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EDITED BY
Paitoon Pimdee,
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REVIEWED BY
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Yan-bang Dong,
Jiangsu Second Normal University, China

*CORRESPONDENCE
Min Luo
✉ luom@sziit.edu.cn

†These authors have contributed equally to this work and share first authorship

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Evaluating and analyzing student labor literacy in China's higher vocational education: an assessment model approach

Suhan Wu[1†], Jingyi Duan[2†] and Min Luo[3*]

[1]School of Economics and Management, Nanjing Polytechnic Institute, Nanjing, Jiangsu Province, China, [2]College of Life and Health, Nanjing Polytechnic Institute, Nanjing, Jiangsu Province, China, [3]School of Management, Shenzhen Institute of Information Technology, Shenzhen, Guangdong Province, China

Introduction: This study addresses the gap in evaluating labor literacy amongst vocational students in China's higher vocational education system. It aims to develop a comprehensive framework for assessing essential labor competencies, thereby contributing to a nuanced understanding of vocational education's role in skill development.

Methods: Employing a multifaceted research methodology, this study integrates questionnaire surveys, econometric analyses, and the Delphi method to assess labor literacy among 749 students from three leading vocational institutions. A pioneering labor literacy assessment model is introduced: $S = 0.5466B_1 + 0.1816B_2 + 0.1623B_3 + 0.1095B_4$, where S denotes the overall labor literacy score. Here, B_1 represents labor concepts, B_2 denotes habits and qualities, B_3 signifies knowledge and skills, and B_4 encapsulates emotions and attitudes, illustrating a comprehensive approach to measuring labor literacy.

Results: Our findings reveal pronounced disparities in labor literacy across the identified dimensions, with particular deficiencies in labor concepts. The study also identifies six determinants—gender, political profile, academic performance, internship and training base utilization, inclination towards innovation and entrepreneurship, and labor education evaluation mechanisms—that significantly influence labor literacy outcomes.

Discussion: Highlighting the imperative for a contextually informed and holistic approach to labor literacy, this study's insights advocate for educational strategies that are both aligned with labor market demands and cognizant of socio-cultural nuances. The developed assessment model not only propels the theoretical discourse in vocational education forward but also provides a pragmatic guide for educators and policy makers, aiming to mitigate disparities and enhance labor competencies through refined educational practices.

KEYWORDS

labor literacy, assessment model, literacy evaluation, empirical research, vocational education

1 Introduction

Labor education, a key facet of China's unique socialist education system, plays an instrumental role in cultivating a sense of labor responsibility, embedding societal values, and enhancing practical skills (Jinping, 2018). The March 2020 endorsement of the *Opinions on Comprehensively Strengthening Labor Education in the New Era* by the Central Committee of the Communist Party of China and the State Council marked a pivotal moment, indicating a reinvigorated commitment to enriching labor education (Fan and Zou, 2020). These directives highlight the critical need to develop an educational framework that not only aligns with modern values but also significantly enhances the

overall development of students, with an explicit focus on labor literacy (Jianjun, 2020). The strategic prioritization of labor literacy elevates its assessment to a key metric for student development and a fundamental benchmark in achieving the renewed ambitions of labor education (Jincai and Fangfang, 2021; Pan et al., 2023).

In a notable development during July 2020, the Ministry of Education in China promulgated the *Guidelines for Labor Education in Universities, Middle Schools, and Primary Schools (Trial)*. This directive significantly bolstered the role of labor literacy assessments in the educational framework, establishing specific standards and objectives, with an acute focus on enhancing the capabilities of higher vocational institutions and colleges (Liang, 2023). Central to these guidelines is the emphasis on vocational education, a linchpin of China's educational system, highlighting its critical role in the development of highly skilled professionals (Le, 2022). These professionals are deemed indispensable for effectively managing the complexities and fulfilling the requirements intrinsic to China's aspirations for high-quality development and industrial modernization (Ding, 2022). The guidelines embody a comprehensive approach in integrating labor education at multiple educational levels, aiming to forge a workforce adept in practical skills alongside theoretical acumen. This strategic emphasis is not solely instrumental in addressing immediate industrial exigencies but is also crucial in nurturing a workforce that is resilient, adaptable, and equipped to make significant contributions to the anticipated societal and economic transformations.

As underscored by the guidelines above, the emphasis on vocational education also accentuates its transformative impact in equipping students with critical labor skills, essential for navigating contemporary socio-economic challenges. These skills, which encompass a spectrum of practical abilities, theoretical knowledge, and ethical work dispositions, constitute key elements of what is broadly defined as labor literacy (Sum, 1999). Labor literacy extends beyond mere proficiency in vocational skills; it entails a holistic understanding and application of work ethics, teamwork, problem-solving capabilities, and adaptability across diverse labor environments (Pengcheng et al., 2022). Consequently, the assessment of labor literacy emerges as a crucial indicator of the efficacy with which vocational education imparts real-world competencies. Addressing this imperative, our research is committed to formulating a scientifically rigorous model for the evaluation of labor literacy among students in higher vocational colleges. This model aims to fill the existing methodological void, offering an all-encompassing framework for assessing various facets of labor literacy, including labor knowledge, skills, habits, attitudes, and emotional intelligence. By implementing such a model, the study not only aligns with China's educational objectives but also proactively responds to both national and international labor market requirements, ensuring the continued relevance and effectiveness of vocational education in an evolving global context.

1.1 Conceptual framework and research motivations

The study's conceptual framework is anchored in the multifaceted nature of labor literacy within vocational education, which is pivotal in equipping students with the competencies essential for the socialist educational paradigm (Spring, 2015). This framework draws on the principles of contemporary educational theories that emphasize skill development, values education, and labor engagement as integral components of holistic education (Ling et al., 2021).

