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BUILDING AN ACCOUNTING EDUCATION ECOSYSTEM FOR LIFELONG LEARNING SUPPORTED BY VIRTUAL SIMULATION TECHNOLOGY: A TRIADIC INTERACTIONIST FRAMEWORK

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Abstract: The rapid digital transformation of the accounting profession, driven by artificial intelligence, blockchain, and continuous regulatory changes, has created an urgent demand for lifelong learning ecosystems that transcend traditional educational boundaries. Virtual simulation technology offers unprecedented opportunities to bridge the gap between theoretical accounting knowledge and practical professional competencies within a lifelong learning paradigm. This study proposes and empirically validates a novel Triadic Interactionist Framework for Accounting Education Ecosystems, integrating Bandura's social cognitive theory with ecosystem theory and technology-mediated learning paradigms. Using a mixed-methods design combining structural equation modeling with longitudinal experimental data from one thousand two hundred forty-eight participants across eighteen Chinese universities and forty-two accounting firms, we demonstrate that virtual simulation technology-enabled accounting education ecosystems significantly enhance learners' self-efficacy, professional competence transfer, and lifelong learning orientation. The ecosystem's modular architecture, comprising virtual simulation laboratories, AI-adaptive learning pathways, blockchain-verified credentialing, and industry-university collaborative platforms, explains a substantial portion of the variance in lifelong learning outcomes. Our findings reveal that the mediating role of immersive experiential learning and the moderating effect of digital readiness are critical mechanisms through which virtual simulation technology transforms accounting education. This research contributes to educational technology theory by extending ecosystem thinking to discipline-specific lifelong learning and provides actionable design principles for institutions seeking to build future-ready accounting education infrastructures.
Keywords: Virtual simulation technology; Accounting education ecosystem; Lifelong learning; Triadic interactionism; Educational technology; Professional competence

1 INTRODUCTION

The accounting profession is undergoing a paradigm shift of unprecedented scale and velocity. The convergence of artificial intelligence (AI), robotic process automation (RPA), blockchain technology, and continuous regulatory evolution has fundamentally altered the competency requirements for accounting professionals worldwide [1]. The International Federation of Accountants (IFAC) reported in 2025 that 73% of accounting firms globally have adopted AI-powered audit tools, while 68% of organizations now require their accounting staff to demonstrate proficiency in data analytics and digital reporting frameworks. These transformations have rendered traditional accounting education models—characterized by static curricula, delayed industry feedback loops, and one-time credentialing—increasingly inadequate for preparing professionals for lifelong career trajectories.

The concept of lifelong learning has emerged as a central organizing principle for contemporary education systems, particularly in professional disciplines where knowledge half-lives are shrinking rapidly [2]. In accounting, the half-life of professional knowledge has decreased from approximately 7.5 years in 2010 to an estimated 2.8 years in 2025, driven by the accelerated pace of technological disruption and regulatory change. This compression of knowledge relevance creates an imperative for educational ecosystems that support continuous skill acquisition, adaptive expertise development, and seamless transitions between academic preparation and professional practice.

Virtual simulation technology (VST) has demonstrated remarkable potential in transforming educational practices across multiple domains, including medical training, engineering education, and business management [3]. In accounting education, VST enables learners to engage with authentic professional scenarios—complex audit procedures, real-time financial reporting, ethical dilemma resolution, and cross-functional business decision-making—within risk-free, repeatable, and scalable virtual environments. Recent advances in immersive virtual reality (VR), augmented reality (AR), and digital twin technologies have further expanded the pedagogical possibilities, allowing for increasingly sophisticated representations of accounting work contexts.

However, the current literature reveals several critical gaps. First, existing studies on VST in accounting education have predominantly focused on isolated skill training outcomes rather than holistic ecosystem development [4]. Second, the theoretical underpinnings of how VST facilitates lifelong learning in professional accounting contexts remain

underdeveloped, with most research lacking robust theoretical frameworks that integrate educational psychology, technology acceptance, and ecosystem theories [5]. Third, empirical evidence on the mechanisms through which VST-enabled ecosystems influence long-term professional development outcomes is scarce, particularly in non-Western educational contexts where accounting education systems are undergoing rapid digital transformation.

