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Research Article

School-Enterprise Cooperation and Vocational Safety Literacy Formation: A Structural Equation Modeling Approach in Chinese Higher Vocational Colleges

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Abstract

School-enterprise cooperation (SEC) is a central pillar of Chinese vocational education policy, yet how its specific dimensions affect students' safety literacy remains empirically underexamined. This study disaggregates SEC into three dimensions: co-developed curriculum, enterprise practicum participation, and enterprise mentor guidance. Based on Theory of Planned Behavior, the mediation chain path of safety cognition → safety attitude → safety behavioral intention is examined to investigate the effect of three dimensions of SEC on vocational safety literacy. A total of 327 higher vocational students are surveyed in a district in Guangdong Province. Bootstrap mediation tests and structural equation modeling are used for statistical analysis. Results Enterprise practicum ($\beta=0.31$, $p<0.001$), guidance model ($\beta=0.19$, $p<0.01$) and co-developed curriculum ($\beta=0.11$, $p<0.05$), have the biggest direct effect (β) in chain mediation, with the first half "attitude to intention" ($\beta=0.29$) reaching significance. As the "last link of the chain", practicum based experiential engagement may be need more to be emphasized rather than the curriculum reform alone, so does formalize safety mentorship.

Keywords

school-enterprise cooperation, vocational safety literacy, structural equation modeling, Theory of Planned Behavior, higher vocational education, China

1. Introduction

1.1. Problem Statement

China operates the world's largest vocational education system, with more than 1,600 higher vocational colleges enrolling nearly 18 million students, but the safety competence of these future workers has not matched the needs of enterprises. According to data from the Ministry of Emergency Management, there were 21,800 workplace accidents in 2024 that resulted in 19,626 deaths, and investigations revealed that the primary factors leading to accidents were a lack of safety training and a high turnover rate of workers. In a cross-sectional survey of 101,577 students in junior colleges across Jiangsu Province, it was found that the average score of students on the occupational safety and health knowledge was only 44.99 ± 12.53, and about a quarter of the students had scores below the passing threshold (Xu et al., 2020). This is by no means a solitary occurrence in China. An international literature review of young worker safety found that limited occupational experience, developmental risk tolerance and pre - employment preparation make nonfatal workplace injury rates among workers aged 15 - 24 nearly double (Turner et al., 2022). Collectively, these findings point in the same direction; the problem lies not in the design of the policies but in the pathways for the acquisition and internalization of safety knowledge.

1.2. Conceptual Definitions

School-enterprise cooperation (SEC) is the primary policy connecting vocational education and workplace practice in China since the late 1970s. After four decades of reform, more than 1,500 vocational education groups and various forms of cooperation emerged, and it was also found that enterprises still had weak participation motivation and unclear organizational carriers(Zhou & Xu, 2023). Most of the studies, however, regarded SEC as an additive influence, without clearly differentiating the impact of specific elements. This study divides SEC into three dimensions: co-developed curriculum (safety courses, professional courses), enterprise practicum experience (on-site time, safety course frequency, post distribution) and guidance frequency (leading frequency and proportion of safety courses). Vocational safety literacy can be divided into three dimensions: safety knowledge, safety awareness, safety behavior capability, rather than being measured as a whole. Previous SEM-based empirical studies on Chinese TVET colleges found that university–industry cooperation partially mediated the relationship between quality culture and perceived employability among 341 vocational students (Li, Khattak, & Shamim, 2024).

1.3. Theoretical Framework and Hypotheses

The TPB is the theoretical cornerstone of this research. It proposes that the variable closest to behavior is behavioral intention, which is determined by attitude, subjective norms and perceived behavioral control. This study proposes a sequential mediating path: SEC

