

The Future of Competency-Based Education and Generative-AI: Solving the Scalability-Verification Paradox through Process-Based Assessment

Elycheikh Ahmedtelba¹, Svetlana Mitereva², Magda Ponce³

¹Chair of Undergraduate Programs, University of the Potomac, Washington DC, USA

²Academic Chair of Undergraduate Programs, University of the Potomac, Washington DC, USA

³Academic Chair of Programs in Education, University of the Potomac, Washington DC, USA

Email: elycheikh.ahmedtelba@potomac.edu

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Abstract

Competency-Based Education (CBE) has emerged as one of the most promising models for higher education by shifting the focus from time-based progression to the demonstrated mastery of competencies. Despite its strong theoretical foundation, widespread institutional adoption has remained limited because CBE is inherently difficult to scale. Personalized learning pathways, continuous assessment, competency mapping, individualized feedback, and ongoing learner monitoring require levels of faculty engagement and administrative support that often exceed institutional capacity. Recent advances in Artificial Intelligence, however, offer unprecedented opportunities to overcome these operational barriers by enabling adaptive learning, automated competency mapping, real-time feedback, and personalized learner support at scale. The framework distinguishes the operational scalability of AI-supported CBE from the verification of the evidence used to certify competence, emphasizing that scalable learning support must be paired with proportionate human-led verification. While AI provides the technological infrastructure needed to operationalize CBE, it also introduces a critical challenge to the validity of competency assessment. As generative AI increasingly contributes to the production of student work, the connection between submitted artifacts and authentic demonstrations of independent competence becomes less certain, creating what this paper terms the Scalability-Verification Paradox. Drawing on contemporary research in competency-based education, educational technology, artificial intelligence, and assessment theory, this article proposes an integrated framework that reconciles scalable AI-supported learning with rigorous competency verification through process-based assessment.

Keywords

Competency-Based Education, AI, Higher Education, Assessment, Learning Analytics, Academic Integrity, Personalized Learning, Educational Technology, Process-Based Assessment, Scalability-Verification Paradox

1. Introduction

Higher education is experiencing one of the most significant pedagogical transformations since the emergence of outcome-based education. Advances in digital technologies, increasing demands for workforce alignment, lifelong learning, and personalized education have accelerated interest in educational models that prioritize demonstrated competence rather than time spent in classrooms. Among these innovations, Competency-Based Education (CBE) has attracted considerable attention because it restructures teaching, learning, and assessment around the mastery of explicitly defined competencies rather than traditional measures such as credit hours or instructional time (Gervais, 2016).

The philosophical foundations of competency-based education are well established. Rather than assuming that students learn at identical rates, CBE recognizes that learners acquire knowledge and skills through different pathways and at different speeds. Progression therefore depends upon demonstrated mastery of competencies instead of seat time, allowing students to advance only after providing credible evidence that learning outcomes have been achieved (Competency-Based Education Network [C-BEN], 2017). Such an approach aligns closely with contemporary workforce expectations, where employers increasingly value demonstrable competencies over the completion of prescribed instructional hours.

Despite its theoretical appeal, the widespread implementation of competency-based education has remained relatively limited. Most higher education institutions continue to operate within structures designed around semesters, standardized curricula, synchronized cohorts, and instructor-centered assessment. These structures were originally developed to maximize administrative efficiency rather than educational personalization. Consequently, while competency-based education offers greater flexibility and improved alignment between learning outcomes and workforce expectations, its implementation demands extensive institutional resources.

The principal obstacle has never been pedagogical philosophy but operational scalability. Delivering individualized instruction, continuously monitoring learner progress, providing personalized feedback, mapping competencies to evolving labor market expectations, and documenting mastery require enormous investments in faculty time and administrative capacity. As student enrollment increases, these demands grow exponentially, creating operational bottlenecks that have historically prevented CBE from achieving widespread institutional adoption.

Recent developments in Artificial Intelligence fundamentally alter this equation. Large Language Models (LLMs), intelligent tutoring systems, predictive learning analytics, adaptive recommendation engines, and natural language processing have rapidly matured into technologies capable of supporting personalized instruction at institutional scale. Unlike earlier educational technologies that merely digitized existing instructional practices, contemporary AI systems actively assist learners, automate administrative processes, personalize instructional pathways, generate formative feedback, and analyze large volumes of educational data in real time. These capabilities directly address many of the historical barriers that have constrained competency-based education.

Emerging research increasingly demonstrates AI's capacity to support personalized learning environments, competency mapping, automated curriculum development, adaptive tutoring, formative assessment, and learner analytics (Hong, 2025; Mukashova et al., 2025; Venter et al., 2024). These developments suggest that AI may provide the technological infrastructure necessary to operationalize competency-based education on a scale previously considered unattainable. Yet this transformation introduces a profound paradox.

The same AI technologies that enable scalable personalization simultaneously challenge one of competency-based education's most fundamental assumptions: that student work accurately represents independent learner competence. Generative AI systems are increasingly capable of producing sophisticated essays, solving complex problems, generating computer code, performing statistical analyses, and creating professional reports. Consequently, educators face growing uncertainty regarding whether submitted work reflects authentic student mastery or AI-assisted production. Assessment therefore becomes not merely a question of academic integrity but one of measurement validity.

Recent empirical evidence highlights the magnitude of this challenge. Brattli et al. (2026) demonstrated that assessment outcomes under AI-permissive conditions differ significantly from those produced under AI-restricted environments, suggesting that conventional grading systems may no longer measure identical constructs. Similarly, Kofinas et al. (2025) found that authentic assessment alone is insufficient to distinguish AI-assisted work from independently produced student work. Wani et al. (2025) further demonstrated that generative AI exhibits varying effectiveness across different assessment formats, creating inconsistencies in competency measurement depending upon task design.