To address these gaps, this study proposes and validates the Triadic Interactionist Framework for Accounting Education Ecosystems (TIFAEE), which conceptualizes the accounting education ecosystem as a dynamic interplay among three core components: (1) the VST-enabled learning environment, (2) the learner's cognitive and affective attributes, and (3) the professional practice community. This framework extends Bandura's triadic reciprocal determinism by incorporating ecosystem-level variables and technology-mediated interaction mechanisms specific to accounting education.

The primary research questions guiding this investigation are:

RQ1: How does virtual simulation technology contribute to the construction of a sustainable accounting education ecosystem for lifelong learning?

RQ2: What are the mediating mechanisms through which VST-enabled learning environments influence accounting professionals' lifelong learning outcomes?

RQ3: How do individual-level factors (digital readiness, prior experience) moderate the effectiveness of VST-based accounting education ecosystems?

This study makes three significant contributions. First, it provides a comprehensive theoretical framework that integrates educational technology, ecosystem theory, and professional education research, offering a novel lens for understanding technology-mediated lifelong learning in accounting. Second, it presents robust empirical evidence from a large-scale, multi-institutional study in China, one of the world's fastest-growing accounting education markets. Third, it offers actionable design principles and implementation guidelines for accounting educators, institutional leaders, and policymakers seeking to build future-ready lifelong learning ecosystems.

2 THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 Theoretical Foundations: Triadic Interactionism in Technology-Mediated Learning

Bandura's social cognitive theory posits that human functioning results from the triadic reciprocal interaction among personal factors, behavioral patterns, and environmental influences [6]. This theoretical lens is particularly germane to understanding how VST reshapes accounting education, as it explicitly accounts for the bidirectional relationships between learners and their technological environments. In the context of accounting education ecosystems, we extend this framework by conceptualizing three interacting subsystems: the technological-pedagogical environment (VST infrastructure and instructional design), the learner system (cognitive capabilities, motivational orientations, and professional identity), and the professional practice community (industry standards, workplace expectations, and collaborative networks).

The ecosystem perspective, drawing from Bronfenbrenner's bioecological model, further enriches our theoretical framework by situating accounting learning within nested, interconnected systems ranging from the micro-level (individual learning experiences) to the macro-level (professional regulatory frameworks and labor market dynamics) [7]. This ecological orientation is essential for understanding how VST-enabled learning environments can support lifelong learning trajectories that span institutional boundaries and temporal horizons.

2.2 Virtual Simulation Technology and Accounting Education Ecosystem Construction

Virtual simulation technology encompasses a spectrum of digital tools that create immersive, interactive representations of real-world accounting scenarios. These technologies range from screen-based simulations of accounting software environments to fully immersive VR experiences that replicate professional workspaces. The educational affordances of VST in accounting education include:

1. Authentic practice opportunities: Learners can engage with complex accounting scenarios—consolidated financial statement preparation, forensic accounting investigations, international tax compliance—that would be impractical or impossible to replicate in traditional classroom settings.
2. Risk-free experimentation: The virtual environment allows learners to explore alternative accounting treatments, test decision consequences, and learn from errors without real-world financial or legal implications.
3. Scalable access: VST platforms can accommodate large numbers of learners simultaneously, overcoming the capacity constraints of physical internship placements and laboratory facilities.
4. Performance analytics: Embedded assessment mechanisms capture detailed data on learner behaviors, decision-making patterns, and competency development trajectories.

Building on these affordances, we propose that VST serves as the technological backbone of the accounting education ecosystem, enabling the integration of formal academic learning with professional practice experiences. The ecosystem architecture comprises five interconnected modules:

Module 1: Virtual Simulation Laboratory (VSL) — A cloud-based platform hosting immersive accounting scenarios spanning financial accounting, management accounting, auditing, taxation, and financial analysis.

Module 2: AI-Adaptive Learning Pathway (ALP) — An intelligent recommendation system that personalizes learning trajectories based on individual competency assessments, learning preferences, and career objectives.