Building on the works of scholars who have explored vocational education models (Yu, 2012; Handoyono et al., 2020; Xiaojie and Naiqing, 2022), our study extends these discussions by focusing on the specific construct of labor literacy. It emphasizes the need for a comprehensive evaluation model that is not only aligned with China's evolving workforce demands but also responsive to global educational standards. By situating labor literacy within this broader theoretical and educational context, the study seeks to contribute to the ongoing discourse on vocational education reform and its alignment with the needs of the 21st-century labor market.

The primary objectives of this research are twofold: firstly, to construct a robust and adaptable model for assessing labor literacy in higher vocational colleges; and secondly, to identify and analyze the determinants that significantly influence labor literacy. By achieving these objectives, the study contributes to the broader body of knowledge in vocational education by providing empirical evidence and practical tools for educators and policymakers. It advances the understanding of labor education's role in student development and the alignment of educational practices with modern labor market demands. Thus, this study is driven to address these questions:

- How can labor literacy in higher vocational colleges be accurately assessed to meet evolving educational and societal demands?
- What are the primary factors influencing labor literacy development among students in higher vocational colleges?
- How can the insights derived from the assessment model and factor analysis guide and refine labor education policies and practices?
- How do the study's findings contribute to advancing educational equity and excellence in the context of China's evolving socio-economic landscape?

Exploring these queries will furnish critical insights into the assessment of labor literacy and its strategic role in steering future educational directions.

The subsequent structure of this paper is methodically organized as follows: Following the introduction, the literature review section ventures into the theoretical underpinnings and contemporary perspectives on labor literacy. Sections 2.1, 2.2 delineate the research gap and the study's significant contributions, respectively. Section 3 articulates the formulation of the model, including the methodology of questionnaire preparation and the establishment of evaluation indices and weights. Section 4 presents a detailed analysis of labor literacy, probing into its current state and influential factors. Finally, Section 5 culminates the paper by offering implications and recommendations for future inquiries, providing a comprehensive overview of the study's findings and their extensive ramifications.

2 Literature review

The concept of literacy has evolved significantly since Harvard professor White (1959)'s publication *Motivation Reconsidered: the Concept of Competence*, which redefined literacy as a dynamic capability rather than a static trait. He posited literacy as a skill developed through continuous learning, enabling effective interaction and adaptation within one's environment. Building upon this foundational idea, researchers such as Xiangdong (2017) and Xiaojie and Naiqing (2022) have expanded the definition of literacy to include a broad spectrum of human capabilities, encompassing cognitive abilities, emotional intelligence, attitudinal orientations, and value systems. They assert that literacy is shaped by a complex interplay of internal psychological attributes and external behavioral factors, continually evolving through education, environment, and personal endeavor. This expanded view positions literacy as an integral, multifaceted construct in personal development and societal advancement (Dwyer, 1977; Howells, 2018).

In the domain of labor education, labor literacy is a multi-dimensional construct initially conceptualized by Sukhomlinsky (1981), encompassing spiritual, moral, and civic facets of labor. Later studies have further examined labor literacy from a theoretical standpoint. Utilizing the Analytic Hierarchy Process (AHP) and expert surveys, Pan et al. (2023) have provided a nuanced understanding of labor literacy, depicting it as an amalgam of values, habits, character, and skills. Similarly, Jiangzhou (2021), adopting a psychological lens, categorizes labor literacy into four domains: values, emotional quality, knowledge and skills, and practices. In the context of China's labor education scenarios, Quanquan et al. (2021) views labor literacy through the prism of core literacy, emphasizing its fundamental components and its heterogeneous nature. On a global scale, Hui et al. (2022) acknowledges the international recognition of labor abilities, spirit, character, attitudes, and values. This global perspective underlines the comprehensive nature of labor literacy, embodying an individual's labor-related knowledge, emotions, intentions, and behaviors, and reflecting a confluence of personal aspirations and societal demands.

The heightened focus on labor education within China has catalyzed scholarly interest in the assessment of labor literacy. Developing effective labor literacy assessment models is central to this research, particularly the identification of relevant evaluation indices and dimensions (Yuan, 2023). A broad consensus exists among scholars for a holistic evaluation framework that comprehensively covers various aspects of labor literacy, including concepts, abilities, spirit, habits, and qualities (Ning et al., 2020; Wang et al., 2021). In academic discourse, this inclusive perspective has gained traction and has been extensively elaborated upon. Jianjun (2020) highlights the necessity of fostering diverse dimensions of labor literacy, encompassing concepts, abilities, habits, qualities, and spirit. This approach synthesizes an array of competencies for task execution, behavioral habits, character traits, and belief systems, which collectively represent an individual's inherent values and ethos in the labor sector. Following this line of research, Qiuyue and Jianjun (2022) employed the Delphi method to categorize labor literacy evaluation indices into four primary dimensions–labor concept, ability, habits and quality, and emotional and attitudinal aspects. These dimensions were further broken down into secondary and tertiary indices, providing a structured approach to evaluation. Their findings suggest that the labor quality level among secondary vocational students is relatively low, attributing this to issues like cultural confusion, technology enchantment, institutional vacancy, and resource barriers. In a similar vein, Ruilin and Wenfeng (2021) developed an evaluation index system for university students' labor literacy, employing a mixed-methods research design. Their study, which involved data collection from six regions including Suzhou and Nanjing, led to the creation of a structured system aimed at enhancing university students' labor literacy. Additionally, Huan and Qingsong (2023) investigated the impact of various factors on labor literacy in higher vocational colleges. Through their study involving 1,140 students from a college in Chongqing, they identified key influences such as labor education design and resource selection in improving students' labor literacy.

