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Integrating industry certification into STEM-oriented vocational undergraduate education: Taking the major of financial technology application as an example

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Abstract

To address the persistent misalignment between competencies cultivated in traditional vocational education and the dynamic requirements of industry, this study–anchored in the STEM education framework–proposes an integrated model for embedding industry-recognized certification within undergraduate programs in financial technology. Using the +X intermediate certification in financial big data processing as a focal point, the research introduces the "STEM-certification double helix" model, operationalized through a closed-loop system comprising competency decomposition, dynamic mapping, and evidence-based traceability. The model enables the effective alignment between industry certification standards and curriculum objectives. Empirical evidence indicates that its implementation significantly enhances the pass rate of 1+X certifications and students' data processing competencies, thereby elevating the overall quality of education and improving graduates' employability. Based on these results, the author puts forward strategic recommendations, including institutional-level promotion, strengthened school-enterprise collaboration, and the establishment of supportive policy frameworks. These measures offer both theoretical and practical pathways for advancing technology-enabled transformation in vocational undergraduate education.

Keywords: industry certification, STEM, vocational undergraduate education, financial technology application major

INTRODUCTION

Fintech is undergoing a paradigm shift, driven by innovations such as blockchain, algorithmic trading, and regulatory technology. On March 4, 2021, the Bank for International Settlements (2021) emphasized in its report on the use of big data and machine learning by central banks that: "In the past few years, central banks' interest in big data and machine learning has increased significantly. Approximately 80% of central banks have formally discussed the topic of big data within their institutions, representing a 30% increase compared to 2015." This trend underscores the need for financial professionals to meet a dual challenge: not only acquiring advanced technical skills–such as mathematical modeling and distributed system development–but also mastering the business logic of the full lifecycle financial product management. However, traditional vocational education has struggled to keep pace with industry demands due to the breakdown of its integrative structure. This threefold structure–separation of disciplinary knowledge, certification lag, and disconnection from practical technical tools–undermines the ability of vocational education to meet industry needs.

As the core carrier for cultivating technical and skilled talent, the key breakthrough in the reform of undergraduate vocational education lies in establishing a dynamic alignment mechanism between educational supply and industry demand. International experience shows that the deep integration of industry certification systems can significantly enhance the efficiency of talent cultivation. For example, the optional practical training policy in the United States allows international students majoring in STEM fields under F-1 visas to obtain a 36-month post-graduation internship qualification (Liao & Hu, 2023). In a similar vein, the Canadian engineering

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Contribution to the literature

- This paper, focusing on Financial Technology Application, first systematically explores integrating industry certification with STEM-oriented vocational undergraduate education, bridging the research gap in this vocational undergraduate field.
- The "STEM-certification double helix" model constructed herein offers an operable framework for aligning vocational skill training with industry needs, enriching related theories and methods.
- Integrating research on AI-driven digital skills cultivation, it expands STEM education applications in vocational undergraduates and provides new insights for future studies.

accreditation board stipulates that engineering programs undergo a structured curriculum renewal process every five years, in accordance with the EUR-ACE (2020) cyclical model. Both systems transform industry standards into binding constraints on educational quality, thereby driving the continuous optimization of program development. These practices reveal that effective industry–education integration should go beyond superficial certificate accumulation. Instead, it is essential to establish a closed-loop adjustment mechanism of "certification standards → curriculum objectives → teaching implementation → feedback and improvement".

This study selects the financial technology application major as a pilot for reform and based on the STEM framework, aims to address two major problems: constructing an interdisciplinary knowledge system and establishing a certification-oriented quality assurance mechanism. It facilitates the real-time adaptation of education to industry needs through the development of a dynamic capability framework, the design of a modular certification system, and the creation of an intelligent demand-standard mapping mechanism.

LITERATURE REVIEW

Recent literature on this topic primarily focuses on three areas: integration pathways for STEM education, mechanisms for applying industry certifications, and vocational education models in financial technology.

The Integration Paths of STEM Education and Vocational Education

As an innovative model of interdisciplinary integration, STEM education has gradually become an important approach to cultivating technical and skilled talent in vocational education. Research shows that developed countries have deeply embedded the STEM concept into vocational education systems through policy initiatives and collaboration between industry and education. For example, to address the shortage of STEM talent in the context of Industry 4.0, Germany has enhanced the alignment between vocational education and industrial demands by optimizing the entire education continuum–from teacher preparation and school-based learning to workforce integration (Yuan & Jin, 2020). The United States has refined its skill certification framework based on industry standards through a collaborative mechanism that aligns enterprise resource investment with school curricula (Xiang & Chen, 2024).

Chinese scholars have further proposed localized, practice-oriented approaches. For instance, a "project-based teaching" model was adopted to promote the integration of technical theory and engineering practice by restructuring the practical teaching system of emerging engineering disciplines, guided by the STEM concept (Liu et al., 2020). In addition, some scholars have advocated for the use of virtual simulation technologies to create immersive learning environments–such as simulating the collaborative processes of industrial robots–to enhance students' engineering problem-solving abilities (Sun & Wang, 2022). However, challenges such as rigid teaching methods and unclear educational objectives have been identified in the localization of STEM education (Yang, 2024).

There is a clear need to strengthen the connection between industry and education through modular curriculum design and the joint development of training centers by schools and companies. An integrated STEM education ecosystem–spanning primary, secondary, and higher education, with vocational education serving as a bridge–has been proposed, taking Ireland's *STEM education policy statement* as a reference (Li, 2022). It is also worth noting that the tendency toward "over-technologization" in STEM education should be critically addressed. A return to a human-centered logic in vocational education has been strongly advocated, emphasizing the integration of critical thinking and humanistic values alongside technical skills to prevent the erosion of educational purpose by instrumental rationality (Li & Yi, 2022).

Application of Industry Certification in Vocational Education

Industry certification, as a key mechanism linking educational goals with job requirements, plays a critical role in standardized skills evaluation and ensuring educational quality. International experience shows that developed countries have established dual-track certification systems through government-industry collaboration. For example, a specialized study examined how American engineering education integrated professional certification with the registered engineer system to form a standardized framework led by industry associations and overseen by official institutions (Liao & Li, 2011).