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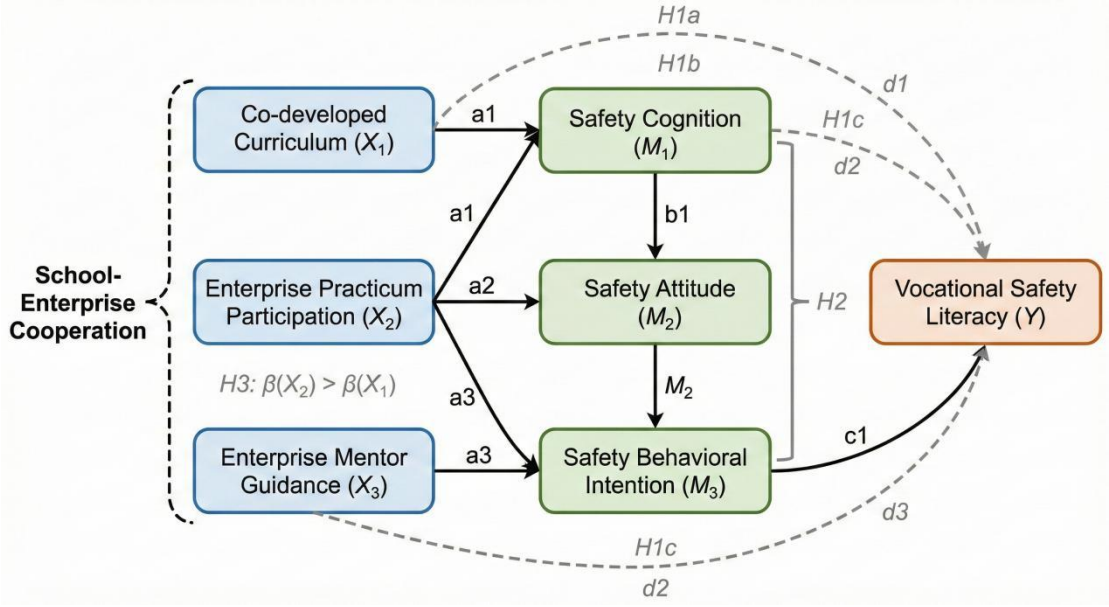
involvement → safety cognition → safety attitude → safety behavioral intention, which collectively constitute vocational safety literacy. A previous study of 1,748 adolescents demonstrated that safety knowledge significantly influenced behavioral intention both via attitude and self-efficacy, supporting the applicability of a TPB-based path model in the educational safety context (Guerin & Toland, 2020). In occupational safety, SEM mediation tests have proven that leader-member exchange influences safety compliance both via safety climate and psychological capital, and that external organizational characteristics can influence the safety behavior of individuals through identifiable mediating cognitive factors (He, McCabe, & Jia, 2021). In a meta-analysis of tests of the TPB with 87 longitudinal studies, it was shown that attitudes predicted intentions, subjective norms predicted intentions, and that even controlling for stability of the temporal construct, intentions predicted behavior (Hagger & Hamilton, 2024).

On this basis, three sets of hypotheses were generated. H1a, H1b, and H1c hypothesized that co-developed curriculum, enterprise practicum participation, and enterprise mentor guidance all positively predicted vocational safety literacy. H2 hypothesized that safety cognition, safety attitude, and safety behavioral intention all play a chain mediating role in the pathway from the three dimensions of SEC to vocational safety literacy. H3 hypothesized that the standardized path coefficient from enterprise practicum participation to vocational safety literacy would be larger than from co-developed curriculum, because workplace experience combined with professional learning has greater potential to shape attitudes compared to classroom knowledge alone. The hypothesized structural model is presented in **Figure 1**.

Figure 1

Hypothesized Structural Model of School-Enterprise Cooperation and Vocational Safety Literacy



2. Research Design

2.1. Sample and Data Collection

This study selected sophomores and juniors of higher vocational colleges in Guangdong Province who had completed at least one school - enterprise cooperative course as the survey objects. First-year students were excluded due to their limited exposure to SEC programs. The method of stratified cluster sampling was adopted. Some intact classes were randomly selected from cooperative programs across three major categories: manufacturing, construction and chemical engineering, which account for the majority of workplace injuries reported by the Ministry of Emergency Management. Paper - based questionnaire were administered in class. Participation was voluntary and anonymous. A 350 target was considered, which was expected to yield 300 (10 observations per estimated parameter, an SEM convention, for a model with 24 observed variables in 7 latent constructs) valid questionnaires after accounting for an estimated 15% invalid rate.

2.2. Instruments

All items were rated (5-point Likert scales, 1 = strongly disagree, 5 = strongly agree). A pilot study with 45 (non-sampled) university students tested items for clarity and estimated completion time, before distribution in the full sample. A few items were reworded following cognitive interview feedback. A total of three SEC dimensions, three TPB mediators, and three safety literacy sub-dimensions yielded 36 items in the instrument (**Table 1**). Most questions were used in the normal rather than the reverse-coded form (15). Controls were gender, major category, year of study, and whether they had interned before.

