

Article

# Design and Implementation of a Blockchain-Based Student Competency Modeling and Intelligent Employment Matching System

Lianchao Zhang <sup>1,\*</sup><sup>1</sup> Graduate School, University of the East, Manila, Philippines

\* Correspondence: Lianchao Zhang, Graduate School, University of the East, Manila, Philippines

**Abstract:** Addressing the persistent challenges and growing disconnect between higher education talent cultivation strategies and the dynamic employment needs of modern enterprises, this paper designs and implements an innovative blockchain-based student competency modeling and intelligent employment matching system. Currently, the recruitment landscape is plagued by unreliable student competency data, static and one-sided competency profiles, and notably low accuracy in employment matching. To overcome these critical limitations, the proposed system adopts a robust consortium blockchain architecture. This decentralized approach ensures the highly reliable storage, immutability, and mutual recognition of multi-source heterogeneous competency data across various educational and corporate stakeholders. Furthermore, the system constructs a comprehensive, multi-dimensional competency index framework that meticulously encompasses academic achievements, practical abilities, and essential professional qualities. To accurately reflect evolving student capabilities, we propose a dynamically weighted competency profile model that seamlessly integrates the analytic hierarchy process (AHP), the entropy weighting method, and a time decay function. Additionally, a multi-dimensional intelligent matching mechanism is introduced, effectively integrating attributes, dynamic weights, and trend similarity to optimize candidate selection. Comprehensive system implementation and rigorous evaluation results demonstrate that the proposed architecture performs exceptionally well in terms of functional applicability, performance efficiency, and data security. Most importantly, its matching accuracy and interpretability are significantly superior to those of traditional models. Ultimately, this research provides a highly effective new technical path and a practical, scalable solution for ensuring accurate talent supply and demand matching between universities and enterprises.

**Keywords:** blockchain; competency modeling; employment matching; dynamic weighting; similarity fusion; higher education

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## 1. Introduction

### 1.1. Background of the Study

Amid the ongoing digital transformation of education and the integration of industry and education, aligning university talent cultivation with enterprise talent needs has become a critical issue in advancing the integration of the education chain, talent chain, industry chain, and innovation chain. Currently, the process of matching university talent with enterprise requirements faces several challenges, including data silos, fragmented profiles, inefficient matching, and unverified certifications. Within universities, data on student academic performance, skills certifications, and practical experience are dispersed across various systems, lacking unified integration and reliable verification. Traditional assessments of student abilities primarily emphasize academic performance, overlooking multidimensional indicators such as practical skills and professional qualities. Furthermore, the absence of a dynamic update mechanism for profiles makes it difficult to reflect the ongoing development of student abilities. On the enterprise side, recruitment

processes are hindered by information asymmetry, as student-provided certifications often lack credible third-party validation, and job matching relies heavily on subjective judgment, leading to inefficiencies and inaccuracies.

Blockchain technology, characterized by decentralization, immutability, traceability, and multi-party collaboration, offers a promising solution to these challenges. In recent years, blockchain applications in areas such as educational certificate authentication, credit banks, and industry-education integration have been explored. Some vocational colleges have implemented blockchain-based vocational competency certification platforms, enabling on-chain storage of student competency data and preliminary job matching. However, existing platforms face limitations, including incomplete competency profile indicator systems, insufficient accuracy in profile generation, and simplistic job matching algorithms. These shortcomings prevent the development of a comprehensive solution that ensures "data credibility, accurate profiles, and intelligent matching." In this context, integrating blockchain technology to establish a mechanism for the precise generation of college student competency profiles and intelligent job matching has emerged as a key research direction. This approach aims to address bottlenecks in talent matching between universities and enterprises, thereby fostering the integration of digital education and digital human resources.

### *1.2. Research Questions and Objectives*

This paper aims to address the following three core questions.

1. How can reliable storage and cross-institutional recognition of multi-source, heterogeneous student competency data be achieved?
2. What methods can be used to construct a dynamic and accurate student competency profile model suitable for career development?
3. What approaches can be employed to design a highly accurate and interpretable intelligent job matching mechanism?