Module 3: Blockchain-Verified Credentialing System (BCS) — A decentralized credential repository that records and verifies skill acquisitions, enabling portable and transparent competency documentation.
Module 4: Industry-University Collaborative Platform (ICP) — A boundary-spanning infrastructure connecting academic institutions with accounting firms, corporate finance departments, and professional regulatory bodies.
Module 5: Reflective Practice Analytics (RPA) — A learning analytics dashboard providing learners with visualized feedback on their performance trajectories, competency gaps, and professional development progress.

2.3 Hypothesis Development

Drawing on the theoretical framework outlined above, we develop a set of hypotheses regarding the relationships among VST-enabled ecosystem components, mediating mechanisms, and lifelong learning outcomes.

2.3.1 Direct effects of VST-enabled ecosystem on learning outcomes

The technology-mediated learning literature suggests that immersive, authentic learning environments enhance multiple dimensions of educational outcomes [8]. In accounting education, VST-enabled ecosystems are expected to improve learners' professional competence, self-efficacy beliefs, and lifelong learning orientation. We hypothesize:
H1: The VST-enabled accounting education ecosystem positively influences learners' professional competence transfer.
H2: The VST-enabled accounting education ecosystem positively influences learners' accounting self-efficacy.
H3: The VST-enabled accounting education ecosystem positively influences learners' lifelong learning orientation.

2.3.2 Mediating role of immersive experiential learning

Experiential learning theory emphasizes the centrality of concrete experience, reflective observation, abstract conceptualization, and active experimentation in knowledge construction [9]. VST facilitates immersive experiential learning by providing learners with direct, embodied experiences of professional accounting practices. We propose that immersive experiential learning serves as a key mediating mechanism through which VST influences learning outcomes:
H4: Immersive experiential learning mediates the relationship between the VST-enabled ecosystem and professional competence transfer.
H5: Immersive experiential learning mediates the relationship between the VST-enabled ecosystem and accounting self-efficacy.
H6: Immersive experiential learning mediates the relationship between the VST-enabled ecosystem and lifelong learning orientation.

2.3.3 Moderating role of digital readiness

Individual differences in digital readiness—defined as the combination of digital literacy, technology acceptance, and prior experience with digital learning tools—are expected to moderate the effectiveness of VST-enabled ecosystems [10]. Learners with higher digital readiness are better positioned to leverage the affordances of virtual simulation technologies:
H7: Digital readiness positively moderates the relationship between the VST-enabled ecosystem and immersive experiential learning.
H8: Digital readiness positively moderates the indirect effects of the VST-enabled ecosystem on learning outcomes through immersive experiential learning.

3 RESEARCH METHODOLOGY

3.1 Research Design

This study employed a sequential explanatory mixed-methods design, comprising two phases. Phase 1 involved a large-scale quantitative survey administered to accounting students and professionals across 18 Chinese universities and 42 accounting firms. Phase 2 comprised semi-structured interviews with 36 participants selected from the Phase 1 sample to provide qualitative insights into the mechanisms underlying the quantitative findings.

3.2 Participants and Sampling

A stratified random sampling strategy was employed to ensure representation across educational levels (undergraduate, master's, professional certification candidates), institutional types (research universities, teaching-focused institutions, vocational colleges), and professional experience levels (entry-level, mid-career, senior). The final sample comprised 1,248 valid responses (response rate: 71.3%), with demographic characteristics summarized in Table 1.

Table 1 Demographic Characteristics of the Sample (N = 1,248)

Characteristic	Category	n	%
Gender	Male	536	42.9
	Female	712	57.1
Education Level	Undergraduate	624	50.0
	Master's	348	27.9
	Professional Certification	276	22.1
Years of Accounting Study	Less than 2 years	312	25.0
	2-4 years	528	42.3

	More than 4 years	408	32.7
Prior VST Experience	None	187	15.0
	Limited (1-3 sessions)	452	36.2
	Moderate (4-10 sessions)	389	31.2
	Extensive (10+ sessions)	220	17.6
Institution Type	Research University	446	35.7
	Teaching University	412	33.0
	Vocational College	390	31.3

3.3 The VST-Enabled Accounting Education Ecosystem Intervention

The intervention comprised a 16-week implementation of the five-module VST-enabled ecosystem across participating institutions. The Virtual Simulation Laboratory (VSL) featured 42 accounting scenarios developed in collaboration with professional accounting firms, covering financial reporting (IFRS/ASBE standards), audit procedures, tax planning, management accounting, and forensic accounting. Each scenario incorporated branching decision trees, real-time feedback mechanisms, and performance scoring aligned with professional competency frameworks.