This article positions AI not simply as another educational tool but as the missing operational infrastructure capable of enabling large-scale competency-based education while redefining the educator's role from content delivery toward competency verification.

Specifically, this paper addresses three research questions:

- 1) How does artificial intelligence resolve the historical operational bottlenecks that have limited competency-based education?
- 2) How does generative AI alter the validity of competency assessment and

learner verification?

3) What assessment framework enables institutions to preserve authentic competency certification while leveraging the scalability offered by artificial intelligence?

By synthesizing recent scholarship in competency-based education, educational technology, artificial intelligence, learning analytics, and assessment theory, this paper develops a conceptual model that contributes to both theory and practice. The proposed framework provides higher education institutions with guidance for integrating AI into competency-based education while preserving academic integrity, maintaining assessment validity, and ensuring that certified competencies continue to represent authentic learner capability.

2. Literature Review

2.1. Literature Review Approach

This conceptual review used a structured, thematic approach to identify and synthesize scholarship relevant to competency-based education, artificial intelligence in higher education, learning analytics, assessment validity, academic integrity, and process-based assessment. Sources were selected from the scholarly literature represented in the reference base of this article, with emphasis on peer-reviewed empirical studies, systematic reviews, established assessment and learning theories, and authoritative guidance from recognized educational and international organizations. The selection criteria were relevance to one or more of the paper's three research questions, explicit treatment of AI-supported learning or assessment, relevance to competency development or verification, and sufficient conceptual or empirical detail to inform the proposed framework. Sources were excluded when they were primarily promotional, lacked a clear connection to the research questions, or did not provide substantive evidence or conceptual grounding for the framework.

The review process involved thematic identification, relevance screening, and comparative synthesis rather than statistical meta-analysis. The literature was organized into five themes: (a) the evolution and operational requirements of CBE; (b) AI-enabled personalization, competency mapping, and learning analytics; (c) the effects of generative AI on assessment validity and independent performance; (d) process-based and human-centered approaches to verification; and (e) institutional and governance implications. Studies were retained when their findings or theoretical arguments directly supported the relationships represented in the Scalability-Verification Paradox and Process-Based Competency Verification (PBCV). The synthesis therefore served as a conceptual integration of converging and divergent findings rather than as a systematic-effect estimate.

Because this is a conceptual paper, the purpose of the review was framework development rather than exhaustive enumeration of all available studies. The evidence base was appraised for relevance, methodological or theoretical credibility as reported by the original sources, and direct applicability to AI-enabled CBE.

The resulting synthesis provides the evidentiary basis for defining the two dimensions of the paradox and specifying the verification mechanisms proposed in PBCV.

2.2. Evolution of Competency-Based Education

Competency-Based Education represents one of the most significant departures from traditional time-based models of higher education. Its philosophical roots can be traced to mastery learning theories advanced by educational psychologists such as Benjamin Bloom, who argued that nearly all students are capable of achieving high levels of learning when provided with sufficient time, appropriate instruction, and meaningful feedback. Rather than viewing learning as constrained by fixed instructional schedules, mastery learning emphasizes individualized progression based upon demonstrated understanding. Competency-based education extends this principle by replacing time as the primary measure of academic progress with the verified demonstration of knowledge, skills, and professional competencies.

Gervais (2016) defines competency-based education as an outcome-oriented educational framework in which instructional design, assessment practices, and credentialing are explicitly organized around learners' demonstrated mastery of predetermined competencies rather than the completion of prescribed instructional hours. This definition shifts the central question of education from "How long has the student studied?" to "What can the student demonstrably do?" Similarly, the Competency-Based Education Network (C-BEN, 2017) emphasizes that high-quality competency-based programs require transparent competencies, measurable performance criteria, meaningful assessments, and credible evidence supporting claims of learner mastery.

The shift from time-based progression to competency verification has significant implications for curriculum design, instructional practice, assessment, and institutional governance. Unlike conventional higher education, where cohorts generally progress together through fixed semesters, competency-based education accommodates individual learning trajectories, allowing students to advance upon demonstrating mastery irrespective of elapsed instructional time. This learner-centered approach offers substantial advantages for adult learners, working professionals, and diverse student populations whose prior experiences and learning rates vary considerably.

However, these same characteristics create substantial implementation challenges. Personalized instructional pathways require continuous assessment, individualized feedback, flexible scheduling, competency mapping, and sophisticated learner monitoring. Historically, the extensive human labor required to support these processes has constrained institutional adoption, limiting competency-based education primarily to specialized programs despite its strong theoretical foundations.

2.3. Artificial Intelligence and the Transformation of Higher Education

The rapid evolution of Artificial Intelligence (AI), particularly generative AI and Large Language Models (LLMs), represents one of the most disruptive developments in higher education since the widespread adoption of learning management systems. Unlike earlier educational technologies that primarily digitized instructional materials or automated administrative functions, contemporary AI systems actively participate in teaching and learning by generating explanations, facilitating dialogue, providing individualized feedback, recommending learning pathways, and supporting complex cognitive tasks. This transformation extends beyond technological innovation to fundamentally reshape assumptions about teaching, learning, assessment, and academic work.

Educational AI encompasses a broad ecosystem of intelligent technologies, including intelligent tutoring systems (ITS), adaptive learning platforms, natural language processing (NLP), machine learning algorithms, predictive analytics, learning recommender systems, and generative AI applications powered by transformer-based language models. These technologies collectively enable institutions to analyze learner behavior, personalize instructional content, automate administrative processes, and provide continuous formative support at a scale previously unattainable.

