Collaborative Problem-Solving Competence of University Students: Conceptual Framework, Structural Components, and Influencing Factors

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Abstract

Collaborative problem-solving (CPS) has become a critical competency in competency-based higher education. This study aims to systematize the theoretical foundations of CPS among university students through a comprehensive review of domestic and international literature. Integrating major theoretical perspectives on competence, problem solving, and collaboration, CPS is conceptualized as a socio-cognitive competence situated in higher education learning contexts. The study synthesizes existing research to clarify the conceptual structure and key behavioral indicators of CPS, as well as major factors influencing its development, including individual characteristics, instructional and learning environments, and socio-professional contexts. In addition, the paper examines competency-based approaches to CPS assessment, highlighting the integration of process-oriented and outcome-oriented measures in collaborative learning activities. Based on this synthesis, a comprehensive theoretical framework for university students' collaborative problem-solving competence is proposed, offering theoretical and practical implications for instructional design and the development of assessment instruments in higher education.

Keywords (for an international academic paper): Collaborative Problem-Solving Competency; University Students; 21st-Century Competencies; Collaborative Learning; Competency-Based Assessment.

1. Introduction

In contemporary higher education, the development of students' core competencies has become a central objective of educational reform worldwide. Competency-based education emphasizes learners' ability to mobilize knowledge, skills, and attitudes to address complex problems in professional and social contexts. This orientation is reflected in national qualification frameworks, including the Vietnam National Qualifications Framework, which underscores the importance of transferable and integrative competencies for university graduates. Within this paradigm, students are expected not only to acquire disciplinary knowledge but also to develop the capacity to collaborate effectively and engage in meaningful interaction with others when addressing real-world problems.

Within this broader trend, collaborative problem-solving (CPS) has been increasingly recognized as a key competence for university students. Recent studies in the Vietnamese context conceptualize CPS as an integrated construct that combines problem-solving and collaborative dimensions, manifested in learners' capacities to analyze problem situations, generate and evaluate solutions, and implement actions through social interaction (Le Thai Hung, Le Thi Hoang Ha, & Duong Thi Anh, 2016; Tran Thi Quynh Trang, 2023).

An expanding body of research has highlighted the important role of instructional approaches that emphasize experiential learning, project-based learning, and collaborative group activities in fostering students' collaborative problem-solving (CPS) competence (Dang Thi Dieu

Hien, 2021; Nguyen Van Cuong & Meier, 2011; Phan Thi Thanh Hoi & Pham Huyen Phuong, 2015). At the same time, higher education has increasingly shifted from a knowledge-transmission paradigm toward a competency-oriented approach, in which competency-based assessment plays a central role in supporting learning and evaluating outcomes. In the Vietnamese context, the development of learning outcomes, assessment criteria, and measurement instruments for problem-solving competence has been addressed in several national studies and policy-oriented guidelines (Nguyen Loc & Nguyen Thi Lan Phuong, 2016; Lam Quang Thiep, 2011; Sai Cong Hong & Le Duc Ngoc, 2017). However, despite these advances, collaborative problem-solving competence among university students remains insufficiently examined in a systematic manner, particularly with respect to its theoretical underpinnings, conceptual structure, and key influencing factors.

Current teaching practices in higher education increasingly engage students in group-based learning activities, including discussions, project-based learning, and collaborative tasks. Nevertheless, the quality of collaboration in such settings is often uneven. In many cases, collaborative activities are reduced to a superficial or mechanical division of tasks, with limited opportunities for meaningful academic interaction and shared problem-solving among students. This gap between pedagogical intentions and actual learning practices highlights the need for a deeper examination of the nature of collaborative problem-solving (CPS) competence, as well as the pedagogical conditions required to foster its effective development among university students.

Previous studies in the Vietnamese context have predominantly focused on secondary school students, with many adopting subject-specific approaches in disciplines such as Physics, Chemistry, and Biology (Nguyen Hoang Bao Thanh & Tran Quynh, 2020; Tran Trung Ninh & Nguyen Thi Thu Thuy, 2018; Tran Trung Ninh & Vu Phuong Lien, 2018). In contrast, research on collaborative problem-solving (CPS) competence in higher education—where learning is characterized by greater academic autonomy, increasing professional demands, and diverse instructional contexts—remains relatively limited. This imbalance points to a clear research gap, underscoring the need for more systematic theoretical and empirical investigations of CPS competence among university students.

Building on the above rationale, this paper aims to elucidate the theoretical foundations of collaborative problem-solving (CPS) competence among university students. Specifically, it addresses: (i) major theoretical frameworks for conceptualizing CPS competence; (ii) its conceptual structure and core manifestations; (iii) key factors influencing the development of CPS competence in higher education; and (iv) approaches to assessing CPS competence from an educational measurement perspective. Drawing on a synthesis of both domestic and international studies, the paper proposes an integrative theoretical framework that provides a scientific foundation for the design of instructional activities and the development of assessment instruments for collaborative problem-solving competence among university students in the context of contemporary higher education reform.