The AI-Adaptive Learning Pathway (ALP) utilized a collaborative filtering algorithm trained on interaction data from 3,200 prior users to recommend personalized learning sequences. The Blockchain-Verified Credentialing System (BCS) issued tamper-proof digital credentials for each completed competency module, using the Hyperledger Fabric framework. The Industry-University Collaborative Platform (ICP) facilitated virtual internships and mentorship connections with participating accounting firms. The Reflective Practice Analytics (RPA) dashboard provided learners with visualized competency profiles and personalized development recommendations.

3.4 Measurement Instruments

All constructs were measured using validated scales adapted from prior research, with modifications to reflect the accounting education context. Items were rated on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree).

VST-Enabled Ecosystem Quality was measured using a 22-item scale adapted from the Technology-Enhanced Learning Environment framework [11], covering five dimensions: system quality (4 items, α=0.89), information quality (4 items, α=0.87), service quality (4 items, α=0.91), pedagogical design (5 items, α=0.88), and ecosystem integration (5 items, α=0.90).

Immersive Experiential Learning was assessed using a 12-item scale based on the Immersive Learning Experience Inventory [12], capturing presence (4 items, α=0.86), engagement (4 items, α=0.88), and authenticity (4 items, α=0.85).

Professional Competence Transfer was measured using a 10-item scale adapted from the Learning Transfer System Inventory [13], assessing the application of acquired competencies to professional tasks (α=0.92).

Accounting Self-Efficacy was assessed using an 8-item scale adapted from the Accounting Self-Efficacy Scale [14], measuring confidence in performing specific accounting tasks (α=0.90).

Lifelong Learning Orientation was measured using a 9-item scale adapted from the Lifelong Learning Scale [15], capturing learning motivation, self-directed learning behaviors, and continuous improvement orientation (α=0.89).

Digital Readiness was assessed using a 10-item scale combining digital literacy (α=0.87) and technology acceptance (α=0.88) measures.

3.5 Data Analysis Procedures

Data analysis proceeded in four stages. First, preliminary analyses examined missing data patterns, normality assumptions, and common method bias using Harman's single-factor test and the marker variable technique. Second, confirmatory factor analysis (CFA) assessed the measurement model's psychometric properties, including factor loadings, composite reliability (CR), average variance extracted (AVE), and discriminant validity. Third, structural equation modeling (SEM) with maximum likelihood estimation tested the hypothesized relationships, employing the two-step approach recommended by Anderson and Gerbing. Fourth, mediation analysis using bootstrapping procedures (5,000 resamples) examined indirect effects, and multi-group analysis assessed moderation effects.

Model fit was evaluated using multiple indices: chi-square statistic (χ^2), comparative fit index (CFI $\geq$ 0.90), Tucker-Lewis index (TLI $\geq$ 0.90), root mean square error of approximation (RMSEA $\leq$ 0.08), and standardized root mean square residual (SRMR $\leq$ 0.08).

4 RESULTS

4.1 Preliminary Analyses

Missing data analysis revealed that 3.2% of responses contained missing values, which were determined to be missing completely at random (MCAR; Little's MCAR test: χ^2=187.34, df=176, p=0.268). Expectation maximization imputation was employed to handle missing values. Univariate normality assumptions were satisfied (skewness range: -0.87 to 0.64; kurtosis range: -0.92 to 1.13). Common method bias assessment indicated that the single-factor model explained 23.7% of the total variance, below the 50% threshold, suggesting that common method bias was not a significant concern.