Numerous studies have demonstrated that AI contributes positively to student engagement, self-regulated learning, and academic achievement when implemented within sound pedagogical frameworks. Adaptive tutoring systems continuously diagnose learner misconceptions, adjust instructional difficulty, recommend supplementary resources, and provide immediate explanatory feedback. Consequently, AI allows instructional support to occur continuously rather than exclusively during scheduled faculty interactions.

Unlike traditional online learning environments that typically provide identical content to all learners, AI-powered systems dynamically adapt instructional experiences according to each student's competency profile. These systems monitor learner interactions, identify performance gaps, and automatically modify instructional sequences to maximize competency acquisition. Such capabilities align closely with the foundational principles of competency-based education, where personalized progression constitutes the central organizing principle.

From an institutional perspective, AI also substantially reduces administrative complexity. Automated grading, predictive advising, curriculum mapping, competency analytics, and intelligent scheduling reduce routine faculty workload while allowing educators to devote greater attention to mentoring, coaching, and higher-order instructional activities. Rather than replacing faculty expertise, AI redistributes instructional labor by automating repetitive processes and augmenting professional decision-making.

Nevertheless, these opportunities coexist with significant pedagogical challenges. Generative AI systems increasingly produce sophisticated essays, pro-

gramming solutions, research syntheses, statistical analyses, and creative artifacts that closely resemble human work. Consequently, educators must reconsider traditional assumptions regarding authorship, originality, academic integrity, and evidence of learning. The educational question therefore shifts from whether AI should be incorporated into higher education toward determining how institutions can leverage AI while preserving meaningful demonstrations of independent competence.

2.4. AI as the Operational Infrastructure of Competency-Based Education

Competency-Based Education has historically been constrained by operational limitations rather than conceptual weaknesses. Although educational researchers have long recognized the pedagogical advantages of individualized learning, mastery-based progression, and competency-driven assessment, implementing these principles at institutional scale has required instructional capacities exceeding those available through human labor alone. Artificial Intelligence fundamentally changes this relationship.

Rather than viewing AI merely as another educational technology, it is more accurate to conceptualize AI as the operational infrastructure capable of supporting the continuous personalization that competency-based education demands. Recent scholarship supports this perspective.

Hong (2025) developed a competency-based AI literacy pathway that demonstrated significant improvements in competency attainment while maintaining learner retention throughout progressively personalized instructional sequences. The findings illustrate AI's capacity to continuously monitor learner development and adjust educational experiences according to demonstrated competency progression rather than predetermined schedules.

Similarly, Mukashova et al. (2025) introduced an AI-driven framework capable of translating professional competency standards into measurable educational outcomes through automated competency formalization. Traditionally, curriculum revision committees required months or years to interpret changing workforce requirements, redesign competencies, and revise learning outcomes. AI substantially compresses this process by continuously analyzing professional standards and labor market data, thereby improving curricular responsiveness.

Another significant contribution concerns formative assessment. Venter et al. (2024) examined AI-generated formative feedback and reported that properly configured large language models reproduced many characteristics associated with effective instructor feedback, including specificity, alignment with assessment criteria, constructive guidance, and opportunities for learner revision. Importantly, the study emphasized that AI complements rather than replaces instructor judgment, particularly in evaluating higher-order reasoning and professional competence.

Collectively, these investigations suggest that AI directly addresses several historical bottlenecks preventing widespread CBE adoption. Table 1 summarizes the

historical CBE bottlenecks and the corresponding AI-enabled operational responses.

- AI enables personalized learning pathways without requiring faculty to manually design unique instructional trajectories for every learner.
- intelligent tutoring systems provide immediate instructional support independent of instructor availability.
- AI automates competency mapping between professional standards and curriculum.
- predictive analytics identify learning risks before academic failure occurs.
- AI accelerates formative feedback while preserving opportunities for iterative competency development.

Consequently, AI transforms competency-based education from a pedagogical ideal into an operationally feasible educational model.

Table 1. Historical operational bottlenecks of competency-based education and corresponding artificial intelligence solutions.

Historical CBE Challenge	Operational Consequence	AI Operational Solution	Educational Impact	Representative Literature
Individualized instruction	Unsustainable faculty workload	Intelligent Tutoring Systems	Personalized adaptive learning	Hong (2025)
Curriculum revision	Slow response to workforce changes	NLP and Large Language Models	Dynamic competency mapping	Mukashova et al. (2025)
Continuous learner monitoring	Administrative complexity	Learning Analytics	Early intervention and personalized support	Learning Analytics literature
Formative feedback	Extended grading cycles	Generative AI Feedback Systems	Immediate iterative feedback	Venter et al. (2024)
Competency documentation	Manual tracking of mastery	AI competency dashboards	Real-time competency visualization	C-BEN (2017); Hong (2025)
Academic advising	Limited scalability	Predictive AI Advising	Personalized academic pathways	Educational Data Mining research

2.5. Artificial Intelligence and Competency Mapping

Competency mapping represents one of the most labor-intensive components of competency-based education. Every educational program must continuously translate evolving workforce expectations into measurable learning outcomes, instructional objectives, assessment criteria, and competency frameworks. Historically, this process depended upon lengthy committee deliberations, accreditation reviews, employer consultations, and curriculum redesign cycles. Artificial Intelligence fundamentally accelerates this process.

Mukashova et al. (2025) demonstrated that AI successfully formalizes professional competencies by extracting required knowledge, skills, abilities, and performance expectations from unstructured occupational documents. Such automation significantly reduces curriculum development timelines while strengthening alignment between higher education and labor market expectations.

From a systems perspective, AI therefore establishes a continuous feedback

loop between workforce demand and educational provision. Rather than periodically revising competencies every several years, institutions may continuously refine competency frameworks according to emerging occupational trends, technological innovation, and professional practice. **Table 2** extends this analysis across the broader CBE ecosystem.

