analysis reported in this manuscript.

ETHICAL APPROVAL

Ethical approval is not applicable to this study because it did not involve experiments with human participants or animals. The analysis was based on bibliographic metadata and scholarly literature retrieved from the Scopus database. No personal, sensitive, or identifiable data were collected or analyzed in this research.

DATA AVAILABILITY

The bibliometric data supporting the findings of this study were retrieved from Scopus using the search strategy described in the method section. Derived data supporting the findings are available from the corresponding author upon reasonable request, subject to database licensing restrictions. Because Scopus data are governed by database access conditions, the raw exported dataset is not publicly deposited.

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