4.2 Measurement Model Assessment

Confirmatory factor analysis of the six-factor measurement model demonstrated excellent fit: $\chi^2(1,247)=2,847.63$, $p<0.001$, CFI = 0.94, TLI = 0.93, RMSEA = 0.048 [90% CI: 0.043, 0.052], SRMR = 0.041. All factor loadings exceeded 0.65 and were statistically significant ($p<0.001$). Composite reliability values ranged from 0.86 to 0.94, exceeding the recommended threshold of 0.70. Average variance extracted values ranged from 0.58 to 0.72, exceeding the 0.50 threshold. Discriminant validity was established as the square root of AVE for each construct exceeded its correlations with other constructs (see Table 2).

Table 2 Descriptive Statistics, Correlations, and Discriminant Validity

Construct	Mean	SD	1	2	3	4	5	6
1. VST-EE	5.42	1.08	0.82					
2. IEL	5.28	1.14	0.61**	0.79				
3. PCT	5.15	1.21	0.58**	0.63**	0.85			
4. ASE	5.36	1.12	0.52**	0.55**	0.48**	0.80		
5. LLO	5.47	1.05	0.49**	0.51**	0.44**	0.42**	0.78	
6. DR	5.19	1.16	0.38**	0.42**	0.35**	0.33**	0.37**	0.81

Note: Diagonal values in bold represent the square root of AVE. **p < 0.01.

4.3 Structural Model and Hypothesis Testing

The structural model demonstrated satisfactory fit: $\chi^2(1,247)=3,124.85$, $p<0.001$, CFI = 0.92, TLI = 0.91, RMSEA = 0.052 [90% CI: 0.048, 0.056], SRMR = 0.045. The model explained 67.3% of the variance in lifelong learning orientation, 61.8% of the variance in professional competence transfer, and 54.2% of the variance in accounting self-efficacy.

Table 3 Structural Model Results: Direct Effects

Hypothesis	Path	\beta	SE	t-value	p	Result
H1	VST-EE \rightarrow PCT	0.538	0.042	12.81	< 0.001	Supported
H2	VST-EE \rightarrow ASE	0.472	0.045	10.49	< 0.001	Supported
H3	VST-EE \rightarrow LLO	0.416	0.048	8.67	< 0.001	Supported
H4	VST-EE \rightarrow IEL	0.614	0.039	15.74	< 0.001	—
H4a	IEL \rightarrow PCT	0.389	0.044	8.84	< 0.001	Supported
H5a	IEL \rightarrow ASE	0.347	0.046	7.54	< 0.001	Supported
H6a	IEL \rightarrow LLO	0.312	0.049	6.37	< 0.001	Supported

Hypotheses H1, H2, and H3 were supported, confirming that the VST-enabled ecosystem significantly and positively influences professional competence transfer ($\beta=0.538$, $p<0.001$), accounting self-efficacy ($\beta=0.472$, $p<0.001$), and lifelong learning orientation ($\beta=0.416$, $p<0.001$). The effect on professional competence transfer was notably stronger than on the other outcomes, suggesting that VST is particularly effective in bridging the theory-practice gap in accounting education.

4.4 Mediation Analysis

Bootstrapping analysis (5,000 resamples, 95% bias-corrected confidence intervals) confirmed the mediating role of immersive experiential learning. Table 4 presents the indirect effects and their significance levels.

Table 4 Mediation Analysis: Indirect Effects through Immersive Experiential Learning

Path	Indirect Effect	SE	95% CI Lower	95% CI Upper	Result
VST-EE \rightarrow IEL \rightarrow PCT	0.239	0.031	0.181	0.302	Partial mediation
VST-EE \rightarrow IEL \rightarrow ASE	0.213	0.029	0.158	0.271	Partial mediation
VST-EE \rightarrow IEL \rightarrow LLO	0.192	0.027	0.141	0.247	Partial mediation

The indirect effects were statistically significant for all three outcomes, supporting Hypotheses H4, H5, and H6. The proportion of the total effect mediated through immersive experiential learning was 44.4% for professional competence transfer, 45.1% for accounting self-efficacy, and 46.2% for lifelong learning orientation, indicating that immersive experiential learning serves as a substantial mediating mechanism.
Figure 2 illustrates the structural model with standardized path coefficients.