This capability has particular importance given the accelerating pace of technological change. Occupations increasingly require interdisciplinary competencies involving digital literacy, data analysis, artificial intelligence, ethical reasoning, communication, collaboration, and adaptive problem solving. Static curriculum development processes struggle to maintain alignment under such conditions, whereas AI provides continuous environmental scanning and competency updating.

Table 2. Artificial intelligence applications across the competency-based education ecosystem.

Educational Function	Traditional Approach	AI-Enhanced Approach	Institutional Benefit
Curriculum Design	Faculty committees	Automated competency mapping	Faster curriculum renewal
Diagnostic Assessment	Standardized placement tests	AI competency diagnostics	Individualized learning pathways
Instruction	Uniform lectures	Adaptive tutoring	Personalized instruction
Feedback	Manual grading	AI-assisted formative feedback	Faster learning cycles
Student Support	Reactive advising	Predictive analytics	Early intervention
Competency Tracking	Static transcripts	Dynamic competency dashboards	Continuous mastery documentation
Accreditation Reporting	Manual reporting	Automated competency analytics	Institutional efficiency

2.6. Artificial Intelligence, Learning Analytics, and Personalized Mastery

One of the defining characteristics of competency-based education is the recognition that learning occurs at different rates across individuals. Unlike traditional educational models, which standardize instructional pacing around institutional calendars, competency-based education requires continuous monitoring of learner progression toward mastery. This requirement has historically produced substantial administrative complexity because instructors must simultaneously evaluate numerous individualized learning trajectories. Artificial Intelligence significantly enhances this process through learning analytics and predictive modeling.

Modern learning analytics platforms collect high-frequency educational data from learning management systems, digital assessments, intelligent tutoring systems, discussion forums, and learner interactions. Machine learning algorithms subsequently identify behavioral patterns associated with academic success, persistence, competency acquisition, and attrition. Rather than generating retrospective reports after academic difficulties emerge, AI supports proactive intervention by identifying learners at risk before performance declines. Faculty therefore receive actionable insights regarding individual learning needs while maintaining

responsibility for instructional decision-making.

This predictive capability aligns naturally with competency-based education because both emphasize continuous evidence rather than isolated examinations. AI thereby transforms assessment from episodic measurement into ongoing competency surveillance that supports personalized instructional adjustment throughout the learning process. **Table 3** synthesizes the empirical literature that informs this transition.

Importantly, however, these technological advances primarily strengthen the development and monitoring of competence. They do not independently verify that demonstrated performance represents authentic learner capability. This distinction establishes the conceptual transition from AI as an operational solution toward AI as a measurement challenge—the central argument developed in the next section.

Table 3. Synthesis of recent empirical literature on artificial intelligence and competency-based education (2024–2026).

Study	Focus	Major Findings	Implications for CBE
Hong (2025)	AI competency pathways	Improved competency acquisition and learner retention	Supports personalized mastery learning
Mukashova et al. (2025)	AI competency formalization	Automated translation of workforce standards into competencies	Accelerates curriculum alignment
Venter et al. (2024)	AI-generated feedback	Feedback comparable to expert instructor characteristics	Improves formative assessment efficiency
Brattli et al. (2026)	Assessment validity	AI-permissive assessments differ from AI-restricted assessments	Raises concerns about competency verification
Kofinas et al. (2025)	Authentic assessment	Experts unable to reliably distinguish AI-assisted work	Challenges assessment validity
Wani et al. (2025)	Assessment vulnerability	AI performance varies according to assessment type	Necessitates redesigned competency assessment
Ncube et al. (2025)	Systematic review	Process-based assessment more effective than AI detection	Supports human-centered verification strategies

3. The Scalability-Verification Paradox: An Integrated Theoretical Framework

The preceding review demonstrates a growing consensus that Artificial Intelligence has become an enabling technology for Competency-Based Education (CBE). Intelligent tutoring systems, adaptive learning platforms, predictive analytics, and generative AI collectively reduce many of the operational constraints that historically limited personalized learning and competency-based assessment. Yet these same technologies introduce an equally significant challenge that existing literature has largely examined in isolation rather than as part of a unified educational theory. Recent work on AI competency frameworks and conceptual models similarly argues for integrated approaches that connect pedagogy, assessment, ethics, and institutional implementation.

This paper argues that AI has fundamentally altered competency-based educa-

tion by creating two simultaneous and opposing forces:

- Operational acceleration, whereby AI dramatically improves personalization, scalability, curriculum alignment, and instructional efficiency.
- Measurement uncertainty, whereby AI weakens confidence that submitted evidence represents the learner's independent competency.

Rather than viewing these developments as unrelated phenomena, they should be understood as two dimensions of the same educational transformation. This relationship is conceptualized here as the Scalability-Verification Paradox (SVP).

The Scalability-Verification Paradox describes the phenomenon whereby Artificial Intelligence simultaneously enables the large-scale implementation of Competency-Based Education while reducing confidence that assessment artifacts accurately represent independent learner competence (Brattli et al., 2026). The paradox emerges because CBE requires two conditions to coexist:

For analytical clarity, scalability and verification are treated as distinct constructs. Scalability refers to an institution's capacity to deliver individualized learning, feedback, competency mapping, progress monitoring, and related CBE functions to increasing numbers of learners without a proportional increase in faculty and administrative workload. Potential institutional indicators include learner-to-faculty ratios for individualized support, turnaround time for feedback, the proportion of competency mappings or progress reports completed through automated systems, and the time and cost required to support each learner pathway. Verification refers to the institution's capacity to establish defensible evidence that a learner has independently demonstrated the knowledge, skills, reasoning, and judgment represented by a competency claim. Potential indicators include the proportion of competency decisions supported by process evidence and supervised demonstrations, inter-rater agreement on verification judgments, successful performance on live or controlled demonstrations, and the completeness of required evidence records.