Table 1

Measurement Instruments and Sources

Variable	Dimension	Items	Source Type	Sample Item
SEC Participation	Co-developed curriculum	4	Vocational cooperation scales	“Safety content in my courses was jointly designed by the college and enterprise.”
	Enterprise practicum	5	Training experience scales	“The enterprise arranged safety training before assigning tasks.”
	Mentor guidance	4	Mentoring instruments	“My enterprise mentor corrected unsafe habits during on-site work.”
TPB Mediators	Safety cognition	4	Safety knowledge scales	“I can identify the main hazard sources in my specialization.”
	Safety attitude	4	Safety attitude instruments	“Following safety procedures is worthwhile even when it slows production.”

	Behavioral intention	4	Intention instruments	"I intend to check safety protocols before starting at a new workstation."
Safety Literacy	Safety knowledge	4	OHS assessments	"I understand workers' legal rights regarding occupational injury."
	Safety awareness	3	Risk perception scales	"I pay attention to potential hazards in my working environment."
	Behavioral capability	4	Self-efficacy instruments	"I am confident in using personal protective equipment correctly."

Note. All items rated 1–5 Likert. Reliability indices (Cronbach's α, AVE, CR) reported in Results.

2.3. Analytical Strategy

Data analysis was done in four steps. Descriptive analysis and Pearson correlations were calculated in SPSS 26.0. Common method bias was investigated using Harman's single-factor test, with a single factor explaining less than 40% of the total variance indicating acceptable results. Confirmatory factor analysis was performed in AMOS 24.0, where factor loadings greater than 0.60, AVE greater than 0.50, and composite reliability greater than 0.70 were desirable for convergent validity, and where square root of each construct's AVE was compared with inter-construct correlations as an indicator of discriminant validity. H1a-H1c, H2, and H3 were all tested by fit for the structural model, whereby fit was recommended where $\chi^2/df < 3.0$, RMSEA < 0.08, CFI > 0.90, TLI > 0.90, and SRMR < 0.08. Indirect mediation effects were tested using bias-corrected bootstrap (5,000 resamples, 95% CI). Multi-group SEM examined whether path coefficients were different across major categories, and configural and metric invariance were tested using the chi-square difference tests before multi-group comparison.

3. Results

3.1. Common Method Bias and Measurement Model

From a total of 350 distributed questionnaires, 327 valid questionnaires were obtained, yielding a valid response rate of 93.4%. Of the respondents, 58.7% were male and 53.2% were sophomores. Harman's single-factor test result was not ideal, with 27.6% variance on the first factor, less than 40%. CFA resulted in an acceptable fit, with $\chi^2/df=1.83$, RMSEA=0.050, CFI=0.932, TLI=0.921, SRMR=0.044 for the nine-factor model, and data in **Table 2** show that loadings all exceed 0.63, AVE=0.51 to 0.62, CR=0.76 to 0.86, and the square root of AVE for each construct exceeded the inter-construct correlations.

Table 2

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CFA Results

Construct	Loading Range	AVE	CR	α
Co-developed curriculum	0.65–0.79	0.52	0.81	0.80
Enterprise practicum	0.67–0.83	0.56	0.86	0.85
Mentor guidance	0.63–0.78	0.51	0.76	0.76
Safety cognition	0.71–0.82	0.58	0.85	0.84
Safety attitude	0.68–0.80	0.55	0.83	0.82
Behavioral intention	0.66–0.81	0.54	0.82	0.81
Safety knowledge	0.69–0.85	0.62	0.86	0.85
Safety awareness	0.70–0.80	0.57	0.80	0.79
Behavioral capability	0.64–0.78	0.52	0.81	0.80

3.2. Structural Model and Hypothesis Testing

The structural model demonstrated acceptable fit: $\chi^2/df=2.04$, RMSEA=0.056, CFI=0.921, TLI=0.910, SRMR=0.058. In **Table 3**, the direct effect of enterprise practicum on safety literacy yielded the largest direct effect ($\beta=0.31$, $p<0.001$), followed by mentor guidance ($\beta=0.19$, $p<0.01$) and co-developed curriculum ($\beta=0.11$, $p<0.05$). H1a-H1c were supported. The coefficient of practicum is significantly greater than that of curriculum, $\Delta\beta=0.20$, Wald test $p<0.01$. H3 was supported.