2. Theoretical Framework and Conceptualization of Collaborative Problem-Solving Competence

Within a competency-based education framework, competence is commonly understood as an integrated construct in which knowledge, skills, attitudes, and personal values are consciously and responsibly mobilized to address complex tasks in specific contexts. Weinert (2001) emphasizes that competence is not a mechanical aggregation of discrete skills, but rather the capacity to coordinate internal resources with external contextual conditions in order to achieve desired outcomes. This conceptualization is consistent with contemporary qualifications frameworks, including the Vietnam National Qualifications Framework, which articulate learning

outcomes in terms of integrated competencies encompassing both cognitive and non-cognitive components.

Problem solving is widely recognized as a foundational competence for individuals in contemporary society. Polya (1973) conceptualized problem solving as a sequence of interrelated stages, including understanding the problem, devising a plan, implementing the plan, and reviewing the solution. Subsequent research has extended this classical framework by emphasizing complex and ill-structured problems that permit multiple plausible solutions and are closely embedded in real-world contexts (Jonassen, 2011; National Research Council, 2012). From this perspective, problem solving transcends the mere application of logical reasoning skills and encompasses the capacity to analyze contextual conditions, manage incomplete or uncertain information, make decisions under uncertainty, and flexibly adapt strategies in response to feedback and changing circumstances.

Collaboration, by contrast, is commonly understood as a process in which individuals work jointly toward a shared goal, with each member assuming responsibility not only for their assigned tasks but also for the collective outcomes of the group. Research on cooperative learning by Johnson and Johnson (1994, 2007) identifies several core conditions for effective collaboration, including positive interdependence among group members, individual accountability, promotive interaction, interpersonal and teamwork skills, and group processing. From a social psychological perspective, collaboration is closely linked to the development of shared mental models, defined as a common understanding of goals, tasks, roles, and strategies among group members (Klimoski & Mohammed, 1994; Mathieu et al., 2000). This perspective underscores that collaboration extends beyond merely "working together" to encompass the co-construction of knowledge and the coordination of actions within specific social and task contexts.

From these two theoretical perspectives, collaborative problem solving (CPS) can be understood as an integrated socio-cognitive competence that emerges when problem-solving activities are situated in group contexts and mediated through social interaction. The CPS assessment framework developed by the OECD (2015) conceptualizes CPS as an organic integration of problem-solving and collaborative processes, highlighting key features such as establishing and maintaining shared understanding, coordinating actions to accomplish tasks, and effectively organizing group activities. Further studies by Greiff et al. and Sun et al. elaborate on the socio-cognitive nature of CPS, arguing that individuals' cognitive processes are inseparable from meaning negotiation, role coordination, and the mutual regulation of actions among group members.

In the Vietnamese research context, several studies conceptualize collaborative problem-solving (CPS) as an integrated competence that links problem-solving and collaboration dimensions (e.g., Le Thai Hung et al.; Tran Trung Ninh et al.; Dang Thi Dieu Hien; Tran Thu Quynh Trang). These studies consistently indicate that CPS is most effectively formed and developed in learning environments that engage students in complex tasks requiring authentic teamwork, such as project-based learning, WebQuest activities, and experiential learning. Within such environments, learners are expected not only to activate higher-order cognitive processes but also to engage in sustained interaction, coordination, and mutual support to achieve shared goals.

Within the context of higher education, students' collaborative problem-solving (CPS) competence can be broadly conceptualized as the ability to mobilize and coordinate cognitive, motivational–emotional, and social resources to jointly identify, analyze, and address complex tasks in group-based learning contexts. This competence is inherently integrative, encompassing not only disciplinary knowledge and higher-order thinking skills but also communication, coordination, and behavioral regulation skills within collective academic activities. The conceptual structure and behavioral manifestations of CPS are elaborated in the following section.

3. Structure and Manifestations of Collaborative Problem-Solving Competence

Collaborative problem-solving (CPS) competence has been conceptualized in both international and Vietnamese research as a multi-component construct in which cognitive problem-solving processes are closely intertwined with the social processes of collaboration. Drawing on the OECD CPS assessment framework (2015), theoretical analyses by Greiff et al. and Sun et al., and competence models developed in the Vietnamese context (e.g., Tran Thu Quynh Trang), the internal structure of CPS among university students can be synthesized into four major component groups. These components not only represent core dimensions of CPS competence but also correspond to four fundamental stages of the collaborative problem-solving process.