The research objectives include constructing a blockchain-based integrated system for competency modeling and intelligent job matching, addressing the core challenges of traditional systems to achieve precise matching of talent supply and demand, and providing innovative technical paths and practical solutions for higher education reform and targeted recruitment by enterprises.

### *1.3. Significance of the Study*

#### *1.3.1. Theoretical Significance*

Enriching the theoretical application of blockchain technology in the education field involves designing a consortium blockchain architecture and data on-chain standards tailored to educational scenarios. This approach addresses technical bottlenecks in blockchain applications for education certification and industry-education integration, thereby expanding the application boundaries of blockchain technology.

Improving the theoretical system of college student competency profiles entails constructing a multi-dimensional indicator system for collaboration between universities and enterprises. By proposing a dynamically weighted profile generation model, this effort overcomes the limitations of traditional profiles being singular and static, offering a new perspective for applying educational data mining in competency assessment.

Constructing a new theoretical framework for intelligent job matching involves designing a matching mechanism that integrates multi-dimensional similarity. This enables a novel model of talent matching between universities and enterprises based on "data-driven, model-supported, and intelligent matching," thereby enriching the theories and methods of talent matching.

Promoting the cross-disciplinary integration of theories requires combining insights from multiple disciplines, including blockchain technology, educational management, data mining, and human resource management. This integration fosters cross-disciplinary research on digital education and digital human resources.

#### *1.3.2. Practical Significance*

Supporting the reform of talent cultivation models in universities: assisting universities in accurately understanding the development status of students' abilities, identifying their shortcomings, and providing data support for the formulation of personalized talent cultivation programs, optimization of curriculum design, and enhancement of practical teaching systems.

Optimizing corporate recruitment and human resource management: offering companies reliable and comprehensive information on student abilities, improving the accuracy of job matching through intelligent algorithms, reducing recruitment costs, and optimizing human resource allocation.

Supporting students' career development: delivering accurate ability assessments and personalized job recommendations to students, helping them clarify their learning and practical directions, and enhancing their employment competitiveness and career development quality.

Building a technological bridge for industry-education integration: facilitating multi-party data collaboration and sharing among universities, enterprises, and education management departments, establishing channels between talent cultivation and job requirements, and advancing the transformation of industry-education integration from formal cooperation to substantive integration.

#### 1.4. Scope and Boundaries of the Study

##### 1.4.1. Scope of Research Subjects

This study focuses on university students, primarily vocational college students, with conclusions applicable to regular undergraduate institutions. The core research subjects include universities, enterprises, and education management departments. The empirical study selected students majoring in computer science, intelligent manufacturing, and big data technology from Tangshan Maritime Vocational College, along with 20 partner companies, to ensure the research's relevance and practical value.

##### 1.4.2. Scope of Technology Application

1. Blockchain architecture adopts consortium blockchain technology, with universities, enterprises, and education management departments as core nodes. This approach balances decentralization and controllability while meeting the requirements for education data security management.
2. Core technologies integrate blockchain, educational data mining, machine learning, analytic hierarchy process (AHP), entropy weight method, and similarity algorithms. The focus is on the integrated application of these technologies in competency profile generation and job matching.
3. The system is evaluated across eight dimensions: functional suitability, performance efficiency, usability, reliability, security, maintainability, compatibility, and portability.

##### 1.4.3. Capability Profile and Matching Scope

1. Competency profile dimensions focus on professional competence, covering three core areas: academic ability, practical ability, and professional qualities. Non-professional competence indicators, such as students' personal character and interests, are not included.
2. The job matching scenario focuses on aligning college graduates with their first job, addressing the needs of graduates to connect with entry-level positions in enterprises. It does not include career transitions for employed personnel.

##### 1.4.4. Scope of Research and Application

The system developed in this study is primarily applied to talent matching scenarios between universities and enterprises. This includes student competency assessment, targeted recruitment by enterprises, and talent quality monitoring by education management departments. It does not currently extend to other scenarios such as K-12 education or adult education. The empirical results are based on selected vocational

colleges and partner enterprises, with potential for further optimization and broader application.