Table 3

Path Coefficients and Hypothesis Testing

Path	β	S.E.	p	Result
Curriculum → Safety literacy	0.11	0.05	0.032	H1a supported
Practicum → Safety literacy	0.31	0.06	<0.001	H1b supported
Mentor → Safety literacy	0.19	0.06	0.002	H1c supported
Cognition → Attitude	0.47	0.05	<0.001	—
Attitude → Intention	0.29	0.06	<0.001	—
Intention → Safety literacy	0.35	0.05	<0.001	—

3.3. Mediation Analysis

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The serial cognition → attitude → intention chain was significant (**Table 4**, H2) for all three SEC dimensions, with an indirect effect that was largest for practicum (β = 0.09, 95% CI [0.04, 0.16]). The attitude → intention chain (β = 0.29) represented the weakest link in the chain, constituting the primary buffering point. The final model with standardized coefficients is summarized in **Figure 2**.

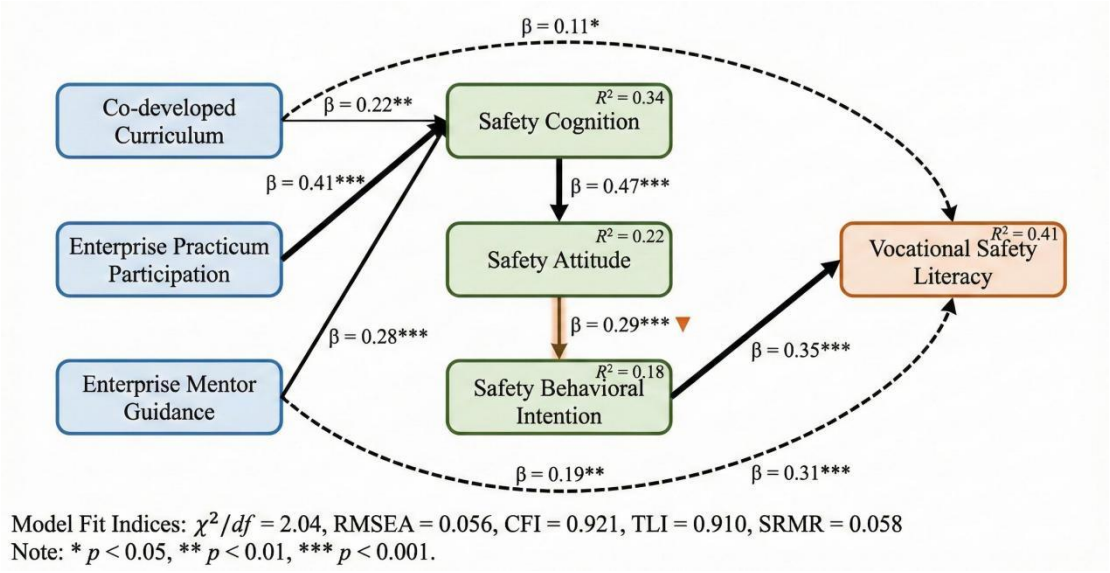
Table 4

Bootstrap Mediation Effects (5,000 Resamples)

SEC Dimension	Direct	Indirect	95% CI	Total
Curriculum	0.11	0.05	[0.01, 0.11]	0.16
Practicum	0.31	0.09	[0.04, 0.16]	0.40
Mentor guidance	0.19	0.07	[0.03, 0.13]	0.26

Figure 2

Final Structural Model with Standardized Path Coefficients



3.4. Supplementary Analysis

The multiple group comparison indicated that the practicum → safety literacy yielded a higher B coefficient, as the practicum → safety literacy paths of the construction (β = 0.39), with higher path coefficients for construction (β = 0.39) and chemical engineering (β = 0.36) than for manufacturing (β = 0.24), suggesting that students in higher-risk disciplines exhibited stronger workplace exposure effects (Δχ2 = 14.7, Δdf = 8, p = 0.065 for metric invariance).

4. Discussion

Instead of a point-by-point discussion of path coefficients, the results of the structural models should be interpreted around the following three focal findings. Each finding is contextualized within the existing literature, and relevant boundary conditions are also discussed.

