Macrothink Institute™
International Journal of Social Science Research
ISSN 2327-5510
2025, Vol. 13, No. 3

Instructional Framework for the Integration of Peeragogy and Higher-Order Thinking Skills (HOTS) in Chinese Higher Vocational Data Analysis Courses

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Received: Sep. 30, 2025 Accepted: Jan. 30, 2026 Published: Feb. 12, 2026

doi:10.5296/ijssr.v13i3.23570 URL: https://doi.org/10.5296/ijssr.v13i3.23570

Abstract

This paper proposes an instructional framework that integrates Peeragogy and Higher-Order Thinking Skills (HOTS) in the design of data analysis courses in Chinese higher vocational education. Grounded in social constructivist theory and Marzano's higher-order thinking theory, the framework emphasises collaborative learning and authentic data analysis tasks as key mechanisms for fostering advanced cognitive processes. The framework development is guided by three research questions: (1) What peer learning tendency patterns exist among students in Chinese higher vocational data analysis courses? (2) What is the level of students' HOTS in these courses? and (3) Does the integration of Peeragogy and HOTS significantly improve students' post-test HOTS performance? The framework contributes theoretically by showing how social and cognitive dimensions of learning integrate to enhance vocational pedagogy. Practically, it provides a model that aligns vocational education with the analytical and collaborative demands of data-driven workplaces. By embedding peer-supported learning and higher-order reasoning into curricula, it transforms teacher-centred practices into learner-centred approaches that develop analytical reasoning, collaborative problem-solving and transferable cognitive skills. For further application, the framework can adopt a mixed-methods research design. This design observes peer learning behaviours, evaluates HOTS through pre- and post-tests, and applies an experimental approach to measure instructional impact.

Keywords: Peeragogy, Higher-Order Thinking Skills (HOTS), Vocational Education, Instructional Design

1. Introduction

This study is situated within the context of data analysis courses offered in Chinese higher vocational colleges, particularly those focused on business data analysis. Such courses require students to engage in a continuous cognitive progression that extends from data processing and interpretation to evaluation and decision-making, making them highly relevant contexts for examining the cultivation of Higher-Order Thinking Skills (HOTS) (Provost & Fawcett, 2013; Anderson & Krathwohl, 2001). Yet, despite this potential, prevailing vocational teaching practices often remain anchored in teacher-centered approaches and emphasize lower-order skills such as memorization and procedural routines (Biggs & Tang, 2011; Trigwell et al., 1999). This imbalance constrains students' opportunities to develop analytical reasoning, critical reflection, and data-driven problem-solving abilities, thereby limiting their preparedness for the demands of modern workplaces (Wheelahan, 2015).

Several challenges within vocational education further spark the need for a reoriented instructional framework. Course curricula frequently emphasize technical routines such as data entry, cleaning, and visualization while neglecting higher-order cognitive processes, resulting in students mastering mechanical skills but lacking analytical depth (Young, 2006; Guo & Lamb, 2010). Pedagogical practices remain dominated by lecture-based instruction, restricting opportunities for active engagement, collaboration, and critical reflection, and positioning students as passive recipients rather than active problem-solvers (Prince, 2004; Jonassen, 1999). At the same time, employers increasingly expect graduates to demonstrate competencies in teamwork, adaptive problem-solving, and data-driven decision-making, yet vocational courses often fail to simulate authentic business contexts that mirror these workplace realities (OECD, 2019; Billett, 2011). Peer learning structures are weak or absent, reducing opportunities for students to engage in peer feedback, co-analysis, and shared inquiry (Topping, 2005; Boud et al., 2014), while assessment practices continue to prioritize lower-order outcomes such as recall and procedural accuracy, leaving students' ability to demonstrate analysis, evaluation, and synthesis underdeveloped (Brookhart, 2010; Anderson & Krathwohl, 2001).