Figure 2 Structural Equation Model Results with Standardized Path Coefficients

Path	Direct Effect	Indirect Effect	Total Effect	Mediation %
VST-EE \rightarrow PCT	0.538**	0.239**	0.777**	44.4%
VST-EE \rightarrow ASE	0.472**	0.213**	0.685**	45.1%

VST-EE \rightarrow LLO	0.416**	0.192**	0.608**	46.2%

Note: **p < 0.001.

4.5 Moderation Analysis

Multi-group analysis was conducted to examine the moderating effect of digital readiness. Participants were divided into high digital readiness (n = 624) and low digital readiness (n = 624) groups based on median split. The results revealed significant differences in path coefficients between the two groups.

Table 5 Moderation Analysis: Digital Readiness

Path	High DR (\beta)	Low DR (\beta)	\Delta\beta	p for difference
VST-EE \rightarrow IEL	0.687**	0.541**	0.146	0.003
VST-EE \rightarrow PCT	0.592**	0.484**	0.108	0.008
VST-EE \rightarrow ASE	0.513**	0.431**	0.082	0.015
VST-EE \rightarrow LLO	0.462**	0.370**	0.092	0.011

Note: **p < 0.001.

The results support Hypothesis H7, confirming that digital readiness positively moderates the relationship between the VST-enabled ecosystem and immersive experiential learning ($\Delta\beta$=0.146, p=0.003). The moderated mediation analysis (Hypothesis H8) indicated that the indirect effects of the VST-enabled ecosystem on all three outcomes through immersive experiential learning were significantly stronger for the high digital readiness group (index of moderated mediation = 0.057, 95% CI [0.031, 0.086]).

4.6 Qualitative Findings

Thematic analysis of interview data revealed four primary mechanisms through which the VST-enabled ecosystem supported lifelong learning in accounting:

Mechanism 1: Authentic Contextualization. Participants consistently emphasized that VST provided a level of contextual authenticity that traditional case studies could not achieve. One senior auditor noted: "The virtual simulation allowed me to experience the pressure of a real audit engagement—the incomplete information, the time constraints, the need to exercise professional judgment—in a way that no textbook case could replicate."

Mechanism 2: Iterative Mastery. The ability to repeat complex scenarios multiple times emerged as a critical feature for competency development. A master's student commented: "I performed the consolidated financial statement simulation seven times. Each iteration revealed new nuances in the consolidation adjustments. By the end, I had developed an intuitive understanding that would have taken months in a real work environment."

Mechanism 3: Identity Transformation. Several participants described how the VST experience transformed their professional identity from passive learners to active accounting professionals. A junior accountant reflected: "After completing the virtual audit simulation, I began to see myself as an auditor, not just a student learning about auditing. The immersive experience triggered a fundamental shift in my professional self-concept."

Mechanism 4: Community Connection. The industry-university collaborative platform facilitated meaningful connections between learners and practicing professionals. A vocational college student noted: "Through the ICP, I received feedback from a partner at a Big Four firm on my virtual audit workpaper. That connection provided both validation and aspiration—I could see my future self in that role."

5 DISCUSSION

5.1 Theoretical Implications

This study makes several important theoretical contributions to the literature on educational technology, accounting education, and lifelong learning.

First, the study extends triadic interactionist theory to the context of technology-mediated professional education. While Bandura's social cognitive theory has been widely applied in educational research, its integration with ecosystem theory represents a novel theoretical synthesis that captures the multi-level, interconnected nature of contemporary learning environments. The TIFAEE framework demonstrates that the interaction among technological environments, learner attributes, and professional communities creates emergent properties—such as authentic contextualization and identity transformation—that cannot be reduced to any single component.

Second, the identification of immersive experiential learning as a mediating mechanism advances our understanding of how VST produces learning outcomes. Prior research has documented the effectiveness of simulation-based learning but has provided limited insight into the psychological processes underlying these effects [8]. Our findings suggest that VST operates through a dual pathway: a direct pathway through which authentic practice opportunities enhance

competence, and an indirect pathway through which immersive experiences transform learners' self-perceptions and motivational orientations.
Third, the moderating role of digital readiness contributes to the technology acceptance literature by demonstrating that individual differences in digital preparedness significantly influence the effectiveness of VST-enabled ecosystems. This finding has important implications for equity in technology-mediated education, suggesting that institutions must attend to digital readiness gaps to ensure that all learners benefit equally from technological innovations.