First, the effect of enterprise practicum participation on safety literacy within a vocational field was the largest (β = 0.31), nearly three times that of co-developed curriculum (β =0.11). This gap widened further in high risk majors like construction (β = 0.39) and chemical engineering (β = 0.36). The general trend is consistent with other evidence that experiential training outperforms classroom lessons: a systematic review and meta-analysis of VR-based construction safety training found an overall standardized mean difference of 0.52 (95% CI [0.32, 0.71]) favoring VR over traditional methods, with the largest effect observed for behavioral outcomes (SMD = 0.74) (Man, Wen, & So, 2024). Witnessing actual hazards and immediate corrective feedback during practicum triggers an attitude change that is difficult to replicate through textbook modules. That said, curriculum-based instruction was not irrelevant — its significant, albeit modest, coefficient (β = 0.11) suggests that declarative safety knowledge provides a necessary foundation, but one that remains insufficient without the experiential reinforcement that practicum and mentoring supply.

The second conclusion concerns the bottleneck in the mediation process. Within the cognition → attitude → intention chain, the attitude-to-intention segment emerged as the weakest link (β = 0.29). Students who recognized hazards and endorsed safe practices did not consistently convert these dispositions into behavioral intention.One plausible explanation involves competing production demands: implicit pressure to meet output targets during practicum may override safety-oriented attitudes, attenuating the translation of positive attitudes into concrete behavioral commitments. This interpretation is consistent with Hiep and Hien's (2023) finding that work pressure significantly moderated the safety motivation–compliance pathway among 967 Vietnamese production workers (Hiep, Hien, & Engineering, 2023).

Third, enterprise mentor guidance partially mediated the relationship between the two factors (β = 0.19), and positively mediated the path of the cognition - attitude - intention chain (β = 0.07), indicating that mentors are responsible for enhancing safety literacy, not only for transmitting knowledge but also for building students' safety self-efficacy, such as setting an example for their safe behavior, correcting mistakes in real time, and fostering their confidence to perform safety behaviors independently. This finding aligns with evidence from the construction industry indicating that supportive leadership enhances safety compliance

and participation, partially mediated by safety self-efficacy (Cui & Mo, 2025). The role of the mentor-student relationship in the internship is also likely to be through this pathway, but the magnitude of this effect is modest, possibly reflecting variation in the quality and formalization of mentoring arrangements across partner enterprises. Not all mentors will spend ample time guiding the students on safety, and the formalization of safety operating procedures is scarce in vocational partner schools in China.

5. Conclusion and Implications

A total of 327 higher vocational students in Guangdong Province are investigated in this study, and the mechanism of the influence of three dimensions of school - enterprise cooperation on vocational safety literacy is examined using structural equation modeling based on the Theory of Planned Behavior. The main conclusion is that enterprise practice (β = 0.31) is the largest contributor to safety literacy, with mentor guidance (β = 0.19) and co - built curriculum (β = 0.11) being significant in the mediating chain, while the intention to action link (β = 0.29) is the most critical bottleneck in the chain.

Based on the above findings, at least three suggestions can be made targeting the educational actors. First, vocational colleges and cooperation enterprises should extend the proportion of structured safety feedback in the practicum rotation, which is the lowest in manufacturing majors (β = 0.24), rather than limiting safety training to an initial induction session. Second, enterprise mentoring activities should set a minimum proportion of safety topics in the content of the mentor-student dialogue, because the guiding effect of mentors is partly mediated through the self-efficacy pathway. Third, co-developed courses could integrate scenario-based safety exercises tailored to the specific occupational hazards of students' respective majors, compensating for the limited capacity of lecture-based instruction to effect attitude change.

Several factors need to be considered in the interpretation. The sample is representative of one province, and it fails to generalize to other provinces, where the proportion of people in different industries could be different. The cross-sectional design precludes causal inference. A follow-up study of the same participants from enrollment to early years after employment could help clarify this. The questionnaires are subject to social desirability bias, and future research could supplement self-report data with objective indicators such as workplace incident records or labor inspection data from graduates' early career years. Finally, the findings reflect students' self-reported perceptions during training and may not fully capture actual workplace safety behaviors post-graduation.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Conflict of interest

The authors declare that there is no Conflict of interest.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

All authors have given their consent.

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