These issues highlight the need for an instructional design that integrates both the social and cognitive dimensions of learning. The present study addresses this need by proposing a framework that combines Peeragogy and HOTS within higher vocational data analysis courses. Grounded in social constructivist theory and Marzano's higher-order thinking theory (Vygotsky, 1978; Anderson & Krathwohl, 2001; Marzano, 1984), the framework emphasizes collaborative learning tasks and authentic data analysis activities as vehicles for fostering advanced cognitive processes (Herrington et al., 2010; Johnson et al., 2007). By embedding peer-supported learning and higher-order reasoning into instructional design, the study aims to enhance students' analytical capacity and improve their ability to make informed decisions. Ultimately, it prepares students to meet the challenges of contemporary business practice (Facione, 2011; OECD, 2019).

2. Higher Vocational Data Analysis Courses

Vocational education has become a strategic pillar of China's education and workforce development system in response to economic restructuring, digital transformation, and the pursuit of high-quality growth. Following a period of marginalisation during market-oriented reforms, vocational education has been repositioned as a key mechanism for skills formation, employment stability, and social inclusion (Hao et al., 2025; Tianzuo et al., 2025; Pan et al., 2025). Contemporary policy reforms increasingly emphasise closer integration between vocational education and industry, highlighting the role of higher vocational education (HVE) in cultivating applied, technically proficient talent capable of supporting industrial upgrading and enterprise innovation (Jin et al., 2025).

Within this policy and economic context, higher vocational data analysis courses have emerged as a strategic response to the growing demand for applied digital competencies across manufacturing, service, and public sectors. As data-driven decision-making becomes integral to organisational performance, these courses aim to equip students with practical analytical skills that align with workplace requirements. Unlike traditional academic programmes that prioritise theoretical modelling, higher vocational data analysis courses emphasise applied analytics, tool-based proficiency, and contextual problem-solving, thereby enhancing graduate employability and enterprise relevance (Pan et al., 2025; Jin et al., 2025). By embedding advanced digital skills within vocational curricula, higher vocational institutions also contribute to reshaping social perceptions of vocational education and strengthening its legitimacy as a future-oriented educational pathway (Yan & Liu, 2025; Yu, 2025).

In practice, business data analysis courses in Chinese higher vocational colleges are designed to develop students' ability to process, interpret, and apply data in authentic business contexts. Typical curricula include foundational competencies such as data collection, data cleaning, and visualisation, alongside more advanced topics such as statistical analysis, predictive modelling, and data-supported decision-making (Provost & Fawcett, 2013; Han et al., 2022). These curricular components reflect the applied orientation of vocational education and its alignment with industry expectations.

However, existing literature indicates that vocational data analysis curricula often place disproportionate emphasis on procedural knowledge and technical routines, while giving insufficient attention to critical reasoning, analytical judgment, and problem-solving skills (Guo & Lamb, 2010; Young, 2006). As a result, students may acquire mechanical proficiency without developing the analytical depth required to address complex and uncertain business problems (Wheelahan, 2015). Scholars therefore argue for a reorientation of course design toward authentic, workplace-simulated tasks that require evaluation, interpretation, and decision-making, enabling students to apply data analysis skills in realistic professional contexts (Herrington et al., 2010).

2.1 Instructional Design

Instructional design in vocational education has traditionally been teacher-centered, focusing on direct instruction and rote learning (Biggs & Tang, 2011). Research indicates that such approaches limit opportunities for students to engage in higher-order cognitive processes (Trigwell, Prosser, & Waterhouse, 1999). Contemporary instructional design theories emphasize learner-centered strategies, particularly collaborative learning, problem-based tasks, and authentic assessments (Jonassen, 1999; Merrill, 2012). In the context of data analysis courses, instructional design must integrate tasks that require students to work with real datasets, interpret findings, and justify decisions (Prince & Felder, 2006). This shift aligns with constructivist principles, where knowledge is actively constructed through experience and interaction (Vygotsky, 1978). Effective instructional design thus serves as the bridge between course content and the cultivation of higher-order thinking skills (Anderson & Krathwohl, 2001).