In summary, the collective body of literature significantly highlights the complex and multifaceted nature of labor literacy. These studies have been pivotal in enriching the understanding of labor literacy, encompassing both psychological and practical dimensions, with a particular emphasis on the context of China's higher vocational education. In the realm of establishing labor assessment models, there is a consensus among scholars on adopting a two-tiered structure of indicators. This structure comprises primary and secondary levels, encompassing a broad range of aspects such as labor cognition, ability, consciousness, concept, attitude, habit, quality, emotion, knowledge, skill, spirit, technology, and participation. The secondary level delves into more detailed elements including service dedication, work ethic, cooperation, legality, safety, honesty, innovation, and rational consumption. These expansive categories collectively reflect the complexity and comprehensive nature of labor literacy. This extensive scholarly work provides a solid foundation for further exploration and refinement of labor literacy assessment models within the sphere of vocational education (Hanushek et al., 2017).

2.1 Research gap

The prevailing literature on labor literacy in the context of vocational education system reveals a significant methodological gap. Traditional approaches have typically relied on qualitative analyses or expert judgments to define evaluation indices and their weights for labor literacy assessments. These methods, while informative, often lack the depth and objectivity that a more empirical approach could provide. Additionally, there is a noticeable shortfall in the literature regarding the variability of labor literacy across different demographics within the vocational student body. Most studies do not sufficiently explore how diverse factors such as gender, political affiliations, and academic backgrounds influence labor literacy levels.

2.2 Contributions

This study represents a significant advancement in the field of labor literacy within China's vocational education system. It transcends traditional research methods and offers innovative insights, addressing critical gaps identified in the existing literature. The contributions of this research are multifaceted, reflecting both methodological improvements and deeper explorations of labor literacy's complex dynamics. Key contributions include:

- By employing Principal Component Analysis (PCA), this research introduces a data-driven approach to determine the indices and weights for evaluating labor literacy.
- Developing an expansive labor literacy assessment model, integrating diverse methodologies for a comprehensive and nuanced understanding.
- Providing in-depth analyses of labor literacy within the unique socio-cultural milieu of China, thus enriching the discourse on regional educational nuances and requirements.
- Identifying key determinants of labor literacy and offering substantive recommendations that can inform and refine educational strategies and practices.

The contributions of this study transcend the confines of China's vocational education system, providing globally pertinent insights in the realm of labor literacy. The adoption of Principal Component Analysis (PCA) for labor literacy assessment heralds a pioneering, data-driven methodology, establishing a benchmark for objectivity and empirical rigor that is applicable across various international educational contexts. The assessment model developed through this research, while tailored to the nuances of labor literacy in China, also serves as a versatile framework suitable for diverse global educational settings. Furthermore, the identification and in-depth analysis of critical factors influencing labor literacy, together with the provision of strategic recommendations, offer invaluable perspectives for educators and policymakers worldwide.

3 Construction and formulation of labor literacy assessment model

3.1 Research method

This section delineates the methodological framework developed for constructing a labor literacy assessment model, tailored to students in higher vocational institutions. The methodology, grounded in a theoretical framework recognizing labor literacy as a multifaceted construct, necessitates a comprehensive approach for its effective assessment, which has been detailed in Section 1. The model is an intricate mathematical entity, carefully crafted to incorporate a range of evaluative indices and their corresponding weights, ensuring the accurate measurement of labor literacy. The methodology is aligned with our research objectives as follows:

1. To assess labor literacy in accordance with evolving educational and societal demands, a data-driven model was developed, capable of adapting to varied contexts. This approach is vital for capturing the dynamic nature of labor literacy in a rapidly changing educational landscape.
2. In identifying the primary factors impacting labor literacy, the study entailed a refinement and clarification of the indices' meanings. This process encompassed an extensive exploration of the various dimensions of labor literacy, thereby ensuring a thorough representation of the factors that influence students' competencies.
3. Empirical studies were conducted utilizing the model to analyze the overall situation of students' labor literacy and to identify contributing factors. This analysis provides a detailed understanding of the current state of labor literacy and its determinants among vocational students.
4. By incorporating a diverse range of variables, the model offers insights into achieving educational equity and excellence. While the focus is on China's socio-economic context, the model's applicability extends globally, offering valuable insights for diverse educational settings.

The first step involved developing a detailed questionnaire to evaluate various aspects of labor literacy. This questionnaire was empirically validated through a survey involving 749 students from three prominent vocational institutions (Table S1, Data Sheet 1). To analyze the data, we utilized Stata/MP 17.0, implementing Principal Component Analysis (PCA). PCA helped identify and assign weights to the principal components based on the proportion of variance each explains (Labrín and Urdinez, 2020).

Further refinement of the model was achieved through the adapted Delphi Method. By engaging a panel of experts, we ensured the precise interpretation and integration of each principal component's connotation (Linstone and Turoff, 1975; Boberg and Morris-Khoo, 1992). To ensure the rigor of our methodology, each step of the process, from questionnaire design to data analysis, was conducted with meticulous attention to detail and grounded in established statistical and research methods. The inclusion of a diverse student sample and the use of a panel of experts in the Delphi Method add to the generalizability of the model. This approach allows the model to be applicable in a variety of vocational education contexts, thus addressing the fourth research question regarding educational equity and excellence.

In summary, this dual approach of quantitative and qualitative methods facilitates a thorough understanding of labor literacy within the vocational education sphere and ensures the model's applicability across diverse contexts (Quyên, 2014; Keegan et al., 2019).

3.2 Development of the labor literacy evaluation questionnaire

The development of the labor literacy evaluation questionnaire represents a thoughtful and extensive endeavor. It synthesizes insights from academic research, policy analysis, and expert consultation within the labor education sector. The questionnaire is grounded in the psychological framework of "knowledge, emotion, intention, and action," aiming to capture the comprehensive essence of labor literacy (Nunez and Freeman, 1999; Masek et al.,

TABLE 1 Eigenvalues and explained variance in principal component analysis.