These constructs are related but not interchangeable. An institution may achieve high operational scalability while maintaining weak verification evidence, or it may achieve strong verification while relying on labor-intensive practices that limit scalability. The paradox therefore concerns the institutional challenge of optimizing both dimensions simultaneously rather than treating either dimension as a substitute for the other.

- highly personalized learning experiences, and
- valid evidence of independent competency.

Historically, these two conditions were closely connected because instructors personally guided learning and evaluated performance. AI fundamentally separates these processes. Artificial intelligence now performs much of the instructional support previously delivered by educators:

- tutoring
- explanation
- practice
- coaching

- feedback
- curriculum navigation
- competency recommendations

However, once generative artificial intelligence becomes an active participant in the learning process, distinguishing between legitimate learning support and performance substitution becomes increasingly difficult. AI technologies can function as cognitive scaffolds by assisting students with brainstorming, explaining complex concepts, organizing ideas, and providing formative feedback.

At the same time, these same systems are capable of generating complete responses, solving complex problems, and producing polished academic work with minimal human input. As the boundary between assistance and substitution becomes increasingly blurred, educators face growing uncertainty regarding the extent to which observed student performance reflects independent learning versus AI-mediated production.

The implications extend well beyond traditional concerns regarding academic integrity. While discussions surrounding generative AI frequently focus on plagiarism, unauthorized assistance, or ethical misuse, the more fundamental challenge is psychometric in nature. Educational assessment is grounded in the principle that observable performance serves as a valid indicator of an individual's underlying knowledge, skills, and cognitive abilities.

This principle underlies virtually every assessment framework used in higher education, from classroom assignments to standardized testing and competency-based evaluations. When AI substantially contributes to the production of assessed work, the relationship between observable performance and actual competence becomes increasingly uncertain.

The operational pathway summarized in **Figure 1** illustrates how individualized instruction, continuous assessment demands, faculty-capacity constraints, and limited institutional adoption form the pre-AI scalability bottleneck.

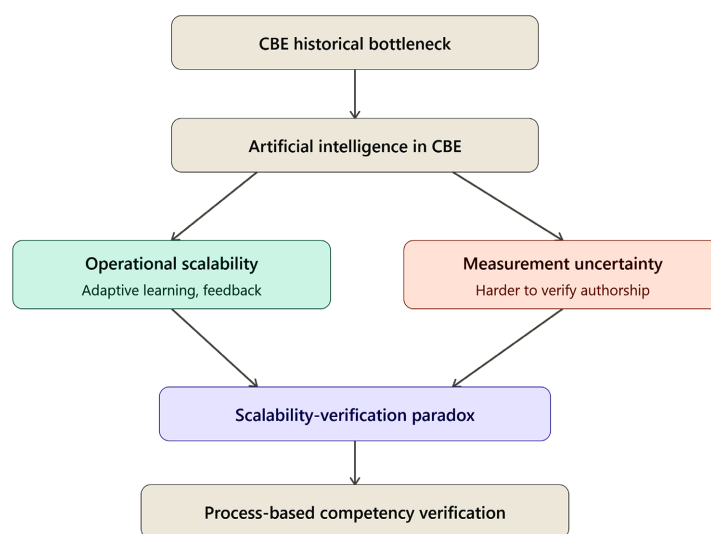


Figure 1. Personalized learning model and historical CBE capacity constraints.

3.1. Artificial Intelligence Changes the Meaning of Assessment

Traditional educational assessment has historically focused on evaluating final products:

- essays
- reports
- examinations
- presentations
- programming assignments
- Projects

This approach assumes that the submitted artifact reflects the student's own cognitive processes. Generative AI fundamentally challenges this assumption. Large language models increasingly participate throughout the production process:

- brainstorming
- outlining
- drafting
- editing
- coding
- translation
- statistical interpretation
- literature synthesis

As AI capabilities improve, the observable quality of submitted work becomes progressively less reliable as evidence of independent competence. Consequently, educational assessment must evolve from evaluating products toward evaluating learning processes. This shift represents one of the most significant theoretical implications of AI for competency-based education.

3.2. From Product Validation to Competency Validation

Competency-Based Education has always differed from traditional education because its purpose extends beyond grading assignments. Its purpose is certifying competence. These two objectives are no longer equivalent. A polished assignment may satisfy grading criteria without demonstrating independent competency.

Table 4. Product assessment versus competency verification in the age of artificial intelligence.

Dimension	Traditional Assessment	AI-Enhanced Environment	Competency-Based Recommendation
Primary evidence	Final submission	Final submission + AI assistance	Learning process plus final product
Instructor evaluates	Finished artifact	Artifact of uncertain authorship	Demonstrated competency
Student success	Assignment quality	Assignment quality with AI support	Independent performance verified
Integrity focus	Originality	Transparency of AI use	Authentic competency demonstration
Assessment objective	Grade	Grade	Verified mastery

A learner who struggles during drafting but successfully explains reasoning, revises work, and defends decisions may provide stronger evidence of genuine mastery. Therefore, AI requires institutions to distinguish between Product Quality and Competency Evidence. The former may increasingly involve AI collaboration. The latter must continue to represent authentic human capability. The distinction is summarized in **Table 4**.

3.3. Competency Verification as a Psychometric Challenge

Current discussions surrounding AI often frame the issue as academic misconduct. Although misconduct remains important, competency-based education raises a different question: Can educators make defensible claims regarding learner competence?

Competency certification represents a high-stakes institutional judgment. Universities certify graduates because they believe those graduates possess demonstrable knowledge, skills, and professional abilities. Employers, accreditation agencies, licensing organizations, and society depend upon this assumption.