2.2 Peeragogy

Peeragogy, derived from social constructivist learning theory, emphasizes the role of collaboration, peer feedback, and shared responsibility in the learning process (Boud, Cohen, & Sampson, 2014). Literature on peer learning demonstrates that students benefit from engaging in dialogue, critiquing each other's work, and co-constructing knowledge (Topping, 2005). In vocational education, peeragogy is particularly valuable because it mirrors workplace collaboration, where problem-solving often occurs in teams (Lave & Wenger, 1991). Studies show that peer-driven learning environments enhance motivation, deepen understanding, and foster critical reflection (Johnson, Johnson, & Smith, 2007). Within data analysis courses, peeragogy provides a mechanism for students to collectively interpret data, challenge assumptions, and refine analytical approaches, thereby supporting the development of higher-order cognitive skills (Hmelo-Silver, 2004).

2.3 Higher-Order Thinking Skills (HOTS)

Higher-order thinking skills (HOTS) are grounded in Marzano's higher-order thinking theory (Marzano, 1984) and focus on analysis, evaluation, and synthesis (Anderson & Krathwohl, 2001). Literature consistently emphasizes that these skills are essential for preparing students to navigate complex, data-rich environments (Facione, 2011). HOTS enable learners to move beyond memorization and procedural tasks toward critical reasoning, judgment, and innovation (Brookhart, 2010). In vocational education, research highlights a persistent gap: instructional practices often fail to cultivate HOTS, leaving students underprepared for professional demands (Wheelahan, 2015). Integrating HOTS into data analysis courses requires deliberate instructional strategies such as case-based learning, problem-solving projects, and reflective assessments (Hmelo-Silver, 2004; Savery, 2015). These approaches encourage students to interrogate data critically, evaluate alternative solutions, and synthesize insights into actionable decisions (Facione, 2011).

2.4 Learning Outcomes

The integration of peeragogy and HOTS within instructional design is expected to yield significant improvements in student learning outcomes. Literature on vocational pedagogy suggests that when students engage in collaborative, cognitively demanding tasks, they develop enhanced problem-solving abilities, stronger analytical reasoning, and greater confidence in data-driven decision-making (Prince, 2004; Johnson et al., 2007). Moreover, such integration fosters transferable cognitive skills that extend beyond the classroom, preparing students for diverse workplace challenges (OECD, 2019). Learning outcomes therefore encompass not only improved academic performance but also the cultivation of professional competencies, including teamwork, critical reflection, and adaptive problem-solving (Billett, 2011). These outcomes align with the broader mission of vocational education: to produce graduates who are capable of contributing effectively to dynamic, data-driven industries (Wheelahan, 2015).

3. Framework of the Study

This study proposes a framework that integrates social constructivist theory and Marzano's higher-order thinking theory (Marzano, 1984) as its theoretical foundations. Social constructivism emphasizes that knowledge is actively constructed through collaboration, interaction, and peer feedback (Vygotsky, 1978), while Marzano's higher-order thinking theory highlights the importance of cultivating advanced cognitive processes such as analysis, evaluation, and synthesis (Anderson & Krathwohl, 2001). Together, these perspectives provide a dual lens for designing instructional strategies that foster both social and cognitive growth.

Within this framework, instructional design serves as the central mechanism for translating theory into practice. Collaborative learning tasks and authentic data analysis activities are embedded into the curriculum to stimulate higher-order cognitive engagement (Herrington et al., 2010). These tasks require students not only to process and interpret data but also to evaluate alternative solutions and synthesize insights into actionable decisions (Jonassen, 1999). By situating learning in authentic business contexts, the framework ensures that students' cognitive development aligns with the demands of real-world vocational practice, as illustrated in Figure 1.