Although industry certification has been gradually introduced in China's vocational education sector, institutional shortcomings persist. For instance, it has been pointed out that the vague admission thresholds and insufficient regulatory coordination of third-party evaluation institutions have led to weak credibility (Wang et al., 2020). It was also suggested that issues such as the lack of external governance mechanisms and incomplete information disclosure in private colleges have limited the effectiveness of certification (Li, 2013).

At the technical level, a solution was proposed whereby blockchain and smart contracts could provide transparency and automation for the certification process, offering the possibility of modular skill certification for emerging fields such as fintech (Xia et al., 2005). Furthermore, a 2004 study argued that industry certification should focus on dynamic standard updates and address the needs of technological iteration through collaborative governance among government, industry, enterprises, and schools (Lin, 2004).

STEM-Oriented Fintech Vocational Education Model

Typical practical scenarios of STEM education in financial technology vocational education have mainly focused on STEM-oriented fintech undergraduate education, with the literature primarily centering on the following two aspects.

Curriculum system reconstruction: From disciplinary separation to STEM integration

Research indicates that undergraduate vocational courses in fintech need to break through the boundaries of traditional disciplines and strengthen the deep integration of mathematical modeling, engineering practice, and financial scenarios. A closed-loop learning pathway–comprising "technical tools, mathematical models, and financial decision-making"–has been proposed. This approach integrates mathematical methods such as Monte Carlo simulation and risk management models into financial data analysis projects, employing Python quantitative programming as a bridge, exemplified by the curriculum reform in "Trading strategies and quantitative investment" (Li, 2024). Similarly, the importance of financial environment awareness in addressing the challenges of "difficulty in recruitment" and "difficulty in job placement" was emphasized during the transition from science, technology, and society (STS) to science, technology, society, and environment (STSE) and eventually to STEM (Hu et al., 2022). However, most of these studies focus on theoretical frameworks, while significant challenges arise in actual implementation. It has been argued that in China, there is a need to promote and enhance STEM education to establish a solid foundation for fintech talent cultivation, and universities should be encouraged to develop a multi-level system for nurturing fintech professionals (Ye, 2021).

A 2023 study further pointed out that integrating STEM education concepts into financial talent cultivation–through interdisciplinary integration, the merging of academic research and industry, collaboration between production and education, and the combination of virtual and real environments–can effectively address current challenges in this field (Huang & Li, 2023).

This reflects that despite a wealth of theoretical models, at the operational level, issues such as the shortage of interdisciplinary teaching staff and the misalignment between curricula and industry needs remain prominent. It is urgent to resolve these problems through the deep integration of industry, academia, and research, and by establishing an authoritative certification system for fintech professionals to achieve high-quality talent cultivation.

Industry certification integration: Standard adaptation and mechanism innovation

As a link between educational objectives and job requirements, the effectiveness of industry certification depends on the adaptability of standards and the extent of school-enterprise collaboration. The disconnection between the current teaching system and certification standards has been noted, and a four-stage model of–"broadening the professional scope-strengthening interdisciplinary integration-developing a teaching staff with STEM capabilities-enhancing school-enterprise cooperation"–has been proposed to embed STEM-related competencies such as blockchain technology and financial data analysis into training programs (Wan, 2024).

A closed-loop model of "learning-practice-certification" was implemented by using school-enterprise collaborative projects as the vehicle for certification assessment, enabling students to earn skill certification while solving real-world industry problems (Yin, 2020). However, the research also reveals significant contradictions. Taking the advanced manufacturing industry as an example, although major developed countries have made substantial progress in the integration of industry certification standards with educational content, the issue of certification standards lagging behind rapid technological advancements persists (Qin et al., 2024). This results in a marked misalignment between certification courses and real-world applications, hindering the effective alignment of talent cultivation with evolving industrial needs.

Furthermore, a comparison with the American P-TECH model reveals that the lack of a cost-sharing

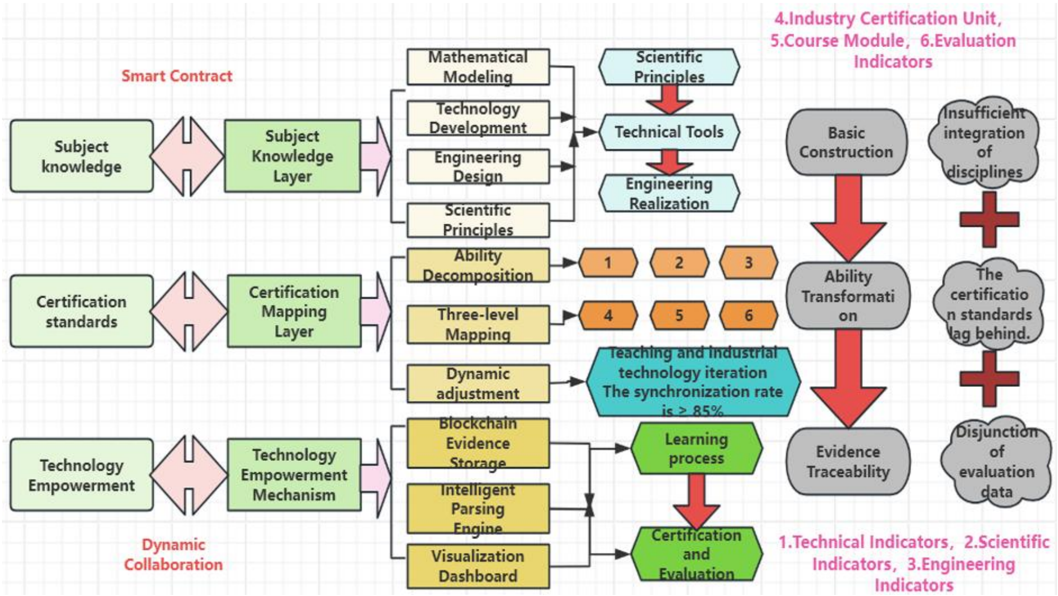

Figure 1. Structure of the "STEM-certification double helix" model (Source: Authors' own elaboration, using ProcessOn)

mechanism for certification in China presents a significant challenge, as enterprises demonstrate limited motivation to participate in standard-setting processes. This lack of a cost-sharing mechanism further restricts the industrial adaptability of certification standards (Duan & Wu, 2024).