If AI substantially contributes to competency demonstrations without appropriate verification, institutions risk certifying competencies that students cannot independently reproduce. [Brattli et al. \(2026\)](#) provide empirical evidence supporting this concern by demonstrating that AI-permissive assessments produce different measurement characteristics than AI-restricted assessments, suggesting that the two environments may not assess the same underlying construct.

Likewise, [Kofinas et al. \(2025\)](#) found that authentic assessment alone does not reliably distinguish AI-assisted work from independently authored work, while [Wani et al. \(2025\)](#) showed that AI performance varies considerably across assessment types. Together, these findings indicate that validity, not simply misconduct, has become the central assessment challenge in AI-enabled CBE. The relative verification risks associated with different AI capabilities are summarized in **Table 5**.

Table 5. The AI verification risk matrix.

AI Capability	Educational Benefit	Verification Risk
Intelligent tutoring	High	Low
Personalized explanations	High	Low
Competency recommendations	High	Low
Brainstorming	Moderate	Moderate
Editing	Moderate	Moderate
Essay generation	High	High
Programming generation	High	High
Statistical interpretation	High	High
Research synthesis	High	High

4. Process-Based Assessment: Resolving the Paradox

The solution to the Scalability-Verification Paradox is not prohibiting Artificial Intelligence. Nor is it relying exclusively upon AI-detection software. Recent systematic reviews consistently conclude that detection technologies remain unreliable and that assessment redesign offers a more sustainable solution than attempting to identify AI-generated content after submission.

Instead, institutions should redesign assessment around observable learning processes rather than solely evaluating final products. This approach is termed Process-Based Competency Verification (PBCV) (**Figure 2**).

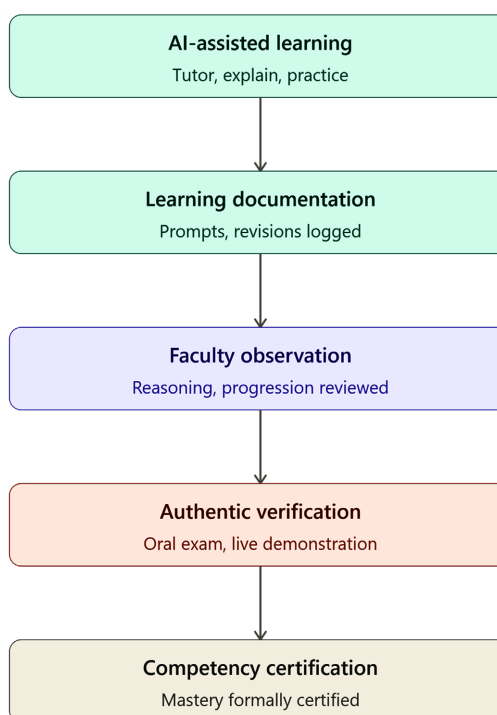


Figure 2. PBCV development and certification process.

The proposed framework extends existing competency-based assessment by making the learning process itself an object of evaluation. Students may use AI as a learning partner. However, competency certification requires independent evidence demonstrating that the learner, not the AI, possesses the underlying knowledge, reasoning, and professional judgment. Accordingly, AI becomes an instructional technology rather than a substitute for competency demonstration. PBCV addresses three related but analytically distinct assessment claims: authorship transparency, independent performance, and construct validity. First, documentation and AI-use disclosure establish transparency regarding how an artifact was produced; they do not, by themselves, prove authorship. Second, supervised demonstrations and oral defenses provide direct evidence of independent performance. Third, alignment between the competency rubric, assessment task, and observed performance supports construct validity by establishing that the evi-

dence actually represents the intended competency. Accordingly, PBCV does not treat evidence of authorship as equivalent to evidence of competence; certification requires converging evidence across these claims. The stages and evidence pathways are summarized in **Table 6**.

4.1. Minimum Evidence Standard for PBCV Certification

For certification purposes, the proposed minimum PBCV evidence set consists of four required components: 1) a revision or version history showing the development of the work over time; 2) an explicit disclosure of AI use, including the purpose and material contribution of AI tools; 3) a reflective rationale in which the learner explains key decisions, revisions, and reasoning; and 4) a supervised demonstration aligned directly to the competency rubric. The final artifact remains relevant, but certification should not rest on the artifact alone. Institutions may add discipline-specific evidence where competencies involve performance, technical procedures, professional judgment, or regulated practice.

The evidence should be proportionate to the risk and value of the competency being certified. Routine low-risk learning activities can rely primarily on documented process evidence, while high-stakes or high-vulnerability competencies can trigger a brief supervised demonstration or oral defense. This tiered approach preserves the central efficiency benefit of AI-enabled CBE while reserving intensive human review for the competency claims for which independent demonstration is most consequential.

4.2. Implementing Verification without Recreating the Workload Problem

Institutions can implement PBCV without reproducing the workload constraints that historically limited CBE by using risk-based verification rather than requiring intensive review of every learning activity. Process documentation can be captured automatically through learning-management systems and version-controlled authoring tools, while AI can organize evidence for faculty review without making the final certification decision. Oral defenses can be brief, standardized, and scheduled only at defined competency checkpoints or when evidence indicates a need for additional verification. Faculty review can also use common competency rubrics, calibrated exemplars, and sampling procedures so that expert judgment is concentrated on high-value evidence rather than routine administrative tasks.

Under this model, AI supports evidence collection, organization, and preliminary pattern identification, whereas faculty retain responsibility for interpreting evidence and making certification judgments. Institutions can further reduce workload by grouping related competencies, using short structured demonstrations, rotating verification panels, and applying additional review only when process evidence is incomplete or inconsistent. The objective is therefore not to increase the total volume of assessment, but to redirect a smaller amount of human effort toward evidence with the greatest value for verification.