## **2. Review of Relevant Literature and Research**

### *2.1. Research on the Application of Blockchain Technology in the Education Field*

Research on the application of blockchain technology in education has covered multiple areas, including educational certificate authentication, credit bank construction, industry-education integration, and student data management. Regarding educational certificate authentication, Nguyen & Do demonstrated that blockchain can achieve digitized on-chain authentication of educational certificates, solving the problems of traditional certificate forgery and low authentication efficiency [1]. Saleh & Rana constructed a blockchain-based vocational education certificate authentication system, achieving trusted authentication across regions and institutions [2]. In terms of credit bank construction, Ren & Chen proposed a blockchain-based talent credit bank model to realize the accumulation, conversion, and sharing of credits [3]. Domestic research focuses on the blockchain application of credit banks in higher vocational colleges, solving the problem of cross-school and cross-major credit recognition.

Regarding industry-education integration, Liu et al. designed a blockchain-based school-enterprise collaborative talent training strategy, achieving trusted sharing of practical teaching data and talent demand data [4]. In the area of student data management, He & Cheng proposed a blockchain-based IoT-assisted privacy protection scheme for educational big data management, enabling secure data mining and sharing [5]. However, existing research mostly focuses on single-function implementation and lacks systematic research on the comprehensive integration of student ability data and the matching of talent between schools and enterprises. A complete system of "data on-chain - profile generation - intelligent matching" has not yet been formed.

### *2.2. Relevant Research on College Students' Competency Profiles*

Research on college student competency profiles mainly revolves around indicator systems, generation methods, and application scenarios. Regarding indicator systems, Luo & Ye constructed a personalized educational competency indicator system encompassing academic ability, practical ability, and innovation ability [6]. However, existing indicator systems are mostly developed solely by universities, lacking collaborative participation from enterprise job requirements, and thus disconnected from actual recruitment needs.

Regarding generation methods, Song & Zhu used deep learning to mine student learning data to generate learning competency profiles; Zhang & Liu combined digital twin technology to construct a student practical competency profile model [7,8]. However, existing research is mostly based on a single data source, with weight determination primarily relying on subjective weighting methods, resulting in insufficient accuracy and objectivity in the profiles, and a lack of dynamic weighting models. In terms of application scenarios, existing research mainly focuses on personalized teaching and academic early warning in universities, with limited research applying competency profiles to university-enterprise talent matching, and precise alignment between competency profiles and enterprise job requirements has not yet been achieved.

### *2.3. Theoretical and Technological Research on Intelligent Job Matching*

Research on intelligent job matching focuses on three main areas: indicator systems, algorithm models, and system applications. The construction of indicator systems centers on the two-way fit between people and jobs. Farrell et al. established a four-dimensional indicator system covering ability, knowledge, skills, and the Holland Personality Test for vocational education scenarios, improving suitability through quantitative weighting [9]. Ni expanded this to include explicit and implicit knowledge dimensions, incorporating scenario-based indicators such as job level and company size [10].

At the algorithm level, traditional machine learning and deep learning are evolving in parallel: the former uses a structured process as a framework, combining TF-IDF and cosine similarity to achieve feature matching; the latter uses models such as Bi-LSTM and JE-CNN to deeply mine text semantics, improving the ability to capture complex features, but suffers from weak interpretability and high computational complexity [9,10].

The system is adapted to specific scenarios, such as online matching platforms for vocational education and digital HR management systems for enterprises. However, it generally lacks a data exchange mechanism for collaboration between schools and enterprises and does not combine blockchain technology to achieve credible authentication of competency information. This results in insufficient reliability and traceability of matching results, making it difficult to meet the needs of precise talent matching between universities and enterprises.

#### *2.4. Relevant Research on Software Quality Assessment and University-Enterprise Collaboration*

Software quality assessment typically relies on ISO/IEC 25010 as the core standard. Alifya and Dewi combined this standard with the DeLone and McLean model to propose a two-dimensional evaluation framework that integrates technical metrics with user perception analysis [11]. It was confirmed that service and information quality significantly impact user satisfaction. In the field of school-enterprise collaboration, existing blockchain-based vocational education competency certification platforms have achieved basic job matching. However, they have not yet introduced this integrated assessment framework to conduct comprehensive system quality testing, nor have they used the assessment results for iterative optimization of profiling and matching models. Therefore, there is still room for improvement in system adaptability and practicality.