Components	Eigenvalues	Variance	Explained percentage	Cumulative percentage
Component 1	5.1973	3.4706	0.3465	0.3465
Component 2	1.7267	0.1827	0.1151	0.4616
Component 3	1.5439	0.5028	0.1029	0.5645
Component 4	1.0412	0.2897	0.0694	0.6339
Component 5	0.7515	0.0347	0.0501	0.6840
Component 6	0.7167	0.0412	0.0478	0.7318
Component 7	0.6756	0.1226	0.0450	0.7769

2022). Through meticulous selection and elimination of redundant elements, 32 principal observation points have been identified to span the full spectrum of labor literacy.

The questionnaire is bifurcated into two segments: the initial part gathers demographic information and explores the implementation of labor education in academic institutions, while the subsequent part concentrates on evaluating labor literacy. The formulation of the questionnaire involved extensive deliberations and iterative refinements by a panel of experts, focusing on the dimensionality of items, option structures, clarity and conciseness of questions, and overall response feasibility. The finalized instrument comprises 48 carefully formulated questions, with 33 dedicated to the first segment and 15 to the second. The second segment is further distinguished by 4 matrix-style questions, each offering 6 to 20 options, thereby enabling an in-depth evaluation of students' labor literacy.

3.3 Quantitative assessment of labor literacy evaluation indices and weight

The evaluation of labor literacy among students in higher vocational colleges and universities involved a comprehensive survey using a carefully structured questionnaire distributed across China. Employing a random sampling method, 860 questionnaires were disseminated, resulting in 749 valid responses and an impressive validity rate of 87.09%. The demographic analysis of respondents displayed a balanced gender distribution with 50.27% male and 49.73% female participants and varied professional backgrounds, including science and technology (44.86%), economics and management (31.38%), arts (9.61%), literature and history (5.47%), and others (8.68%). Additionally, their residences spanned rural (35.51%), urban (24.17%), town (20.43%), and county (19.89%) areas, ensuring the inclusivity and representativeness of the study population.

The reliability of the questionnaire was rigorously validated using Stata/MP 17.0. The Cronbach's alpha coefficient of 0.7698 denotes good reliability, affirming that the instrument effectively measures its intended constructs (Bujang et al., 2018). The questionnaire's second part was subjected to the KMO and Bartlett's Sphericity Test, yielding a KMO value of 0.876 and a significant p-value of 0.000 in Bartlett's test, indicating meaningful correlations between the questions (Grossman et al., 1991). These robust statistical underpinnings facilitated the application of principal component analysis, which identified four significant components, each with an eigenvalue exceeding 1.0, reinforcing their importance in the assessment model (Wold et al., 1987). For clarity and focus, this paper includes the analysis of only the first seven components (refer to Table 1). These components were selected based on their higher eigenvalues and interpretative value, offering a detailed perspective on the pivotal aspects of labor literacy while ensuring the analysis is streamlined and pertinent.

The evaluation of the factor loading matrix confirmed the validity of the principal component analysis, as indicated by variance uniqueness values for each question not exceeding 0.6. This validation process, grounded in established statistical methodology, ensures the robustness of the analysis (Archer and Jennrich, 1973; Bekker, 1986). Let A_i denote the score of ith question, and a_{ij} denote the coefficients of A_i $(i = 1, 2, ..., 15)$, therefore, the jth principal component B_j $(j = 1, 2, 3, 4)$ can be calculated by:

$$B_j = \sum_{i=1}^{15} a_{ij} A_i, (j = 1, 2, 3, 4) \quad (1)$$

In this equation, A_is are obtained from the questionnaire and statistical results, and a_{ij} are coefficients extracted from the principal component analysis feature matrix (see Table 2). Thus, this approach facilitates a precise and mathematically rigorous assessment of the labor literacy model.

In the labor literacy model, weights assigned to the principal components are derived using the cumulative explained variance from the PCA. Specifically, the weight of the ith principal component, denoted as b_i, is calculated based on its proportion of explained variance. Consequently, the weights are as follows: $b_1 = \frac{0.3465}{0.6339}$, $b_2 = \frac{0.1151}{0.6339} = 0.1816$, $b_3 = \frac{0.1029}{0.6339} = 0.1623$, and $b_4 = \frac{0.0694}{0.6339} = 0.1095$, as detailed in Table 1. These calculations determine the weights for the four primary evaluation indices within the labor literacy framework, with the first index B_1 being accorded the highest weight, thereby indicating its predominant influence in the assessment. This systematic and quantitative approach ensures a balanced and precise representation of each component's contribution to the overall labor literacy evaluation.

Therefore, the mathematical formulation of the labor literacy assessment model for higher vocational students is concisely captured as:

TABLE 2 Feature matrix from principal component analysis.

Indices	a_{i1}	a_{i2}	a_{i3}	a_{i4}
1	0.0505	0.3006	0.5935	−0.0188
2	0.0494	0.3180	0.5854	−0.0943
3	0.2941	0.2974	−0.2324	−0.1350
4	0.3528	0.3042	−0.1241	−0.1103
5	0.2055	0.0184	0.0179	0.5669
6	0.2826	−0.0948	−0.1714	0.2738
7	0.2792	−0.0155	0.0651	0.2602
8	0.2101	−0.0218	0.1651	0.5568
9	0.3422	0.2448	−0.2111	−0.1457
10	0.3410	0.2765	−0.1387	−0.1881
11	0.2097	−0.3723	-0.0234	-0.0687
12	0.2708	−0.2784	0.1668	−0.1852
13	0.2600	−0.2807	0.1841	−0.1839
14	0.2122	−0.3420	0.1240	−0.2179
15	0.2767	−0.2632	0.1816	−0.0966

$$S = \sum_{i=1}^{4} b_i B_i = 0.5466B_1 + 0.1816B_2 + 0.1623B_3 + 0.1095B_4$$

In this equation, the principal components B_1, B_2, B_3 and B_4 represent the four core evaluation indicators of labor literacy for vocational students. The coefficients b_1, b_2, b_3 and b_4 are their corresponding weights, which are integrated to reflect the relative impact of each indicator. The subsequent sections will delve into the specific meanings and implications of each evaluation index.