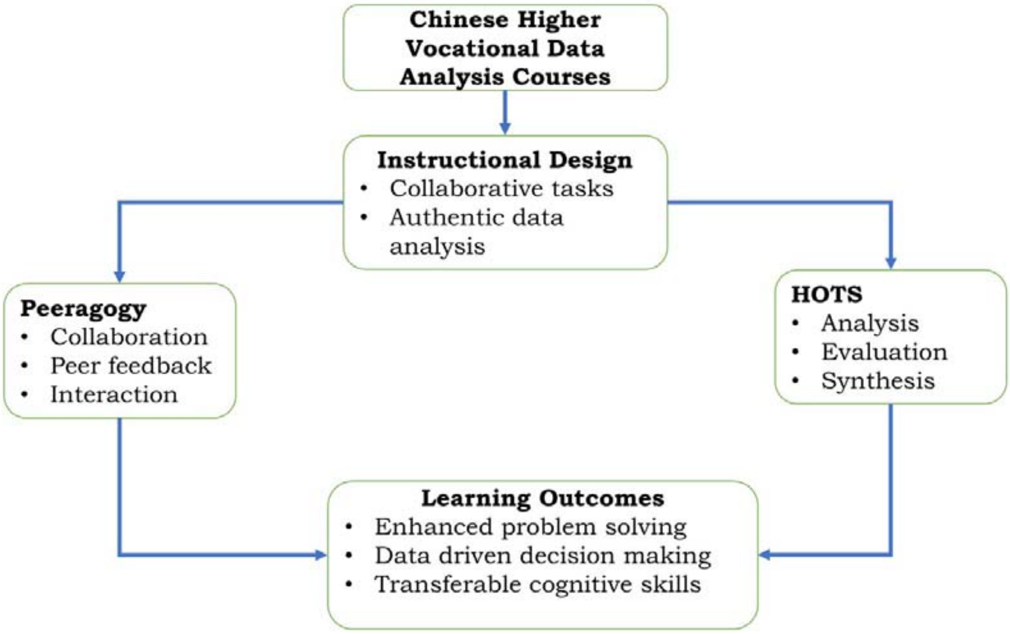

Figure 1. The proposed framework

The framework positions Peeragogy as the social dimension of learning, enabling students to co-construct knowledge through dialogue, critique, and shared inquiry (Vygotsky, 1978; Boud et al., 2014; Topping, 2005). Simultaneously, Higher-Order Thinking Skills (HOTS) represent the cognitive dimension, guiding students toward deeper levels of reasoning and problem-solving (Anderson & Krathwohl, 2001; Brookhart, 2010; Facione, 2011). Instructional design acts as the bridge between these dimensions, ensuring that collaborative tasks are deliberately structured to activate HOTS while reinforcing peer-supported learning (Jonassen, 1999; Merrill, 2012; Herrington et al., 2010).

Thus, the framework converges on a set of learning outcomes that include enhanced problem-solving abilities, improved data-driven decision-making, and the cultivation of transferable cognitive skills (Prince, 2004; OECD, 2019; Billett, 2011). These outcomes align with the broader mission of vocational education: to prepare students not only for academic success but also for effective participation in dynamic, data-driven workplaces (Wheelahan, 2015; OECD, 2019).

3.1 Potential Application of the Framework

In data analysis courses offered in Chinese higher vocational colleges, it can be applied as an operational instructional framework to guide teaching practice that aligns vocational learning with analytical and collaborative demands of contemporary workplaces (Billett, 2011; Guo & Lamb, 2010; OECD, 2019). Specifically, it can be applied to support instructors in translating course objectives into learning activities that emphasize collaborative problem-solving and higher-order analytical reasoning, which are essential for effective data analysis and data-driven decision making (Han et al., 2022; Provost & Fawcett, 2013).

Instruction can begin with the design of authentic data analysis tasks situated in vocational and industry-related contexts. These tasks function as problem-based activities that require students to interpret datasets, evaluate analytical methods, and generate evidence-based solutions, reflecting the nature of real-world data analysis work (Herrington et al., 2010; Savery, 2015; Hmelo-Silver, 2004). Task complexity can be intentionally aligned with higher-order cognitive processes such as analysis, evaluation, and creation, as articulated in Marzano's higher-order thinking theory (Marzano, 1984), ensuring constructive alignment between learning outcomes, activities, and assessment (Biggs & Tang, 2011).

During classroom implementation in data analysis courses, it can be applied to structure the learning process through small peer groups with shared responsibility. Students can be organized into collaborative groups to explore datasets, discuss analytical approaches, and collectively interpret results. This application positions peer interaction as the primary learning mechanism, consistent with research demonstrating the effectiveness of peer learning and cooperative learning in higher and vocational education contexts (Boud et al., 2014; Johnson et al., 2007; Topping, 2005). Learning activities can be sequenced progressively from initial data familiarization to deeper analysis and solution formulation, supporting situated and socially mediated learning (Lave & Wenger, 1991).