#### *2.5. Study on Synthesis*

Existing research has made some progress in areas such as blockchain applications in education, competency profiling, and job matching, but there are still significant research gaps. First, the application of blockchain technology in education lacks a systematic school-enterprise talent matching system and often focuses on single functions. Second, the competency profiling indicator system lacks school-enterprise collaboration, and the generation method suffers from issues such as single data sources and static weights. Third, job matching lacks deep integration with competency profiling and has not combined blockchain to achieve credible authentication of competency information. Fourth, related systems lack comprehensive evaluation and large-sample empirical verification based on the ISO/IEC 25010 standard [12].

To address the aforementioned gaps, this study constructs a capability profile index system for school-enterprise collaboration, designs an educational scenario alliance chain architecture, proposes a dynamically weighted profile generation model and a multi-dimensional fusion matching mechanism, develops a prototype system, and conducts empirical research, thereby filling the existing research gaps.

#### *2.6. Conceptual Framework*

This study employs an Input-Process-Output (IPO) model to construct a conceptual framework and combines it with a "data-model-decision" ternary integration paradigm to clarify the research logical chain.

##### *2.6.1. Input Phase*

This phase involves multi-source heterogeneous data, including student academic, practical, and certificate data, as well as enterprise job demand data. It incorporates technical tools and frameworks such as blockchain, data mining, and machine learning algorithms. Additionally, it adheres to standards and specifications like the ISO/IEC25010 standard and education data on-chain specification. The phase also addresses the needs of multiple stakeholders, including talent cultivation in universities, precise recruitment by enterprises, and the career development requirements of students [13].

##### *2.6.2. Process Stages*

It encompasses five core components: data collection and on-chain processes, including data preprocessing, standardization, and on-chain storage; the construction of a capability profile indicator system, which involves indicator definition and mapping for school-enterprise collaboration; the accurate generation of capability profiles through a dynamic weighted model and visualization; the design of an intelligent job matching mechanism, incorporating demand quantification and multi-dimensional similarity calculation; and system development and optimization, including prototype development and testing evaluation [14].

### 2.6.3. Output Stage

It generates theoretical outcomes, including a theoretical framework, generative model, and matching mechanism; technical outcomes, such as a consortium blockchain architecture and core algorithm; system outcomes, including a prototype system; and evaluation and application outcomes, such as a quality assessment report and empirical analysis report. Continuous optimization is achieved through a closed-loop feedback mechanism [15-16].

### 2.7. Terminology Definitions

1. Blockchain technology refers specifically to consortium blockchain technology, which is collaboratively maintained by universities, enterprises, and education management departments to enable trusted storage and sharing of student ability data.
2. The College Student Competency Profile is based on multi-source blockchain data. It provides a depiction of students' professional abilities in a multi-dimensional, quantitative, and visual manner, supporting dynamic updates.
3. Intelligent job matching utilizes student ability profiles and enterprise job requirements to achieve accurate matching and personalized recommendations through multi-dimensional similarity algorithms.
4. Dynamic weighting combines subjective weights derived from the Analytic Hierarchy Process (AHP) with objective weights from entropy weighting. The weights are dynamically adjusted to account for data timeliness and job requirement priorities.
5. Multi-dimensional similarity fusion involves a weighted fusion calculation of comprehensive attribute similarity, weighted similarity, and trend similarity.
6. ISO/IEC 25010 is an international software quality assessment standard that encompasses eight core quality characteristics for comprehensive system evaluation.

## 3. Methodology

### 3.1. Research Design

This study employs a hybrid research approach, integrating descriptive, developmental, and quantitative characteristics. It follows the Cross-Industry Data Mining Standard Process (CRISP-DM) and incorporates a Rapid Application Development (RAD) model to ensure both scientific rigor and practical applicability.

1. Descriptive research involves conducting literature reviews, university-industry surveys, and interviews to analyze the current research status, define core issues, and construct an indicator system.
2. Developmental research adopts the "data-model-decision" ternary integration paradigm, designing blockchain architecture, capability profiling models, and matching mechanisms, as well as developing a prototype system.
3. Quantitative research involves the use of questionnaires, data collection, and experimental analysis to verify the effectiveness of the model and system. A quality assessment is conducted in accordance with the ISO/IEC 25010 standard.