3.4 Establishing the evaluation indicators for labor literacy model

The determination of connotations for labor literacy evaluation indicators and the establishment of corresponding measurement model was conducted through a comprehensive and methodical process. As delineated in Equation 1, the principal components B_1, B_2, B_3, and B_4, identified via PCA, were linearly related to the scores derived from the questionnaire. To refine the model and ensure its relevance and accuracy, expert insights were sought through an adapted Delphi method. This approach incorporated a review of current authoritative literature on labor literacy, its evaluation methodologies, and the statistical relationship between questionnaire responses and the principal components. Consultations were conducted with a diverse panel of 18 experts across various fields pertinent to labor literacy, thereby enriching the model with a broad range of perspectives and expertise.

The analytical examination of questionnaire items and their corresponding correlations with each principal component facilitated the discernment of distinct dimensions represented by each component, as illustrated in Table 2. Notably, questions 1 and 2 exhibited a pronounced correlation with the third principal component, epitomizing the knowledge, skills, abilities, and innovations pertinent to labor. Conversely, questions 5 through 8, closely aligned with the fourth component, predominantly encapsulate labor-related preferences, attitudes, and intentions. Questions 3, 4, 9, and 10, which align with the second component, are emblematic of labor habits and ethical considerations, encompassing virtues such as honesty and cooperation. Lastly, a collective range of questions from 3 to 15 underscore labor cognition, values, and spirit, demonstrating a robust association with the first component.

After conducting three iterative rounds of surveys and garnering feedback, a consensus emerged regarding the distinct connotations of the four principal components delineated as follows:

- B_1 is synonymous with labor concepts, embodying students' foundational cognition and perspectives concerning labor.
- B_2 pertains to labor habits and qualities, indicative of the behavioral propensities and positive personality attributes cultivated through consistent labor engagement.
- B_3 denotes labor knowledge and skills, mirroring the competency and adeptness necessary for the successful execution of labor tasks.
- B_4 captures labor emotions and attitudes, enveloping the spectrum of sentiments and viewpoints toward labor, fellow laborers, and the outcomes of laborious efforts developed over time.

Significantly, the labor concepts represented by B_1 were identified as having a profound influence on overall labor literacy.

The culminating formula for appraising labor literacy among higher vocational students is succinctly presented as:

$$S = 0.5466B_1 + 0.1816B_2 + 0.1623B_3 + 0.1095B_4 \quad (2)$$

This equation synthesizes the weighted components of labor literacy–labor concepts (B_1), habits and qualities (B_2), knowledge and skills (B_3), and emotions and attitudes (B_4). Each component B_j (for $j = 1, 2, 3, 4$) is computed from questionnaire data A_i (for $i = 1, 2, ..., 15$), facilitating an encompassing quantification of labor literacy scores. This formula plays a pivotal role in evaluating and discerning the determinants of labor literacy among higher vocational students, thereby serving as a potent instrument for educational appraisal and analytical deliberation.

As the discourse transitions from the model's formulation to its empirical application, it is imperative to reiterate the foundational premises established in preceding discussions. The model, a confluence of empirical evidence and expert validation, portrays the comprehensive spectrum of labor literacy in higher vocational education. The subsequent section will engage in an intensive exploration of the present state of labor literacy among vocational students, applying the formulated model to dissect data and derive substantive insights.

4 Analysis of labor literacy assessment model

This section embarks on a detailed analysis of the labor literacy assessment model tailored for higher vocational education. Initially, we provide an in-depth evaluation of labor literacy levels among vocational students, focusing on assessing the proficiency and capabilities as they currently stand. This evaluation is critical to understanding how effectively the current educational framework is supporting the development of labor competencies. Following this, our analysis extends to a rigorous examination of the various elements influencing labor literacy. This part of the analysis aims to identify key factors that shape labor literacy outcomes in vocational students. By dissecting these components, the study offers a comprehensive insight into both the manifestation of labor literacy and the dynamics influencing its development. This dual-faceted analysis not only sheds light on the current state of labor literacy but also provides a nuanced understanding of the factors contributing to its variation, thereby offering critical perspectives for refining labor education strategies and aligning them with educational and societal demands.

4.1 Evaluating current labor literacy levels

Delving into the first facet of our analysis, this subsection focuses on evaluating the current levels of labor literacy among students in higher vocational education. The approach is bifurcated into two interconnected segments. The initial segment presents a quantitative assessment of the labor literacy scores obtained by the students. This quantitative evaluation serves as a foundational basis for understanding the overall proficiency and skill levels in labor literacy within the student cohort. Following this, the analysis progresses to examine the differences in labor literacy across various student groups. This examination is crucial for identifying the diversity and range in labor education outcomes, shedding light on the varied experiences and competencies among the students. Collectively, these analyses provide a comprehensive picture of the labor literacy landscape in vocational education, setting the stage for a deeper exploration of the factors influencing these outcomes.

4.1.1 Overview of labor literacy scores

Employing Equations 1, 2, our analysis encompassed labor literacy scores across a sample of 749 vocational students. The results indicated a highest score of 15.952 and a lowest of 5.925, with an average score residing at 14.063. The quartile distribution, specifically with Q_1 at 13.324, Q_2 at 14.290, and Q_3 at 15.004 (refer to Table 3), reflects a commendable level of labor literacy, with 75% of students achieving scores above 13.324. The relatively narrow 16.47% range between the highest scores and the third quartile underscores a tendency toward higher proficiency levels among the majority of students, indicating an overall positive state of labor literacy within this group.

Diving deeper into the four indices of labor literacy evaluation–labor concepts, habits and qualities, knowledge and skills, and emotions and attitudes–variances in student competencies become apparent. Although the mean score of the sample is approximately 14.0, there is a marked variation in standard deviations across the indices. Labor concepts exhibit the most considerable fluctuation, with a standard deviation of 2.280, followed by labor habits and quality at 1.314, labor knowledge and skill at 1.243, and labor emotions and attitudes at 1.020. These figures highlight substantial disparities in students' grasp and execution of various labor literacy facets. Furthermore, the maximum scores achieved in each dimension exceed the highest aggregate labor literacy score, revealing an uneven development among students in these areas.