In instructional facilitation within data analysis courses, it can be applied to shift the teacher's role from direct instruction to guided facilitation. Instructors can monitor peer group interactions and intervene selectively through questioning, clarification, and the provision of analytical tools or templates when needed. Such scaffolding practices support learners' development of higher-order thinking and critical reasoning, and can be gradually withdrawn as students demonstrate increasing independence in data interpretation and collaborative problem-solving (Vygotsky, 1978; Merrill, 2012; Facione, 2011). This facilitative approach aligns with constructivist instructional design principles that emphasize learner engagement and cognitive responsibility (Jonassen, 1999; Prince, 2004).

Throughout the learning process, it can be applied to systematically integrate peer interaction as a learning resource. Students can be encouraged to articulate their analytical reasoning, challenge peers' interpretations, and justify conclusions using empirical evidence from datasets. Periodic inter-group exchanges can be applied to expose learners to diverse analytical perspectives and to support formative assessment, enabling instructors to identify misconceptions and reasoning gaps common in data analysis learning (Brookhart, 2010; Prince & Felder, 2006).

Finally, in reflection and assessment in data analysis courses, it can be applied to combine evaluation of analytical outcomes with examination of collaborative learning processes. Students can engage in guided reflection activities focusing on their analytical strategies and peer contributions, while instructors assess group outputs, peer feedback, and observed interactions. Evidence generated from these assessments can be applied to refine subsequent instructional cycles by adjusting task complexity, group composition, and facilitation strategies. Through this iterative application, the framework can be applied to support the development of higher-order data analysis skills and collaborative competencies that are central to vocational knowledge formation and workplace readiness (Wheelahan, 2015; Young, 2006).

4. Contextual of Framework with Research Questions

The conceptual framework of this study is deliberately constructed to provide a systematic response to the three research questions. By integrating Peeragogy and Higher-Order Thinking Skills (HOTS) within instructional design, the framework establishes both the social and cognitive dimensions necessary for analyzing peer learning tendencies, assessing levels of HOTS, and evaluating the effectiveness of their integration (Vygotsky, 1978; Anderson & Krathwohl, 2001; Boud et al., 2014).

For RQ1, What are the peer learning tendency patterns among students in Chinese higher vocational data analysis courses?, the framework positions Peeragogy as the primary lens. Through collaborative tasks, peer feedback, and interaction, the framework enables the observation and analysis of how students engage with one another in authentic data analysis contexts (Topping, 2005; Johnson et al., 2007). This alignment allows the study to capture peer learning tendencies and examine their role in shaping cognitive engagement (Lave & Wenger, 1991; Boud et al., 2014).

For RQ2, what is the level of HOTS among students in Chinese higher vocational data analysis courses? The framework anchors HOTS in Marzano's higher-order thinking theory (Marzano, 1984), emphasizing analysis, evaluation, and synthesis (Anderson & Krathwohl, 2001). Instructional design elements, such as authentic data tasks and problem-based learning activities, are structured to elicit these higher-order processes. This design provides a basis for measuring students' existing HOTS levels and tracking their progression throughout the course (Brookhart, 2010; Hmelo-Silver, 2004).).

For RQ3, Does the integration of HOTS and Peeragogy significantly improve students' post-test HOTS performance?, the framework demonstrates its integrative function. By embedding collaborative learning tasks that require advanced cognitive processing, the framework creates conditions for testing whether the combined application of Peeragogy and HOTS leads to measurable improvements in students' post-test performance (Prince, 2004; Johnson et al., 2007). The convergence of these pathways toward enhanced learning outcomes such as problem-solving, data-driven decision-making, and transferable cognitive skills that provides the evaluative structure for determining the effectiveness of the intervention (Facione, 2011; OECD, 2019).

Hence, the framework aligns with the research questions by mapping Peeragogy to the analysis of peer learning patterns (RQ1), HOTS to the assessment of cognitive levels (RQ2), and their integration to the evaluation of instructional impact (RQ3), consistent with established models of constructivist and outcomes-oriented instructional design (Jonassen, 1999; Herrington et al., 2010). The summary is as presented in Table 1.