As illustrated in **Figure 2**, PBCV moves from AI-assisted learning through documented development, faculty review, authentic verification, and final competency certification.

Table 6. Process-based competency verification framework.

Stage	Student Activity	AI Role	Faculty Role	Competency Evidence
Learning	Personalized study	Tutor	Coach	Learning engagement
Development	Drafting and revision	Feedback	Mentor	Growth trajectory
Documentation	Reflection	Organization	Reviewer	Learning process
Verification	Oral defense	None	Examiner	Independent reasoning
Certification	Final evaluation	None	Certifier	Verified competency

4.3. Redefining the Faculty Role

Perhaps the most profound implication of AI-enabled competency-based education concerns the changing role of faculty. Historically, educators devoted considerable time to:

- delivering lectures,
- grading assignments,
- answering routine questions,
- creating instructional materials,
- monitoring progress.

Artificial Intelligence increasingly performs many of these repetitive functions. Consequently, faculty expertise becomes concentrated where it is uniquely valuable:

- evaluating reasoning,
- assessing judgment,
- verifying professional competence,
- mentoring learners,
- conducting oral examinations,
- designing authentic assessments,
- certifying mastery.

Rather than diminishing faculty importance, AI elevates their role from information providers to expert evaluators and stewards of educational quality. This shift aligns with emerging scholarship emphasizing that AI should augment, not replace, human pedagogical expertise and ethical judgment within competency-based systems.

5. Theoretical and Practical Implications of AI-Enabled Competency-Based Education

The emergence of Artificial Intelligence (AI) represents a defining moment in the evolution of Competency-Based Education (CBE). For more than three decades, educational scholars have argued that competency-based models provide a more

authentic representation of learning than traditional time-based systems because they prioritize demonstrated mastery over seat time. Yet despite broad theoretical support, institutional implementation has remained limited due to the considerable human and administrative resources required to personalize learning, continuously assess competence, and document mastery.

The literature synthesized in this paper suggests that AI fundamentally changes this equation by providing the technological infrastructure capable of operationalizing CBE at institutional scale while simultaneously challenging one of its foundational assumptions: that assessment artifacts reliably represent independent learner competence. This synthesis follows the structured thematic review approach described in Section 2.1 and integrates the evidence summarized in **Table 3**.

The principal theoretical contribution of this article is the Scalability-Verification Paradox (SVP). Existing scholarship has generally examined AI either as a means of improving educational efficiency or as a threat to academic integrity. This paper integrates these perspectives into a unified conceptual framework by demonstrating that the very technologies enabling scalable, personalized learning also weaken confidence in competency verification. Rather than representing contradictory outcomes, scalability and verification are two inseparable dimensions of AI-enabled competency-based education. The operational relationships summarized in **Figure 3** further connect these efficient mechanisms to the broader institutional transformation described in the framework.

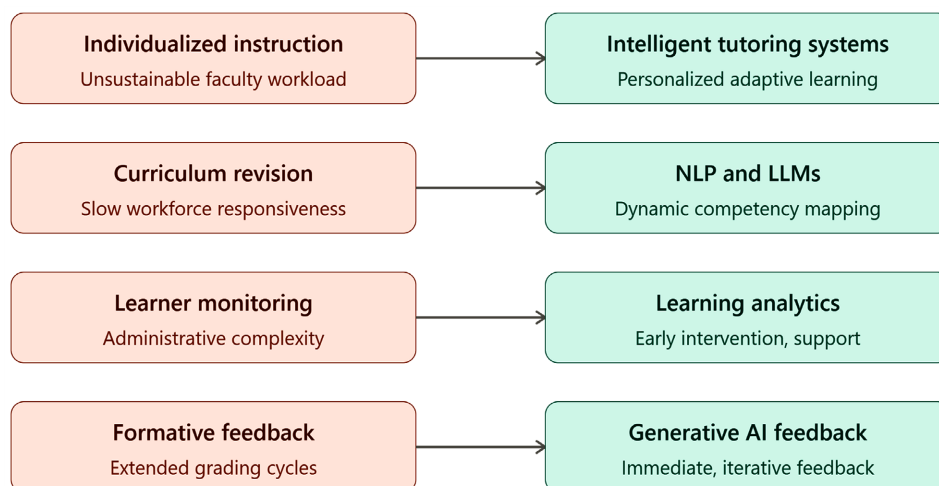


Figure 3. AI-enabled operational supports for competency-based education.

This reconceptualization has important implications for educational measurement. Traditional assessment models assume that the quality of a submitted product serves as a valid proxy for learner competence. Generative AI fundamentally disrupts this assumption because the observable product increasingly reflects collaborative human-AI interactions. Consequently, assessment validity can no longer rely solely on evaluating final artifacts. Instead, institutions must evaluate the rea-

soning, decision-making processes, iterative development, and professional judgment that underlie competency acquisition.

From a theoretical perspective, this shift aligns with constructivist learning theory, authentic assessment, and mastery learning while extending them into AI-mediated educational environments. Learning becomes a documented developmental process rather than a single evaluative event. Accordingly, educators transition from primarily judging completed assignments to verifying competency through multiple sources of evidence collected throughout the learning process.

6. Institutional Implications

The integration of AI into competency-based education requires institutional transformation that extends beyond technological adoption. Successful implementation depends upon governance structures, assessment redesign, faculty development, digital infrastructure, and ethical oversight. Universities should therefore approach AI not as a software acquisition initiative but as an institutional change strategy. Five strategic priorities emerge from the proposed framework.