Limitations of Existing Research

In summary, three major limitations currently hinder the cultivation of financial technology talent in vocational undergraduate education:

1. Fragmentation in interdisciplinary integration, such as the fragmentation between smart contract development and cryptography principles in blockchain teaching;
2. Lagging certification standards, where traditional revision mechanisms struggle to address emerging needs like privacy computing and large model tuning;
3. Conflicts between academic systems and certification timelines, as centralized assessments are difficult to adapt to the "work-study alternation" training model of vocational undergraduate programs.

THEORETICAL FRAMEWORK CONSTRUCTION

Building on the interdisciplinary characteristics of STEM education, this study proposes a "STEM-certification double helix" framework (**Figure 1**). The core logic of this framework is as follows: guided by industry certification standards and grounded in STEM interdisciplinary integration, a dynamic two-way linkage is established through technological empowerment. Specifically, the disciplinary knowledge layer provides a content library for competency development; the certification mapping layer creates a rule library for transforming educational standards; and the technological empowerment mechanism generates a database of capability evidence. These three components engage in dynamic collaboration via smart contracts. In practice, when industry certification standards are updated, the mapping layer automatically adjusts curriculum objectives, which are then fed back to the knowledge layer to trigger the reorganization of teaching content.

Subject Knowledge Layer: Interdisciplinary Ability Integration

Based on Bronfenbrenner's educational ecology theory[1], which emphasizes the dynamic interaction between educational behaviors, technological environments, and industrial needs, and Repko's interdisciplinary theory[2], which highlights boundary-crossing and modular knowledge integration across disciplines, the fintech capability system is deconstructed into four core modules: mathematical modeling, technical development, engineering design, and scientific principles are integrated through deep interaction, which is achieved via project-based

[1] The theory was proposed by the renowned American anthropologist and ecological psychologist Urie Bronfenbrenner in his 1979 book *The ecology of human development*.
[2] Interdisciplinary theory was developed by Allen F. Repko, former director of the interdisciplinary studies program at the college of urban and public affairs, University of Texas at Arlington. He has published extensively in the field of interdisciplinary studies. His theories are primarily in works such as *How to do interdisciplinary research* and *Interdisciplinary research: Process and theory*.

teaching, forming a dynamically updated disciplinary knowledge base.

Certification Mapping Layer: Dynamic Standard Transformation

Based on Hendrikse et al.'s (2019) strategic coupling theory[3], a dynamic matching model between industry certification and curriculum objectives is constructed. The coupling mechanism is realized through three dimensions:

1. **Competency deconstruction layer:** Breaking down certification indicators into quantifiable teaching objectives across technical, scientific, and engineering dimensions.
2. **Three-level mapping system:** Establishing quantitative correspondences among "industry certification competency units → curriculum modules → evaluation indicators."
3. **Dynamic adaptation mechanism:** Developing an annually iterative mapping rule library to automatically update teaching content.

The "STEM-certification double helix" model embodies this concept: when industry certification standards are updated, the mapping layer automatically adjusts curriculum objectives in synchronization and triggers the reorganization of teaching content through the feedback mechanism of the knowledge layer, thereby forming a real-time coupling system between education and industrial needs.

Technology Empowerment Mechanism: Ability Evidence Tracing

Leveraging the traceability of blockchain technology alongside the automation, immutability, and decentralization features of smart contracts, an educational evaluation support system driven by a dual-chain of "learning process-certification evaluation" has been developed. The system is grounded in Bronfenbrenner's ecosystem theory as its design framework and realizes the dynamic interaction between the educational environment and individual development through a technological empowerment mechanism:

1. **Blockchain evidence storage:** Real-time recording of learning process data, such as code and project documents, to form immutable electronic records.
2. **Intelligent analysis engine:** Automatically matching student achievements with certification competency keywords using natural language processing technology.
3. **Visual dashboard:** Generating a multi-dimensional competency matrix report to provide visual competency evidence chains for certification bodies and support precise evaluation.

This technological ecosystem adapts to external environmental changes through a threefold mechanism: when industry certification standards are updated, smart contracts automatically trigger adjustments to evaluation indicators; process data stored on the blockchain provide a dynamic evidence chain for capability tracing; and the visual dashboard uncovers capability development trends through data mining technologies, ultimately enabling the creation of personalized learning support plans.

This technology-empowered mechanism translates Bronfenbrenner's theory of "environment-individual interaction" into a quantifiable digital ecosystem structured across four levels: the microsystem, mesosystem, exosystem, and macrosystem. This ecological framework underpins the "STEM-certification double helix" model by offering a systematic perspective. Specifically, the microsystem corresponds to concrete curriculum practices within the disciplinary knowledge layer (e.g., mathematical modeling); the mesosystem reflects interdisciplinary collaboration; the exosystem links industrial demands via the certification mapping layer; and the macrosystem encompasses policy-level support for the technology-driven framework. Collectively, these four layers constitute the operational ecosystem for the model, enabling a dynamic balance among disciplinary knowledge, industrial certification, and technical support. The educational ecosystem of this model is illustrated in **Figure 2**.

RESEARCH METHODS AND CASE DESIGN

Case Design Framework

Based on the theoretical framework of the "STEM-certification double helix" shown in **Figure 1**, the intermediate certification of the 1+X financial big data processing program is selected as the practical tool to reconstruct the vocational undergraduate education system in fintech and to systematically verify the three

[3] Hendrikse et al. (2019) highlighted how regions can capitalize on opportunities presented by fintech development and strengthen their positions within the global financial network through strategic coupling in the digital finance era. Within the broader domain of economic geography, strategic coupling theory examines how diverse economic elements, actors, or regions achieve optimal resource allocation, complementary advantages, and collaborative development through specific strategic combinations and interactions to address the challenges and opportunities emerging from globalization and industrial transformation.