### 3.2. Research Subjects

#### 3.2.1. Main Research Object

The research subjects include four main entities: college students (primarily full-time vocational college students), colleges (academic affairs, student affairs, and practical training departments), enterprises (small and medium-sized enterprises in the manufacturing and information technology industries), and education management departments (local education departments or bureaus and vocational education research institutions).

### 3.2.2. Empirical Research Subjects

The selection criteria include 1,500 graduating students from Tangshan Maritime Vocational College in the 2025 cohort of Computer Science and Intelligent Manufacturing programs. The sample included 10 professional teaching and research offices and 20 partner companies (14 information technology companies and 6 manufacturing companies) as empirical subjects to ensure the representativeness of the sample.

### 3.3. Sample Size and Sampling Techniques

A stratified random sampling method was adopted, and the sample size was calculated according to the Slovin formula ( $n=N/(1+Ne^2)$ , with an error range of  $e=0.05$ ). The final sample size was determined to be 463 people, including 316 university students, 80 university teachers/administrators, and 67 enterprise managers/technical supervisors. The sampling was stratified by major, job position, and enterprise type to ensure that the sample structure was consistent with the population.

### 3.4. Research Instruments

1. The indicator system questionnaire is divided into a university version and an enterprise version. It uses a 5-point Likert scale and includes 30 capability indicators to determine the indicator weights.
2. The system user satisfaction questionnaire is designed according to the ISO/IEC 25010 standard. It contains 40 items, employs a 5-point Likert scale, and incorporates open-ended questions to gather feedback.
3. The multi-source data collection scale is divided into a student ability data collection scale and an enterprise job requirement data collection scale, facilitating the integration of quantitative and qualitative data.
4. The system performance testing index system includes technical performance indicators, such as transaction speed and response time, as well as application effect indicators, such as profile accuracy and matching accuracy.

All research instruments were pre-tested, achieving a Cronbach's  $\alpha$  coefficient of 0.7 or higher and a content validity index of 0.8 or higher, ensuring strong reliability and validity.

### 3.5. Data Collection Procedure

Data collection is organized into three distinct stages to ensure comprehensive coverage and accuracy.

1. Data related to the indicator system and weights is gathered through a combination of literature review, in-depth interviews with five professional leaders and five corporate human resources directors, and questionnaire surveys.
2. For model validation, data is collected on student academic performance, practical experience, and certifications from university systems. Additionally, job requirement data is obtained from enterprises, and a standardized dataset is created after preprocessing.
3. During the three-month trial operation of the system, data is collected on technical performance, user satisfaction through questionnaires, and the effectiveness of application matching.

Data is collected using both online and offline methods. After anonymization, it is securely stored in a database to ensure data integrity and privacy protection.

### 3.6. Statistical Processing of Data

Data processing was conducted using tools such as SPSS 26.0 and Python 3.9, ensuring robust statistical analysis.

1. Descriptive statistics were used to describe the distribution of data through frequency, percentage, mean, and standard deviation.
2. The reliability and validity of the questionnaire were assessed using Cronbach's alpha coefficient, the content validity index, and factor analysis.
3. Indicator weights were calculated by combining subjective weighting through the analytic hierarchy process (AHP) and objective weighting using the entropy weighting method to determine comprehensive dynamic weights.
4. Cosine similarity and a weighted fusion method were applied to calculate multi-dimensional matching degrees.
5. Inferential statistics, including T-tests and analysis of variance (ANOVA), were employed to compare differences among groups and verify the effectiveness of the model and system.
6. Content analysis was utilized to process qualitative data from interviews and open-ended questions.

### 3.7. System Development Process

The Rapid Application Development (RAD) model is adopted, consisting of six phases to ensure efficient and iterative system development.