The observed variances in labor literacy across different dimensions point toward areas that may require targeted educational focus. For academic researchers, these variations offer a fertile ground for studies exploring the effectiveness of pedagogical approaches in vocational education. Practitioners, on the other hand, can utilize this data to pinpoint specific areas within labor literacy that require enhanced teaching methods or additional resources. Such targeted interventions are crucial for addressing the disparities in students' competencies and fostering a more balanced development across all aspects of labor literacy.

4.1.2 Variability in labor education across cohorts

The application of Analysis of Variance (ANOVA) has elucidated statistically significant disparities at the 1% level across six dimensions of labor education implementation (see Table 4). These dimensions encompass the variety of course and material types, diversity in teaching methods, forms of labor practice, availability of practice bases, and the distinct roles played by teachers. Notably, variations in course format contribute modestly to the overall variance at 1.9%, whereas more pronounced differences are perceived in teaching methods, labor practices, and the infrastructure for practice, collectively accounting for over 8.3% of the total variance. Such findings underscore the significant impact these facets of labor education have on the variability in student labor literacy.

The disparities revealed by the ANOVA analysis in labor education across diverse student cohorts offer critical insights with far-reaching implications. These findings are particularly valuable for academic research, providing a basis for studies that examine how differences in educational delivery across cohorts affect student learning outcomes. For educators and policy-makers in the field of vocational training, this data is instrumental in highlighting the need for differentiated teaching approaches and resource distribution. Tailoring educational strategies to suit the unique characteristics of each student cohort can lead to a more personalized and effective learning experience. Furthermore, these insights are essential for developing policies that acknowledge and address the varying needs of student groups, thereby fostering a more inclusive and equitable vocational education system.

Following this analysis of educational variability, the next phase of our study involves a detailed exploration of the specific factors that influence labor literacy. Employing regression analysis, we aim to unravel the complex interplay of these determinants and gauge their collective impact on students' labor literacy levels. The forthcoming subsection engages in this empirical inquiry,

TABLE 3 Distribution of labor literacy and evaluation scores among higher vocational students.

Evaluation indicators	Minimum	$Q_1(25\%)$	$Q_2(50\%)$	$Q_3(75\%)$	Maximum	Standard deviation
Labor concepts	0.5608	12.6819	14.2853	15.6083	17.2955	2.2798
Labor habits and qualities	7.0627	13.1483	14.1552	14.8299	18.3782	1.3140
Labor knowledge and skills	8.8506	13.5275	14.3308	14.8523	16.2920	1.2426
Labor emotions and attitudes	9.4934	13.5150	14.0717	14.6403	17.1093	1.0204
Labor literacy	5.9250	13.3241	14.2903	15.0044	15.9520	1.2906

Quartiles (Q_1, Q_2, Q_3) represent the 25th, 50th, and 75th percentiles, respectively.

TABLE 4 ANOVA results of labor education implementation in higher educational institutions.

Dimensions	Difference between groups (SSB)	F-value	P-value
Labor education curriculum format and teaching materials	23.7379	4.82	0.0025
Teaching mode of labor education	107.3125	17.53	0.0000
Forms of labor practice	102.5056	22.26	0.0000
Labor education practice bases	103.7012	22.54	0.0000
Practical training sites	109.2982	35.87	0.0000
Full-time or part-time teachers of labor education	72.1218	11.43	0.0000

offering valuable perspectives for enhancing labor literacy through informed educational strategies.

4.2 Exploring determinants of labor literacy in vocational students

This subsection delves into the empirical examination of factors influencing labor literacy, utilizing a robust assessment model previously established. The overall labor literacy score, denoted as S and derived from Equation 2, is scrutinized as a continuous variable using the Ordinary Least Squares (OLS) regression method. In this model, S is posited as the dependent variable and is articulated as $S = \beta_0 + \sum_i \beta_i X_i + \varepsilon$, where X_i denotes a set of independent variables, and ε represents the error term. This methodical approach aims to provide a nuanced understanding of the various factors impacting students' labor literacy levels.

The regression model was calibrated, controlling for 12 demographic and academic variables such as grade, major, household type, and hometown location. It also includes six principal independent variables encompassing gender, political profile, academic performance, and labor education evaluation mechanisms. The analysis was conducted using Stata/MP 17.0 software. The resulting model demonstrates an R^2 value of 0.3241, an F-value of 23.43, and a highly significant P-value of 0.000. These statistics indicate that the regression coefficients are substantially different from zero, suggesting that the included variables have a meaningful and statistically significant impact on labor literacy, as elaborated in Table 5.

Table 5 elucidates that all primary independent and control variables within the model exhibit Variance Inflation Factor (VIF) values under 8, suggesting negligible multicollinearity concerns (Huan and Qingsong, 2023). This finding substantiates the reliability and unbiased nature of the estimated regression coefficients, β_i, affirming them as trustworthy estimators of the true coefficients. Consequently, this reinforces the credibility of the regression analysis and the integrity of its conclusions (Wooldridge, 2010).

Further, the regression analysis underscores the significant influence of gender on comprehensive labor literacy, a distinction observed at the 10% significance level. For the purposes of this study, male students are coded as "0" and female students as "1." The results indicate that female students, on average, score approximately 0.150 points higher in labor literacy compared to their male counterparts. This difference manifests in the average labor literacy scores, with male students at 13.939 and female students at 14.188. Thus, it is approximated that female students exhibit labor literacy that is about 1.1% superior to that of male students (Yongjun et al., 2020).