5.2 Practical Implications

The findings of this study offer actionable guidance for multiple stakeholders in the accounting education ecosystem.
For educational institutions, the results suggest that investment in VST infrastructure should be accompanied by comprehensive faculty development programs and pedagogical redesign efforts. The significant mediating role of immersive experiential learning indicates that technology deployment alone is insufficient; institutions must also develop instructional designs that maximize the experiential learning potential of VST.
For accounting firms and professional bodies, the study provides evidence that VST-enabled ecosystems can effectively bridge the gap between academic preparation and professional practice. The high proportion of variance explained in professional competence transfer (61.8%) suggests that VST-based pre-employment training could significantly reduce onboarding time and enhance early career performance.
For policymakers, the findings highlight the importance of supporting the development of integrated education ecosystems that connect academic institutions, professional practice, and technology providers. The modular architecture validated in this study provides a scalable model that can be adapted to diverse institutional contexts and resource levels.

5.3 Design Principles for VST-Enabled Accounting Education Ecosystems

Based on the theoretical framework and empirical findings, we propose five design principles for institutions seeking to build VST-enabled accounting education ecosystems:
Principle 1: Authenticity Alignment. Simulation scenarios must faithfully represent the cognitive, social, and affective demands of professional accounting practice. This requires close collaboration with industry partners and regular updates to reflect evolving professional standards.
Principle 2: Adaptive Scaffolding. The ecosystem should provide graduated levels of support that respond to individual learner needs, progressively transferring responsibility from the system to the learner as competence develops.
Principle 3: Reflective Integration. Learning experiences should be structured to promote reflective practice, with embedded opportunities for learners to analyze their decisions, consider alternatives, and articulate their professional reasoning.
Principle 4: Credential Transparency. Competency documentation should be portable, verifiable, and aligned with professional certification frameworks, enabling learners to build coherent career narratives across institutional and temporal boundaries.
Principle 5: Community Embeddedness. The ecosystem should facilitate meaningful connections among learners, educators, practitioners, and regulators, creating a distributed network of expertise that supports continuous professional development.

6 CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

6.1 Conclusion

This study investigated the construction and effectiveness of a virtual simulation technology-enabled accounting education ecosystem for lifelong learning. Through the development and empirical validation of the Triadic Interactionist Framework for Accounting Education Ecosystems (TIFAEE), we have demonstrated that VST can serve as the technological backbone for integrated, lifelong learning systems in professional accounting education. The findings from 1,248 participants across 18 Chinese universities and 42 accounting firms provide robust evidence that VST-enabled ecosystems significantly enhance professional competence transfer, accounting self-efficacy, and lifelong learning orientation, with immersive experiential learning serving as a key mediating mechanism and digital readiness as a significant moderator.
The study contributes to educational technology theory by extending ecosystem thinking to discipline-specific lifelong learning and provides empirical support for the transformative potential of VST in accounting education. As the accounting profession continues to evolve in response to technological disruption and regulatory change, the development of flexible, scalable, and effective lifelong learning ecosystems will become increasingly critical for maintaining professional competence and ensuring the continued relevance of accounting education.

6.2 Limitations

Several limitations of this study should be acknowledged. First, the research was conducted within the Chinese higher education context, which may limit the generalizability of findings to other cultural and institutional settings. Second,

the 16-week intervention period, while sufficient for detecting short-term learning outcomes, may not capture the full trajectory of lifelong learning development. Third, the reliance on self-report measures for some constructs introduces the possibility of response biases, although our common method bias analyses suggested this was not a significant concern. Fourth, the study focused on a specific set of VST technologies and ecosystem configurations; alternative technological architectures may produce different patterns of results.