1. Requirements analysis and definition: This phase involves clarifying functional requirements, such as data on-chain, profile generation, and intelligent matching, as well as non-functional requirements, including security and reliability.
2. Prototyping: Core module prototypes are developed, user feedback is collected, and rapid iterations are performed to refine the system.
3. User feedback and improvement: Prototype functions and interfaces are optimized based on input from multiple stakeholders to enhance usability and functionality.
4. Design and Development: The system utilizes a microservice architecture and is developed using technologies such as Spring Boot, Vue 3, and Hyperledger Fabric.
5. Testing: Comprehensive testing is conducted, including unit testing, integration testing, system testing, and user acceptance testing, to ensure the system's stability and availability.
6. Deployment: The system is deployed to universities and enterprises for trial operations, followed by continuous optimization based on operational feedback.

### 3.8. Ethical Considerations

Data security mechanisms include AES-256 encrypted transmission, RBAC access control with four levels of permissions, data anonymization, and other measures to ensure data security.

Compliance design adheres to the IEEE 2030.5 smart grid standard, ISO 55000 asset management certification, and GDPR data privacy requirements.

Research ethics guidelines emphasize the principles of voluntary participation, anonymization, and data confidentiality. All data is used exclusively for academic research and cannot be disclosed without authorization.

## 4. Results and Analysis

### 4.1. Standardized Competency Index System

A practical three-tiered indicator system for university students' career development was successfully constructed, addressing the limitations of traditional competency classification, which often emphasizes theory over practice. The system clearly defined the connotation, quantitative standards, and weights of each indicator, providing a standardized framework for competency modeling.

### 4.2. Education-Oriented Consortium Chain Architecture

Layered authorization and collaborative management of multiple nodes were achieved, enabling trusted storage, full lifecycle traceability, and cross-institutional

mutual recognition of multi-source heterogeneous competency data. This addressed the trust limitations of traditional centralized databases and resolved the issue of unreliable competency data.

#### 4.3. Dynamic Profiling Model and Multi-Dimensional Matching Mechanism

The dynamic weighted model enables precise and adaptive characterization of students' competencies, aligning with their developmental trends. The multi-dimensional matching mechanism overcomes the constraints of traditional static weighting and single-algorithm approaches, resulting in enhanced accuracy and improved interpretability in matching processes.

#### 4.4. System Quality Assessment Results

Based on the assessment results of the ISO/IEC 25010 standard, the system demonstrates strong performance across all eight quality dimensions, including functional applicability, performance efficiency, reliability, security, and availability. These findings confirm the overall quality and robustness of the system. Comparative experiments with traditional models indicate that the model proposed in this study offers significant theoretical advantages in terms of matching accuracy and interpretability.

### 5. Conclusions and Future Prospects

#### 5.1. Research Conclusions

This paper successfully constructed a blockchain-integrated system that incorporates trusted storage of capability data, dynamic and accurate profiling, intelligent employment matching, and system quality assessment. The research highlights the necessity and advantages of blockchain technology in achieving trusted data sharing. The dynamic weighted and multi-dimensional similarity fusion model demonstrates significant improvements in accuracy and interpretability compared to traditional models. This study addresses data barriers between universities and enterprises, compensates for the functional limitations of existing systems, establishes a novel framework for precise talent supply and demand matching, and facilitates the deep integration of blockchain technology with university student career development services.

#### 5.2. Future Outlook

**System Implementation:** Promote pilot applications in universities and enterprises, conduct multi-scenario empirical tests, and optimize node settings, data on-chain processes, and smart contract deployment based on practical feedback to enhance system usability and adaptability across various scenarios.

**Continuous Model Optimization:** Continuously iterate and refine the competency profiling model and intelligent matching algorithm, determine the optimal parameters for dynamic weights through large-sample empirical research, incorporate additional industry job demand data, and improve the generalization capabilities of the model and algorithm.

**Expanding Research Scope:** Integrate factors such as organizational management and system adoption behavior into the research framework, incorporate models like COBIT 5 and UTAUT, construct a more comprehensive academic information system success evaluation framework, and conduct longitudinal studies to monitor the development of student capabilities and evolving job requirements.

**Ecosystem Construction:** Further refine the incentive and risk control mechanisms for blockchain-based competency verification, encourage the involvement of third-party certification bodies, facilitate cross-regional and cross-industry mutual recognition of competency data, and provide robust data support for higher education reform and precise enterprise recruitment.

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