The study's regression analysis reveals a significant impact of political profile on students' labor literacy, evident at the 5% significance level. Political profiles were classified into "CPC member (including preparatory)," "CPC activist," "Youth League member," "mass," and "others." The results demonstrate a tiered effect: as students transition from one political category to the next (e.g., from "CPC member" to "CPC activist" or from "CPC activist"

TABLE 5 OLS regression results on labor literacy in higher vocational students.

Variable name	Regression coefficient	Standard error	T-value	Significance	VIF	1/VIF
β_0	16.6665***	0.4395	37.93	0.000	2.23	0.4489
Gender	0.1496*	0.0834	1.79	0.073	2.23	0.4489
Political profile	−0.1150**	0.0534	−2.15	0.032	1.47	0.6798
Academic performance	−0.1340**	0.0546	−2.46	0.014	1.31	0.7643
Utilization of the school's internship and practical training sites	−0.1942***	0.0516	−3.77	0.000	1.12	0.8912
Implementation of labor education in the school	−0.4209	0.2785	−1.51	0.131	1.13	0.8850
Evaluation and supervision mechanism of labor literacy	−0.4565***	0.0706	−6.47	0.000	1.07	0.9356
Willingness to participate in innovation and entrepreneurship	−0.4012***	0.0448	−8.96	0.000	1.07	0.9381
Grade level	−0.0248	0.0684	-0.36	0.716	2.03	0.4933
Specialty	−0.0008	0.0301	-0.03	0.978	1.5	0.6649
Hukou type	−0.0047	0.0736	-0.06	0.949	1.42	0.7037
Hometown location	0.0068	0.0393	0.17	0.863	1.33	0.7497
Experience as a leader	−0.1060	0.0862	−1.23	0.219	1.28	0.7814
Father's occupation	0.0049	0.0200	0.25	0.806	1.27	0.7902
Mother's occupation	0.0245	0.0224	1.09	0.276	1.2	0.8338
Father's education	0.0645	0.0431	1.5	0.135	1.15	0.8666
Mother's education	−0.0333	0.0457	−0.73	0.466	1.14	0.8806

*, **, and *** indicate that the regression coefficients passed the test at 10%, 5%, and 1% significance, respectively.

to "Youth League member"), there is an associated decrease of 0.115 in the labor literacy score. This decrement, equivalent to 0.82% of the mean labor literacy score in the sample, indicates a stratification of labor literacy with the highest scores among those most closely affiliated with the CPC, decreasing progressively with each subsequent category. Such findings suggest a nuanced relationship between political affiliation and labor literacy, with more prominent involvement in the CPC correlating with higher literacy levels.

Academic performance, quantified by GPA ranking percentage, significantly influences labor literacy at the 5% level. In this study, academic performance is segmented into quartiles based on GPA: top 25%, 25%–50%, 50%–75%, and bottom 25%. The analysis elucidates that with each successive quartile decrease in GPA ranking—moving down one performance grade—there is a corresponding decrease of 0.134 in the labor literacy score. This decrement equates to roughly 0.95% of the mean labor literacy score within the sample, underscoring the profound effect of academic achievement on fostering labor literacy.

The influence of school labor education on students' literacy is highly significant, as evidenced at the 1% level. This impact is particularly salient in three key areas, emphasizing the critical role of comprehensive and effective labor education programs. The nuanced details of these areas are as follows:

1. The paramount importance of a well-structured evaluation and supervision mechanism within school labor education is evident through its direct correlation with student literacy levels. The research stratifies these mechanisms into four distinct grades: perfect, average, lacking, or non-existent. A descending grade in the system quality correlates with a substantial reduction in labor literacy scores. Specifically, a downgrade results in a significant 0.456-point decrease in scores, equivalent to 3.2% of the overall mean score. This underscores the imperative role of robust evaluation and supervision in elevating the quality and efficacy of labor education. Consequently, the development and enhancement of such mechanisms are vital within educational institutions, serving as a cornerstone in guiding, evaluating, and improving the labor education framework.
2. The propensity of students to participate in innovation and entrepreneurship activities markedly influences their labor literacy. The study delineates this propensity into varying degrees of willingness, ranging from "very willing" to "very unwilling." It is observed that a decrement in this willingness level correlates with a 0.401-point reduction in the comprehensive labor literacy score, representing 2.9% of the aggregate mean. This emphasizes the integral role of innovation and entrepreneurship as foundational components in vocational education, nurturing critical skills such as creativity, collaboration, and resilience. Therefore,

fostering student engagement in such initiatives is not merely advantageous but imperative for developing a well-rounded labor skill set.

3. Engagement with school internship and training sites is shown to significantly bolster students' labor literacy. Active and regular interaction with these practical settings yields a substantial increase in labor literacy–students regularly utilizing these resources demonstrate a 1.5% higher literacy level compared to occasional users, and 1.4% higher than those seldom engaging with them. This illuminates the pivotal role of hands-on, experiential learning within vocational education. It underscores the current educational emphasis on active involvement and real-world application in labor education, advocating for the indispensability of practical, experiential learning in cultivating a skilled and competent workforce.

The detailed regression analysis offers insightful revelations into the specific factors influencing labor literacy in vocational education. For academicians, these findings underscore the complexities inherent in labor literacy development, opening avenues for further exploration into how each determinant, such as gender, political profile, academic performance, and engagement with educational initiatives, contributes to shaping student competencies. This empirical evidence is particularly valuable for vocational education practitioners and policy-makers. For instance, the notable impact of gender on labor literacy suggests a need for gender-sensitive educational approaches. Similarly, the influence of political profile and academic performance on labor literacy underscores the importance of integrating civic engagement and academic excellence into vocational training programs. Furthermore, the significant role of practical training and innovation initiatives in enhancing labor literacy points to the need for educational institutions to prioritize hands-on learning experiences. By incorporating these insights into policy formulation and program design, educators can develop more targeted strategies that not only address the diverse needs of their student population but also contribute effectively to the enhancement of overall labor literacy.