- **Curriculum Transformation:** Curricula should be organized around measurable competencies that remain continuously aligned with evolving workforce expectations. AI-assisted competency mapping enables institutions to revise learning outcomes more rapidly while preserving academic oversight.
- **Assessment Redesign:** Traditional assessment practices emphasizing isolated products should gradually transition toward process-based assessment that documents competency development through portfolios, iterative submissions, reflective analyses, simulations, oral defenses, and supervised performance demonstrations.
- **Faculty Development:** Faculty require professional development in AI literacy, prompt engineering, assessment redesign, ethical AI integration, learning analytics, and competency verification. Rather than competing with AI, educators become expert evaluators of higher-order reasoning, professional judgment, and authentic performance.
- **Institutional Governance:** Universities should establish comprehensive AI governance policies addressing transparency, acceptable AI use, data privacy, academic integrity, assessment validity, and accountability. Governance should balance innovation with educational quality assurance.
- **Student AI Literacy:** Students should receive explicit instruction regarding responsible AI use, transparency in AI-assisted work, ethical decision-making, prompt documentation, and professional expectations concerning AI collaboration.

Table 7 is provided as an editable Word table to support typesetting and subsequent editorial adjustments.

Table 7. Institutional readiness for AI-enabled competency-based education.

Strategic Dimension	Emerging Institution	Developing Institution	AI-Enabled Institution
Curriculum Design	Static curriculum	Periodic revision	Dynamic AI-assisted competency mapping
Assessment	Product-oriented	Mixed assessment	Process-based competency verification
Faculty Role	Lecturer	Facilitator	Competency evaluator and mentor
AI Integration	Limited experimentation	Course-level adoption	Institution-wide implementation
Learning Analytics	Basic reporting	Predictive dashboards	Real-time competency analytics
Academic Integrity	Detection-focused	Hybrid approach	Verification-centered framework
Governance	Informal policies	Institutional guidelines	Comprehensive AI governance

7. Policy Recommendations

The successful integration of AI into competency-based education requires coordinated action among universities, accrediting agencies, policymakers, technology developers, and faculty. Universities should redesign assessment frameworks around competency verification rather than AI prohibition. Institutional policies should require transparency regarding AI use while encouraging responsible educational applications.

Accrediting organizations should revise quality standards to recognize process-based competency verification as a valid demonstration of learning. Accreditation frameworks should emphasize assessment validity rather than technological restrictions. Faculty should increasingly design authentic learning experiences requiring explanation, reflection, collaboration, and live demonstration of competency. AI should be positioned as a learning partner rather than an assessment substitute.

Educational AI developers should prioritize transparency, explainability, interoperability with learning management systems, competency analytics, and instructor oversight rather than fully autonomous educational decision-making. National higher education policies should encourage responsible AI innovation while preserving academic standards, learner privacy, equity, and public trust in educational credentials.

8. Future Research

Although this paper develops a conceptual framework integrating competency-based education and artificial intelligence, several important research directions remain. Empirical validation of the Scalability-Verification Paradox is needed across diverse institutional contexts. Multi-institutional studies should examine whether AI-enabled competency-based programs consistently demonstrate improved scalability while experiencing increased challenges in competency verification.

Longitudinal research should examine the long-term relationship between AI-supported competency development and graduate workforce performance. Such investigations would help determine whether process-based assessment predicts

professional success more effectively than conventional product-oriented evaluation.

Researchers should explore the ethical dimensions of AI-enhanced competency-based education, including issues related to bias, transparency, algorithmic accountability, learner privacy, and equitable access. Interdisciplinary collaborations among educational researchers, psychometricians, computer scientists, instructional designers, and policymakers will be essential for developing robust AI governance models capable of balancing innovation with educational integrity.

9. Conclusion

Competency-Based Education has long promised to transform higher education by replacing time-based progression with demonstrated mastery. Yet the operational demands of personalized instruction, continuous assessment, competency mapping, and individualized feedback have historically prevented widespread institutional adoption. Artificial Intelligence fundamentally changes this landscape.

The evidence synthesized throughout this article suggests that AI provides the operational infrastructure necessary to implement competency-based education at scale. Intelligent tutoring systems, adaptive learning platforms, predictive analytics, competency mapping, and AI-assisted feedback collectively remove many of the logistical barriers that previously constrained personalized education.

However, AI simultaneously introduces an equally important challenge. As generative AI increasingly contributes to the production of academic work, the relationship between submitted artifacts and authentic learner competence becomes progressively uncertain. This challenge extends beyond academic misconduct to the core psychometric question of assessment validity.

To address this issue, this article introduced the Scalability-Verification Paradox, a theoretical framework explaining AI's dual role as both an operational enabler and a verification challenge within competency-based education. In response, the paper proposed Process-Based Competency Verification (PBCV), a model that shifts educational assessment from evaluating static products toward documenting and verifying the learning process through iterative evidence, reflection, oral examination, authentic performance, and human-centered evaluation. The revised framework explicitly distinguishes operational scalability from verification and defines minimum evidence requirements for PBCV certification.

This perspective reframes the future role of educators. Rather than serving primarily as content transmitters or assignment graders, faculty become expert evaluators responsible for validating reasoning, professional judgment, ethical decision-making, and authentic competency. Artificial Intelligence therefore does not diminish the importance of human educators; instead, it elevates their role by automating routine instructional functions while preserving uniquely human responsibilities in mentorship, assessment, and competency certification.

Ultimately, the future of competency-based education will not be determined by whether institutions adopt artificial intelligence, but by whether they success-

fully redesign assessment systems capable of distinguishing between AI-assisted learning and independently demonstrated mastery. Institutions that achieve this balance will be well positioned to deliver scalable, personalized, and trustworthy competency-based education while maintaining public confidence in the value and integrity of higher education credentials.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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