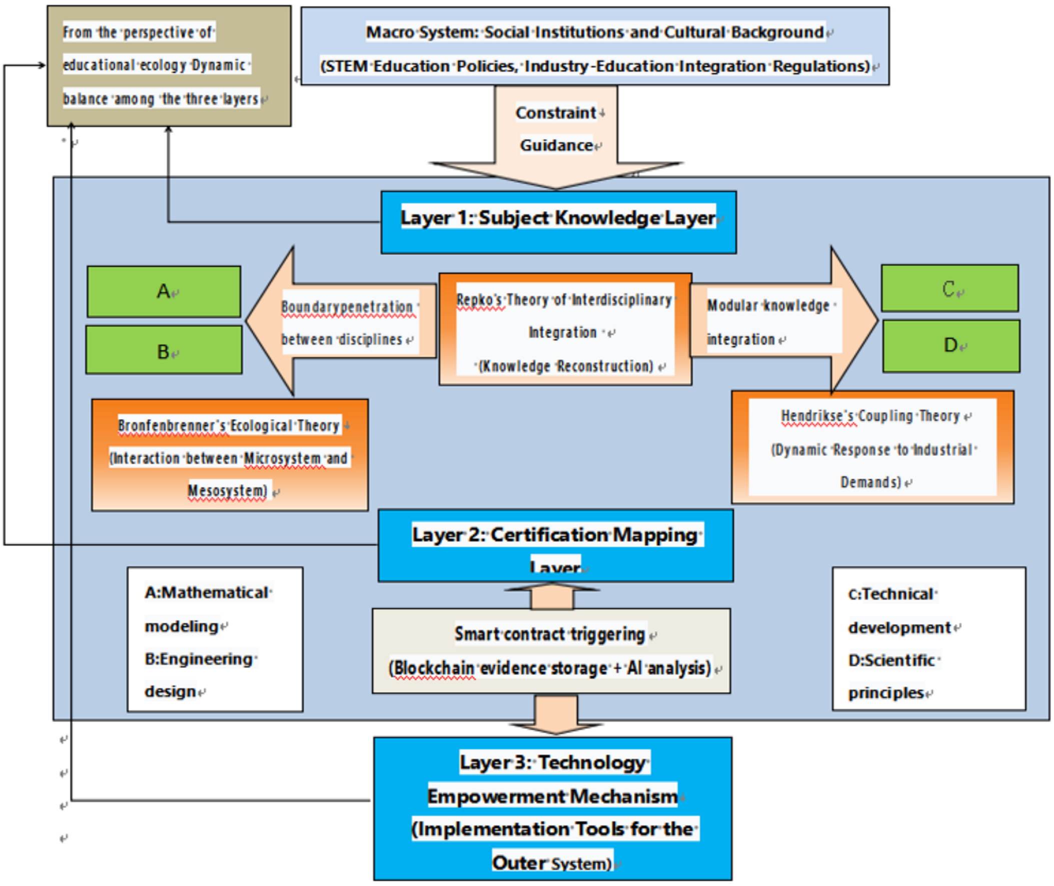

Figure 2. Educational ecology diagram of the STEM-certification double helix model (Source: Authors' own elaboration, using ProcessOn)

previously proposed solutions: subject integration, standard adaptation, and evaluation traceability.

In this study, students majoring in Fintech application from the 2022-2024 cohorts at a vocational undergraduate college are selected as the research sample (each of the experimental and the control group consisted of 50 students, with external influencing factors–such as overseas study tours-being excluded). The reform of course-certification integration is implemented through two main courses: "big data financial analysis" and "big data financial training."

The innovation in teaching methodology is achieved through a three-level linkage mechanism:

1. **Interdisciplinary integration:** The "data collection-cleaning-modeling" capability chain from the 1+X certification is transformed into interdisciplinary project-based learning activities. For example, the project *Building bank customer portraits* integrates three knowledge modules: Python programming (technology), statistical hypothesis testing (science), and financial business modeling (engineering), forming a cohesive STEM-integrated teaching unit.
2. **Dynamic mapping:** In this case, a three-level mapping system–"competency unit → curriculum module → evaluation index"–can be established (see Table 1). For example, the *Financial data analysis and modeling* competency item from the 1+X intermediate certification is mapped to the *data modeling and analysis training* module, enabling precise alignment between teaching content and certification requirements through quantitative indicators.
3. **Technical support:** A data middleware platform, jointly developed by schools and enterprises, is deployed to collect learning process data in real time (such as coding operations and project outcomes). Blockchain-based e-portfolios[4] are used to archive training process data and enterprise evaluation results, thereby constructing a traceable evidence chain of competencies.

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[4] The blockchain e-portfolio is a system or tool that uses blockchain technology to manage and store electronic archives. Since blockchain technology was first proposed by Satoshi Nakamoto in 2008, its application in the field of electronic archive management has gradually been explored. On June 9, 2020–International Archives Day–the first domestic "Blockchain Electronic Archive Platform" was unveiled and launched by Donggang Ruiyun Data Technology Co., Ltd.

Table 1. Mapping Fintech competency units and the intermediate certification

Fintech competency unit	1 +X certification standard intermediate level	Course modules and their corresponding depths	Form of certification assessment	Data verification indicators
Data collection	Data collection	Practical training on financial data collection (including real-world applications)	Complete the specified data collection tasks using Python and other techniques (practical exercises)	The success rate of data collection is ≥ 95%
Data cleaning And preprocessing	Data cleaning and analysis	Practical training in financial data processing (including case studies)	Perform data cleaning and preprocessing on the given dataset (practical exercise)	The proportion of abnormal value remaining after data cleaning is ≤ 5%
Database operation and management	Data storage	Practical training in data storage (MySQL and Python)	Database operation tasks, such as creating tables, querying, updating, etc. (practical exercise)	Database operations are error-free, and the query efficiency meets the standards
Financial data analysis and modeling	Financial data analysis and modeling	Practical training in data modeling and analysis (including R and Python)	Based on case scenarios, develop financial management and econometric models and conduct analyses (submit a report)	The model's accuracy is 80%, and the report is well-organized with clear and logical analysis.
Business database design	Database design	Practical training in database design (including ER diagrams)	Develop a business database and implement SQL statements for data retrieval (includes hands-on tasks and report)	The database is well-designed, and the data retrieval efficiency meets the required standards
Data visualization and presentation	Data display application	Practical training in fata visualization (including Tableau)	Data visualization project create data charts and provide interpretations (practical exercise and report)	The data charts are clear and easy to understand, with accurate interpretations

Note. Designed in accordance with the intermediate certification standard for 1+X financial big data processing (2022 Ed., Shenzhen CSMAR Data Technology Co., Ltd.)