In summary, the comprehensive analysis conducted in this study not only elucidates the current state of labor literacy in higher vocational education but also highlights the multifaceted determinants that influence it. These insights extend beyond the immediate context, offering valuable guidelines for the adaptation and implementation of labor literacy assessment models in diverse educational settings. The findings suggest that such models should account for demographic, academic, and socio-political factors to accurately reflect the labor literacy levels of students. This approach is crucial for developing globally relevant and adaptable labor literacy frameworks that can be effectively utilized in different regions and educational systems. By doing so, these models can contribute significantly to the enhancement of vocational education, aligning it more closely with the labor market's evolving demands and societal expectations. As we transition to the conclusion, we synthesize these insights, drawing broader implications for vocational education and identifying potential avenues for future research in this vital domain.

5 Conclusion

5.1 Main results

This study introduces a labor literacy assessment model for higher vocational education in China, characterized by its multifaceted and data-driven approach. Articulated as $S = 0.5466B_1 + 0.1816B_2 + 0.1623B_3 + 0.1095B_4$, the model uniquely employs Principal Component Analysis (PCA) to objectively determine the number and weights of the indices. This approach marks a significant departure from traditional models, which often rely on subjective human judgment for these determinations. The data-driven method enhances the model's accuracy and reliability in assessing labor literacy across four dimensions: concepts, habits and qualities, knowledge and skills, and emotions and attitudes.

The application of this model has unveiled key insights into labor literacy among vocational students. It has identified notable variances across different dimensions of labor literacy, with particular disparities in labor concepts compared to more consistent development in areas like emotions and attitudes. This underscores the complex nature of labor literacy and the need for diverse educational strategies to address these variances.

Moreover, the study has highlighted the significance of both institutional educational practices and individual student attributes in influencing labor literacy. Factors such as political engagement, academic performance, and active participation in innovation and entrepreneurship have emerged as key contributors to higher labor literacy levels. This finding enriches the understanding of labor literacy determinants, offering a more comprehensive view of the factors that impact vocational education outcomes.

The model presented in this study marks a significant stride in the assessment of labor literacy within vocational education. It adeptly incorporates a range of dimensions, extending beyond cognitive skills to include emotional and attitudinal aspects, thus fully embracing the complexity of labor literacy. Merging quantitative analysis with qualitative insights, this model offers a holistic view of labor competencies in vocational students. It brings to light the variations in labor literacy across different dimensions and underlines the pivotal influence of individual and institutional factors. These detailed insights not only enrich academic understanding of labor literacy but also provide a robust foundation for continued exploration in this critical area.

5.2 Implications and suggestions for future research

This study underscores the need for a multifaceted approach in vocational education, highlighting the necessity to address a broad spectrum of labor literacy aspects, including conceptual understanding, skill acquisition, and attitudinal development. The significant influence of diverse teaching methodologies and practical experiences on enhancing labor literacy suggests the imperative of integrating hands-on, experiential learning within vocational curricula. Additionally, the role of individual attributes like political engagement and academic achievement in influencing labor literacy underscores the importance of holistic

student development. These findings offer actionable insights for educators and policymakers, providing directives to refine vocational education strategies in alignment with the evolving labor market demands and students' diverse goals.

The study's outcomes also suggest specific policy measures to enhance vocational education's effectiveness. Firstly, it's vital to establish dynamic educational partnerships between vocational institutions and industry players. These partnerships can facilitate regular updates to the curriculum, ensuring it stays relevant to the ever-evolving labor market demands. Secondly, policies should encourage the establishment of diverse and inclusive learning environments. This involves creating opportunities for students with varying political affiliations and academic backgrounds to engage in meaningful vocational training, thus promoting a culture of inclusivity and respect for diversity in educational settings.

Furthermore, the study advocates for the implementation of robust evaluation and feedback systems within vocational institutions. These systems can provide continuous monitoring and adjustment of teaching methodologies, guaranteeing that they cater effectively to the varied learning styles and developmental needs of students. Lastly, considering the impact of extra-curricular activities on labor literacy, policies should support the integration of entrepreneurship and innovation programs within vocational education. Such initiatives can not only enhance students' practical skills but also inspire creativity and leadership qualities, preparing them for diverse career paths in the modern workforce.

However, the study is not without limitations. The primary constraint lies in its sample size and demographic scope, which may affect the generalizability of the findings. Future research should aim to expand the data pool, including inputs from a broader spectrum of higher vocational students across various regions and cultural contexts. Such expansion would not only enhance the model's robustness and cross-validation but also augment its overall reliability and applicability.

Further research should also explore the dynamic nature of labor literacy in the context of global educational frameworks. Comparative studies examining different vocational education systems and their impact on labor market readiness could provide invaluable insights, especially in terms of policy formation and international educational standards.

The incorporation of advanced technologies, such as machine learning, in future models presents another exciting direction. These technologies could be leveraged to develop models that are both dynamically adaptable and reflective of the changing profiles of student populations and educational paradigms, thereby offering a more personalized and effective approach to vocational education.

In conclusion, this study contributes new knowledge by providing a robust, adaptable framework for assessing labor literacy in vocational education. It bridges theoretical research and practical applications, offering valuable insights for educators and policymakers in developing effective vocational education strategies. The study underscores the importance of experiential learning and the development of individual competencies in vocational training, promoting a more inclusive and impactful educational approach. By laying the groundwork for future research and inviting the academic community to engage in practical, actionable scholarship, this study not only advances the theoretical discourse in vocational education but also serves as a catalyst for meaningful educational reform. Its implications extend beyond vocational education, influencing policy-making and curriculum design to better align vocational training with contemporary labor market demands and societal expectations.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SW: Data curation, Formal analysis, Investigation, Resources, Software, Validation, Writing – review & editing. JD: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. ML: Data curation, Formal analysis, Methodology, Project administration, Validation, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1361224/full#supplementary-material

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