Table 1. Alignment of research questions with the framework

Research Question#	**Framework Component#**	**Methodology#**	**Expected Contribution#**
RQ1: Peer learning tendency patterns#	Peeragogy (collaboration, peer feedback, interaction)#	Observation of peer interactions, analysis of collaborative tasks#	Identification of peer learning behaviors and their influence on cognitive engagement#
RQ2: Level of HOTS among students#	HOTS (analysis, evaluation, synthesis)#	Pre-test/post-test assessments, task-based evaluation#	Assessment of students' existing HOTS and progression during instruction#
RQ3: Effect of integration on post-test HOTS#	Integration of Peeragogy and HOTS via instructional design#	Experimental design, comparison of pre- and post-test HOTS scores#	Measurement of improvement in HOTS performance and validation of instructional effectiveness#

5. Conclusion

This study develops an instructional framework that integrates Peeragogy and Higher-Order Thinking Skills (HOTS) within Chinese higher vocational data analysis courses. Grounded in social constructivist theory and Marzano's higher-order thinking theory (Marzano, 1984), the framework emphasizes collaborative learning tasks and authentic data analysis activities as vehicles for fostering advanced cognitive processes. By situating learning in authentic business contexts, the framework ensures that students progress cognitively from data processing to analysis, evaluation, and decision-making.

The framework directly addresses the study's research questions. Peeragogy provides the foundation for examining peer learning tendency patterns (RQ1), HOTS offer the lens for assessing students' cognitive levels (RQ2), and their integration establishes the conditions for evaluating improvements in post-test HOTS performance (RQ3). This alignment demonstrates the framework's methodological coherence and its capacity to generate meaningful insights into the role of collaborative and higher-order learning in vocational education.

The findings are expected to contribute both theoretically and practically. Theoretically, the framework advances understanding of how social and cognitive dimensions of learning can be integrated to enhance vocational pedagogy. Practically, it provides a model for instructional design that prepares students for the demands of data-driven workplaces by cultivating analytical reasoning, collaborative problem-solving, and transferable cognitive skills.

The integration of Peeragogy and HOTS within instructional design offers a pathway for transforming vocational education from teacher-centred, lower-order practices toward learner-centred approaches that emphasize critical reasoning and authentic application. This study thus contributes to the broader mission of vocational education: equipping students with the competencies necessary to thrive in complex, data-rich professional environments.

6. Limitations and Future Research

While this study has developed an instructional framework that integrates Peeragogy and Higher-Order Thinking Skills (HOTS) within Chinese higher vocational data analysis courses, certain limitations must be acknowledged. The framework is primarily conceptual and has not yet been empirically tested. Although it provides valuable theoretical insights into how social and cognitive dimensions of learning can be combined to enhance vocational pedagogy, its practical effectiveness remains provisional until validated through systematic research.

Future research should therefore focus on empirical validation of the proposed framework. Quantitative studies could employ pre- and post-test designs to measure changes in students' HOTS performance, complemented by experimental or quasi-experimental approaches to assess the instructional impact of integrating Peeragogy with HOTS. Qualitative investigations, such as classroom observations and interviews, would provide deeper insights into peer learning behaviours, collaborative dynamics, and students' perceptions of higher-order cognitive tasks. Mixed-method designs are particularly recommended, as they would allow for triangulation of findings and strengthen the robustness of the framework.

In addition, longitudinal studies could examine how sustained exposure to peer-supported, higher-order learning environments influences students' motivation, engagement, and professional readiness over time. Comparative studies across different vocational institutions or regions would also be valuable, as they could highlight contextual variations in the effectiveness of the framework and inform its adaptation to diverse educational settings.

By pursuing these empirical directions, future research can validate, refine, and extend the proposed instructional framework, ensuring that it not only advances theoretical understanding but also provides actionable guidance for educators, curriculum designers, and policymakers seeking to transform vocational education into a more collaborative, learner-centred, and cognitively demanding practice.

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