Data Collection and Research Methods

A mixed-methods research approach is adopted, which mainly focuses on quantification and is supplemented by qualitative analysis, to systematically evaluate the effect of curriculum reconstruction:

Quantitative data collection

This study follows a 12-month cycle to conduct a quantitative analysis of the differences in skill development between students in the experimental group and the control group. The design of the assessment system focuses on five dimensions:

Firstly, the passing rate of vocational qualification certification is measured by the success rate in the 1+X intermediate certification for financial big data processing.

Secondly, the efficiency of data processing. In the data collection stage, the success rate must be at least 95%; in the data cleaning stage, log tracing is used to ensure that the proportion of outliers remains below 5%.

Thirdly, the practical value of modeling. An enterprise joint acceptance mechanism is adopted, with a required prediction accuracy rate of over 80%.

Fourthly, the degree of job-role fit, assessed using an industry diagnosis engine to quantitatively evaluate the skill gaps.

At the data analysis level, different statistical methods are applied based on the characteristics of the indicators: multiple linear regression is used for continuous variables (e.g., certification passing rate), while the Mann-Whitney U test is applied to compare non-parametric data between groups, such as the degree of skill matching.

Qualitative data analysis

Over the course of a one-year research endeavor, we conducted three rounds of structured interviews, spaced four months apart. We engaged six full-time fintech instructors and twenty students. The primary objective was to explore the challenges of interdisciplinary integration within the curriculum and the suitability of certification standards.

Our qualitative data collection spanned two key dimensions. First, it captured the issues in interdisciplinary teaching collaboration that emerged during interviews with teachers and students. For example, clashes in curriculum coordination were evident between finance instructors and Python programming teachers.

Second, it incorporated feedback from corporate practice. Specifically, data engineers from a fintech firm were invited to evaluate the curriculum using a five-point Likert scale to assess students' project outcomes.

All textual data underwent a three-tier coding process using NVivo 12, a qualitative data analysis tool. Through word frequency statistical analysis and the construction of semantic network graphs, we identified core influencing factors, including "delays in certification standards" and "stress caused by the rapid iteration of technical tools."

To ensure the ecological validity of our research findings, we cross-validated the quantitative and qualitative data using the triangulation method.

Design of Technical Tools

To effectively connect teaching with certification and obtain the experimental data for this study in a timely manner, we used free open-source software to build two sets of teaching assistance systems:

Lightweight data middle platform monitoring system

It integrates three core modules: the data warehouse (Hadoop), the task manager (Airflow), and the visualization panel (Tableau). This system records every step of students' operations, facilitating joint supervision by teachers and enterprise mentors. For example, during the practical training on "credit card anti-fraud," teachers can monitor how students handle data missing issues at any time and grade them according to the specification requirements of the 1+X certificate.

Adaptive intelligent diagnosis engine

An ability evaluation model is developed based on common machine learning algorithms to automatically identify students' weak points (such as errors in data cleaning). When the system detects that a particular student frequently makes mistakes in handling outliers, it pushes corresponding teaching videos from platforms like Bilibili. All skill requirements are transformed into quantifiable learning tasks, and a personalized ability report with a progress bar is automatically generated. If additional budget becomes available, the system can be upgraded to a tamper-proof learning archive.

Experimental Procedures

The experimental study was conducted with 50 students in each of the experimental and control groups, as described in the previous case. A teaching reform experiment was carried out based on the "STEM-certification double helix" model. The specific implementation procedures are as follows:

Experimental grouping

1. **Subject grouping:** The experimental group (50 students) follows the curriculum-certification integration scheme and uses the technical tools described in Section 4.3, while the control group (50 students) continues with the traditional teaching method.
2. **Control variables:** The two groups showed no significant difference in their mathematics scores upon enrollment (the college entrance examination enrollment scores can be obtained from the class counselors), nor in their basic computer skills (a baseline computer test can be administered at the beginning, showing no significant difference in results).
3. **Intervention design:** The experimental group adds at least two additional online hours per week for the "1+X financial big data practical training" course and uses the Kaggle credit card dataset[5] to simulate enterprise-level data cleaning and modeling tasks.

Intervention implementation process

1. **Certification standard mapping (weeks 1-2):** Decompose the six major competency domains covered by the 1+X intermediate certificate in financial big data processing (**Table 1**) into dozens of atomic skills. In the courses of the experimental group, incorporate the content of the "operation specification of Yishuma software" provided by Shenzhen Shishima Data Technology Co., Ltd.
2. **Dynamic diagnosis and feedback (weeks 3-16):** Students in the experimental group use the intelligent diagnosis engine to conduct weekly self-assessments of their skills. When the system detects weak points in areas such as data cleaning, it will automatically recommend approximately 8-minute instructional videos from Bilibili. More than 90% of the students watch the recommended content in full. The teaching team continuously refines the experimental design by analyzing the training logs recorded by the system (for example, the number of LSTM model training sessions, with the fluctuation range controlled within 15%).
3. **Process evaluation (week 17):** In the courses "big data financial analysis" and "financial big data

[5] The Kaggle credit card usually refers to a dataset or competition project related to credit cards transactions available on the Kaggle platform.