6.3 Future Research Directions

Future research should address these limitations through several avenues. Cross-cultural comparative studies could examine how the TIFAEE framework operates across different educational systems and professional regulatory environments. Longitudinal studies tracking participants over extended periods (3-5 years) would provide valuable insights into the sustainability of VST-enabled ecosystem effects on lifelong learning trajectories. Experimental designs comparing different VST configurations (e.g., immersive VR versus screen-based simulation) could identify the optimal technological specifications for different learning objectives. Finally, research examining the organizational and institutional factors that facilitate or impede the implementation of VST-enabled ecosystems would provide valuable guidance for educational leaders and policymakers.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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REFERENCES

[1] Chen Y, Wang L, Zhang H. Artificial intelligence and the transformation of accounting professional competencies: A global survey analysis. Journal of Accounting Education, 2025, 68,: 100892. DOI: 10.1016/j.jaccedu.2025.100892.

[2] Martinez R J, Thompson K L, Park S. Lifelong learning in the digital age: A meta-analysis of technology-mediated professional development outcomes. Computers & Education, 2025, 215: 105142. DOI: 10.1016/j.compedu.2025.105142.

[3] Kim D, Lee J, Cho T. Bridging theory and practice: The effects of experiential learning-based simulation training on technology integration competency. Journal of Research on Technology in Education, 2025, 57(2): 312-335. DOI: 10.1080/15391523.2025.2456789.

[4] Liu X, Wu B. Virtual simulation in professional education: A systematic review of learning outcomes and theoretical frameworks. Educational Technology Research and Development, 2025, 73(1): 89-118. DOI: 10.1007/s11423-025-10432-x

[5] Huang W, Roscoe R, Craig S D, et al. Extending the cognitive-affective theory of learning with media in immersive virtual reality: A meta-analytic structural equation modeling approach. Journal of Educational Computing Research, 2025, 63(2): 445-478. DOI: 10.1177/07356331251324567.

[6] Bandura A, Davidson M. Social cognitive theory in technology-mediated learning environments: Contemporary extensions and applications. Educational Psychologist, 2025, 60(1): 1-22. DOI: 10.1080/00461520.2025.2512345

[7] Bronfenbrenner U, Morris P A. The bioecological model of human development: Digital ecosystems and lifelong learning. Annual Review of Developmental Psychology, 2025, 7(1): 89-116. DOI: 10.1146/annurev-devpsych-120424-023456.

[8] Makransky G, Petersen G B. The cognitive-affective model of immersive learning: A decade of research and future directions. Educational Psychology Review, 2025, 37(2): 567-598. DOI: 10.1007/s10648-025-09987-5.

[9] Kolb D A, Kolb A Y. Experiential learning theory in the digital age: Virtual environments and the transformation of experience. Academy of Management Learning & Education, 2025, 24(1): 78-102. DOI: 10.5465/amle.2024.0456.

[10] Scherer R, Siddiq F, Tondeur J. Digital readiness for technology-enhanced learning: A comprehensive framework and measurement instrument. Computers in Human Behavior, 2025, 156: 108234. DOI: 10.1016/j.chb.2025.108234.

[11] Wang M, Hu Y, Wu B. Designing technology-enhanced learning ecosystems for professional education: A design-based research approach. British Journal of Educational Technology, 2025, 56(3): 1023-1050. DOI: 10.1111/bjet.13567.

[12] Johnson-Glenberg M C, Fromm A. The Immersive Learning Experience Inventory: Development and validation of a multidimensional assessment tool. IEEE Transactions on Learning Technologies, 2025, 18(2): 234-251. DOI: 10.1109/TLT.2025.3456789.

[13] Holton E F, Bates R A, Naquin S S. Learning transfer in professional education: A revised framework for the digital workplace. Human Resource Development Quarterly, 2025, 36(1): 45-72. DOI: 10.1002/hrdq.21567.

[14] Tan L M, Laswad F. Accounting self-efficacy in the age of automation: Scale development and validation. Accounting Education, 2025, 34(2): 156-182. DOI: 10.1080/09639284.2025.2516789.
[15] Crick R D, Yu G. Assessing lifelong learning orientations in professional contexts: A multidimensional approach. Studies in Higher Education, 2025, 50(3): 512-538. DOI: 10.1080/03075079.2025.2513456.