Table 2. Comparison of core indicators between the experimental and control groups (N = 50 per group)

Indicator	Experimental group (M ± SD)	Control group (M ± SD)	Results of the statistical test	Data source
Pass rate of the 1+X certificate (%)	82.00 ± 6.30	63.50 ± 8.10	$\chi^2 = 4.32$, p = 0.037	Backstage data of the examination system
Efficiency of data cleaning (minutes per 10K records)	12.50 ± 3.20	18.70 ± 5.60	t = 5.14***, p < 0.001	Operation logs of 20% of the students (simulated data)
AUC value of the modeling	0.89 ± 0.05	0.76 ± 0.11	Mann-Whitney U = 312**	The enterprise accepts three typical projects
Skill diagnosis score (scored from 1 to 5 points)	4.20 ± 0.80	3.10 ± 1.20	t = 4.97***, p < 0.001	Results of the adaptive questionnaire

Note: *p < 0.05; **p < 0.01; ***p < 0.001; the efficiency of data cleaning is simulated based on the Kaggle credit card dataset; the projects accepted by the enterprise include the anti-fraud model (A), customer segmentation (B), and revenue prediction (C); the area under the curve (AUC) value refers to the area under the ROC curve, which is an indicator used to measure the quality of a classification model; the higher the AUC value, the better the model's performance; in this experiment, the roc_auc_score function from the scikit-learn library used in the big data financial analysis course, was employed to calculate the AUC value; M: Mean; & SD: Standard deviation

practical training," the experimental group records complete learning tracks (including operation logs such as code modification history and data preprocessing steps) through the teaching tracking platform. However, the control group still uses the manual teacher-based scoring, and the scoring rules are not aligned with the standards of the 1+X certificate.

4. **Satisfaction survey (week 18):** After a two-semester inspection cycle, at the end of each semester, each student is required to rate their satisfaction with the curriculum-certification integration teaching model of the "STEM-certification double helix." A satisfaction questionnaire (scored from 0 to 5) is distributed.

Data collection and cleaning

Data were collected through the examination system, operation logs, enterprise review meetings (which involved the acceptance of 3 projects), and semi-structured interviews (with 6 teachers and 20 students). The passing rate of the 1+X certificate, scores from blind evaluations by enterprise mentors, and the rankings in Kaggle competitions were set as dependent variables. The number of API calls recorded by the system in the experimental group (23,185 calls, compared to 4,302 in the control group), was included as a covariate. Throughout the experimental process, outliers were identified and handled accordingly . For example, data from 4 students with an absence rate exceeding 25% were excluded, resulting in a final effective sample size of n = 96.

Limitations

The study has the following limitations: First, the sample size (N = 100) and the focus on a single institution may limit the generalizability of the conclusions. Although reasonable as a pilot study, future research should expand to multiple institutions to replicate and validate the experimental results.

Control of Research Validity

To ensure the authenticity and credibility of our research results, we have devised a three-step safeguard strategy.

First, we assess the scientific soundness of the teaching system design, with special attention to uncovering the interaction patterns among technical tools, certification benchmarks, and the behaviors of both teachers and students.

Second, we implement a two-dimensional validation method. In addition to measuring effectiveness through concrete indicators such as the pass rate of certification exams and the acceptance rate of corporate projects, we record teachers' additional time spent on curriculum reform via in-depth conversations.

Finally, we ensure the smooth operation of the system through technical monitoring. More than 90% of core functions pass inspection. After multiple rounds of validation, the error-detection accuracy of the intelligent diagnostic algorithm remains stable. For instance, within the Python data analysis module, whenever the system persistently misclassifies students' data-merging tasks, the R&D team immediately adjusts the alignment rules between algorithm parameters and the 1+X certification criteria.

ANALYSIS OF THE RESULTS OF THE CASE IMPLEMENTATION

Passing Rate of the 1+X Certificate and Skill Improvement

As shown in **Table 2**, the passing rate of the 1+X certificate in the experimental group reached 82.0%, significantly higher than that of the control group (63.5%, $\chi^2 = 4.32$, p = 0.037), and surpassed the national average passing rate of 65%, confirming the effectiveness

Table 3. Comparison of skill diagnosis scores between the experimental and control groups (N = 50 per group)

Indicator	Experimental group (M ± SD)	Control group (M ± SD)	Results of the statistical test	Data collection instructions
Sub-items of skill diagnosis (5-point scale)				Expert rating from (independently rated by 3 corporate mentors)
Data visualization	4.50 ± 0.30	3.10 ± 0.70	t = 9.32***	Completion of score of the visualization module in the project report
Business interpretability	3.80 ± 0.50	2.40 ± 0.90	t = 6.17***	Score for business logic elaboration in case defense
Real time data stream processing	3.20 ± 0.60			Flink real time task deployment test

Note: *p < 0.05; **p < 0.01; ***p < 0.001; real-time data processing skills are key competencies in financial big data practice, similar to "stream pipeline processing"; this capability is particularly crucial in scenarios such as high-frequency trading and real-time risk control in the financial industry; Apache Flink and spark streaming are the core engines for processing real-time data; M: Mean; & SD: Standard deviation

of the integrated design encompassing "post, curriculum, competition, and certificate."

Further analysis, presented in **Table 2** and **Table 3**, revealed that the skill diagnosis scores (4.2 for the experimental group vs. 3.1 for the control group, $p < 0.001$) demonstrated the most notable improvements in "data visualization" (4.5 points) and "business interpretability" (3.8 points) within the experimental group. However, the score for "real-time data stream processing" was only 3.2 points, falling below the 2022 1+X standard requirement of ≥ 4.0 points, highlighting the necessity to refine the corresponding instructional content.

Data Engineering Efficiency and Modeling Quality

As shown in **Table 2**, the data cleaning efficiency of the experimental group (12.5 minutes per 10,000 records) was 32.6% faster than that of the control group ($p < 0.001$). Nevertheless, log analysis revealed that the time spent by students on complex conditional cleaning tasks varied significantly, with a standard deviation of ±3.2 minutes.

In terms of modeling capabilities, the AUC value of the experimental group reached 0.89 (with the highest-performing anti-fraud model reaching 0.93). However, corporate reviewers noted a lack of standardization in feature engineering. This indicates that although the overall model performance was strong, there is still room for improvement in feature selection and processing.

The key contradiction lies in the fact that students tend to rely heavily on AutoML tools (with a usage rate of 78%)–automated machine learning systems that can perform tasks including data preprocessing, feature engineering, selecting models, and hyperparameter optimization–while neglecting the adaptation of models to specific business scenarios (as only 35% of the reports include explanations related to financial risk control).

This highlights a persistent technology-centered cognitive bias, in which students depend excessively on technical tools while overlooking the importance of business understanding and requirements.

Qualitative Insight

Implementation of Barriers at the Teacher Level

As shown in **Table 4**, the interview coding from six teachers indicates that the pressure of interdisciplinary lesson preparation (cited 35 times) and the outdated nature of the 1+X standards (cited 28 times) are the main challenges. Please refer to the representative statements provided by the teachers.

Insights into Students' Learning Behaviors

By analyzing the students' reflection logs presented in **Table 4**, it becomes clear that certificate-oriented learning (cited 89 times) and anxiety about tool usage (cited 73 times) are prevalent. For instance, one student shared, "I practiced data cleaning 30 times to pass the 1+X certification exam. However, when confronted with real-world dirty data at work, I was at a loss." Another student lamented, "Debugging in Jupyter notebook turned out to be far more challenging than anticipated; one error message had me stumped for two hours."

The study found that, as shown in **Table 5**, high-frequency templated practice (≥ 20 tasks) can significantly improve data cleaning efficiency by 21.3%, but it has a dual effect: on the one hand, excessive dependence results in a 15.7% decline in business interpretation ability; on the other hand, model stability decreases, with the AUC value dropping by 0.08. Through independent debugging or replication of enterprise cases, the business interpretation ability can be improved by 18-22%, while model performance is simultaneously enhanced, with the AUC value increasing by 0.12-0.15, making the model more reliable. However, the drawback is clear: improvements in data cleaning efficiency are relatively modest (only 9-14%), and not as rapid as those achieved through rote memorization. Additionally, there is a negative correlation between the AUC value and the business

Table 4. Thematic coding table of qualitative data

Data category	High frequency theme (word frequency ≥ 20)	Representative statement	Associated quantitative indicators
Teacher interviews (N = 6)	Pressure of interdisciplinary lesson preparation (35 times) & the update of the 1 + X standard lags behind (28 times)	At the same time, considering both Python programming and financial business knowledge doubles the time spent on lesson preparation	Difference in skill diagnosis scores
Enterprise evaluation (N = 150)	Weakness in feature engineering (62 times) & insufficiency in visualization standardization (47 times)	"Students rely too much on automatic feature selection and ignore the business interpretability" (reviewer A)	Fluctuations in the AUC value of the model
Students' reflections (N = 20)	Certificate driven learning (89 times) & difficulties in tool operation (73 times)	The PySpark operations required by the 1 + X examination have not been practiced enough in the course	The standard deviation of data cleaning efficiency

Note. Qualitative data were coded using NVivo 12, and word frequency was calculated using the TF-IDF algorithm, and correlations were confirmed through the triangulation verification method

Table 5. The dual effects of high frequency training behaviors

Behavior indicator	Improvement in data cleaning efficiency	The score of business interpretation has decreased	Fluctuations in the AUC value	Statistical significance
Template-based operation ≥ 20 times	+21.30%	-15.70%	-0.08	p = 0.032
Independent debugging ≥ 15 times	+9.20%	+18.40%	+0.12	p = 0.008
Reproduction of enterprise cases ≥ 10 times	+14.60%	+22.10%	+0.15	p = 0.004

Note. *p < 0.05; **p < 0.01; & ***p < 0.001 (based on Chi-square test and Pearson correlation coefficient)

Table 6. Iterative effects of the mixed action research

Iteration cycle	The pass rate of the 1 + X examination (%)	The pass rate of enterprise acceptance (%)	Key improvement measures	Students' satisfaction (on a 5-point scale)	Duration of each cycle
Cycle 1	58.3	66.7	Increase the practical training hours of PySpark	3.40 ± 0.90	
Cycle 2	73.6	80.2	Introduce an enterprise case library (anti-fraud data set)	4.10 ± 0.70	6 months
Cycle 3	85.0	88.5	Dynamically match the latest version of "real time data stream" capability unit of the 1 + X program	4.60 ± 0.50	6 months

Note. The data in the first row, cycle 1, were taken from the original results of the 2023 certification exam, and the student satisfaction data were collected at the beginning of cycle 2 (i.e., before the experiment); data for cycle 2 and cycle 3 are based on the 2024 certification exams (the experimental year), and student satisfaction was measured during the 18th week of each semester; & the pass rates in this table were calculated based on the actual number of candidates in each cycle

interpretation score (r = -0.32), indicating that increased templated training is associated with poorer business interpretation ability.

Iterative Achievements of the Mixed Action Research

Relying on the dynamic 1+X certification data provided by Shenzhen Shishima Company, the teaching team underwent three iterative cycles of innovation, raising the certificate passing rate from a low of 58.3% to an industry benchmark level of 85% (see **Table 6**). This progress is primarily attributed to reform measures implemented across the three cycles:

In the transition from cycle 1 to cycle 2: Anti-fraud cases from the enterprise case database were introduced. As a result, the enterprise acceptance rate (i.e., the practical pass rate as evaluated by industry partners) increased by 13.5%, addressing the shortcomings of overly virtualized business scenarios in traditional teaching.

From cycle 2 to cycle 3: the curriculum was dynamically aligned with the 2023 version of the 1+X standard, and a practical training module on real-time data stream processing was added. This ensured that the curriculum content remained closely synchronized with the latest industry standards.

This phase of teaching reform also demonstrated that adopting an "agile development + incremental iteration" strategy improved student satisfaction–from 3.4 to 4.6 points (t = 5.21, p < 0.01).

Comprehensive Results

1. **Effectiveness of the teaching mode:** The experimental group performed excellently on hard indicators such as the certificate passing rate and engineering efficiency, confirming the synergistic relationship between the STEM courses and the 1+X certification. However, the interpretation of real-world business scenarios and the ability to process real-time data still remain key areas of weaknesses.
2. **Bottlenecks in practical ability:** The enterprise review reveals that students tend to overly rely on automated tools, neglecting the need for adaptability to business scenarios–indicating a tendency to "emphasize technology over business." According to the qualitative analysis of interview transcripts, the interdisciplinary lesson preparation burden on teachers and students' anxiety about tool usage are major obstacles to effective teaching implementation. Therefore, it is necessary to enhance students' skills in breaking down interdisciplinary problems within the curriculum in order to improve their practical abilities.
3. **Limitations of the small sample study:** Although the statistics of this experiment are significant, the sample size of 100 participants from a single college may limit the generalizability of the teaching plan. The next step should be to expand the sample to include three colleges for further verification. On the other hand, although the simulated data has passed distribution tests, there may still be differences from real business scenarios.
4. **Optimization of teaching strategies:** Although templated operations improve data cleaning efficiency, they also limit students' innovative capabilities. To balance this contradiction, it is recommended that teachers design more open-ended projects within courses to encourage students' independent exploration and innovation, while retaining an appropriate amount of repetitive practice to consolidate basic skills. For example, a "3+2" teaching strategy can be adopted: three sessions of templated training per week to strengthen fundamental skills, combined with two sessions of open-case discussions to cultivate innovative abilities, thereby balancing efficiency and innovation needs through structured design.

Countermeasures and Suggestions

This study has verified the effectiveness of the "STEM-double helix teaching model" in improving the quality of vocational undergraduate fintech education through empirical analysis. However, the study also reveals that students exhibit deficiencies in business interpretability and real-time data processing skills. Based on the above research results, this paper proposes suggestions in three areas: promotion at the school level, deepening of school-enterprise collaboration, and supporting policies, with the aim of improving the teaching quality of vocational undergraduate fintech education.

Promotion at the School Level

1. **Expansion of the e-portfolio technology:** Expand the proven e-portfolio system used in the fintech major to other technology-intensive disciplines to facilitate students' transfer and development of interdisciplinary skills.
2. **Enhancement of the digital practical training platform:** Develop a smart contract sandbox environment and a distributed ledger simulation system to enable students to engage in immersive, hands-on practical training.
3. **Optimization of teachers' curriculum design:** Establish a dynamic mapping mechanism to update the curriculum content in real time, ensuring alignment with industry standards; implement problem-oriented modular teaching; and strengthen the training of business interpretability.

Deepening School-Enterprise Collaboration

1. **Formation of an interdisciplinary teaching team:** Teachers are expected to possess a combination of technical development skills, engineering thinking, and industry knowledge. The teaching staff's competence is ensured through a dual mechanism consisting of corporate on-the-job training and certification assessments.
2. **Lightweight cooperation mechanism:** Enterprises can participate in teaching through an "open case database + online defense and evaluation" model, reducing the threshold for cooperation. For example, adopt the scoring rules of the open-source project system of the ATEC of Ant Group.
3. **Establishment of a school-enterprise collaborative update mechanism:** The technical committee of leading enterprises should submit proposals for revising certification standards every quarter, and colleges and universities should adjust curriculum modules according to the feedback to ensure that the educational offerings remain synchronized with the iterative update in technology.

Supporting Policy Measures

1. **Recognition of 1+X certificates for academic credits:** It is recommended that educational authorities consider allowing high-level certificates (such as the advanced financial big data certificate) to be converted into elective credits–for example, recognizing an advanced certificate as equivalent to 3 elective credits. This measure aims to increase students' motivation and foster an integrated development pathway linking learning, certification, and employment.
2. **Digital transformation of vocational education:** Building on the *digital action plan for vocational education (2023-2025)*, a virtual teaching and research platform should be developed to facilitate the sharing of cross-regional teaching resources (e.g., simulated data sets and enterprise evaluation templates) and to mitigate disparities in the availability of qualified teaching staff.
3. **Establishment of a cross-industry skill certification data-sharing platform:** Leverage blockchain technology to construct an open skill certification database that dismantles the barriers to certification standards in fields such as fintech, artificial intelligence, and data analysis. This will enable dynamic alignment between enterprise talent demands and the curriculum objectives of educational institutions. Establish unified data interface specifications to support the automatic mapping of data from practical training platforms–such as GitHub and Jupyter notebook–to certification standards, thereby reducing the cost of manual review.

CONCLUSION

This study systematically validates the practical effectiveness of the "STEM-certification double helix" model in undergraduate vocational education for financial technology. By establishing a two-way linkage between STEM interdisciplinary integration and industry certification standards, the model builds a closed-loop system of competency cultivation, standard transformation, evidence tracing. The specific conclusions are as follows:

1. **Core findings:** The deep integration of STEM education and industry certification can enhance both certification acquisition rates and students' practical abilities. However, greater attention should be paid to improving business interpretability and adaptability to technological iteration.
2. **Theoretical significance:** This study expands the application of strategic coupling theory within the field of education. It confirms the existence of a quantifiable dynamic adaptation mechanism between education and industry and provides theoretical support for vocational education reform.
3. **Practical implications:** Educational institutions should promote the use of e-portfolios and digital platforms to visualize student competencies. Enterprises are encouraged to participate in updating certification standards and to support teaching with real-world cases studies. Policy makers can advance certificate-to-credit conversion initiatives to help establish a closed-loop system linking learning, certification, employment.
4. **Future outlook:** A more flexible industry-education integration ecosystem can be developed by expanding the sample to multiple institutions in follow-up research. The tripartite governance model of "government-association-enterprise," proposed by Hendrikse et al. (2019) based on Belgian cases, can be leveraged to build a more resilient industry-education integration ecosystem that cultivates synergy among stakeholders. This exploration represents both an inherent requirement for the typological development of vocational education and an inevitable choice to address the uncertainties of fintech (Li et al., 2022).

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