First, *identifying and analyzing the problem in a collaborative context* constitutes a core component of collaborative problem-solving competence. This component reflects students' ability to work with group members to clarify task requirements, identify the essential elements of the problem situation, and determine relevant constraints and contextual conditions. Unlike individual problem solving, problem understanding in collaborative settings is not solely an individual cognitive activity but emerges from processes of information sharing, joint interpretation, and the comparison of multiple perspectives among group members. When collaborative problem-solving competence is well developed, students do not merely comprehend task instructions; rather, they actively pose clarifying questions, reframe the problem to enhance shared understanding, identify ambiguities in task requirements, and propose strategies to make implicit assumptions explicit for the group.

Second, *establishing shared goals, developing plans, and allocating tasks* represents a central component of collaborative problem-solving competence. Once a shared understanding of the problem has been achieved, group members are required to articulate common goals and success criteria, formulate appropriate problem-solving strategies, and develop an implementation plan. This process also involves the allocation of tasks based on individual members' strengths and limitations. As such, this component reflects the intersection of strategic thinking and organizational coordination within collaborative work. Students with well-developed CPS competence typically demonstrate active engagement in collective decision-making processes, the capacity to negotiate and compromise when necessary, and a strong sense of responsibility for fulfilling their assigned roles within the overall group plan.

Third, *communicating, sharing, and coordinating activities to implement solutions* most explicitly represents the social dimension of collaborative problem-solving competence. During the implementation phase, group members are required to continuously exchange information, share

progress, provide mutual support, and adjust coordination in response to evolving task demands. This component encompasses the ability to articulate ideas clearly, engage in active listening, provide constructive feedback, manage interpersonal conflicts, and sustain a productive collaborative climate. Research on academic interaction (Mercer, 1996; Roschelle & Teasley, 1995; Mercer & Howe, 2012) demonstrates that the quality of dialogue—particularly exchanges involving explanation, reasoning, and critical discussion—is a decisive factor in determining whether groups genuinely co-construct shared knowledge or merely engage in a mechanical division of labor. Among university students, this component is reflected in proactive participation in discussions, the strategic use of open-ended and probing questions, responsiveness to peers' difficulties, and effective coordination to prevent task overlap or omission.

Fourth, *monitoring, evaluating, and adjusting solutions based on feedback* represents the metacognitive and social regulation dimension of collaborative problem-solving competence. Throughout the collaborative problem-solving process, group members are expected to regularly review progress, assess the quality of interim products, evaluate the suitability of selected strategies, and consider the consequences of specific decisions for overall outcomes. This component encompasses behaviors such as comparing interim results with established goals, identifying errors or shortcomings, proposing revisions to plans, reallocating tasks when necessary, and reflecting on collaborative experiences to inform subsequent activities. When collaborative problem-solving competence is well developed, students do not rely solely on instructors' evaluations; instead, they actively engage in self-assessment and peer assessment, drawing on feedback from instructors, peers, and collective work products to enhance both the quality of solutions and the effectiveness of the collaborative processes through which they are produced.

From a behavioral perspective, the four component groups described above are operationalized through observable manifestations in university learning contexts. At the task initiation stage, students with well-developed collaborative problem-solving (CPS) competence typically engage in behaviors such as posing clarifying questions, synthesizing the problem for the group, and proposing feasible approaches. During the planning phase, they contribute ideas, participate actively in discussions to evaluate and select solutions, and assume responsibility for tasks aligned with their capabilities. Throughout the implementation phase, students maintain frequent interaction with group members, share progress updates and resources, provide support when difficulties arise, and adapt their strategies in response to changing task demands. In the final stage, they collaboratively review group outputs, evaluate them against established criteria, engage constructively with critical feedback, reflect on lessons learned, and propose improvements for subsequent collaborative activities.

In summary, the structure of collaborative problem-solving competence among university students comprises both cognitive components related to understanding and addressing problems and social components related to communication, coordination, and regulation within groups. These components function through a sequence of interrelated processes, including collaboratively understanding and analyzing problems, establishing shared goals and plans, coordinating actions to implement solutions, and monitoring and adjusting performance based on feedback.

4. Factors Influencing University Students' Collaborative Problem-Solving Competence

University students' collaborative problem-solving (CPS) competence does not emerge from the mere accumulation of isolated knowledge; rather, it develops through complex interactions among individual learner characteristics, instructional environments, and broader social and technological contexts. A synthesis of international and Vietnamese research indicates that the factors influencing CPS competence can be examined across three interrelated levels: (i) the individual level; (ii) the instructional and learning environment level; and (iii) the social and professional context in the digital era.

At the individual level, students' cognitive and non-cognitive characteristics play a foundational role in the development of collaborative problem-solving (CPS) competence. Foundational knowledge, higher-order thinking skills, emotional self-regulation, and communication abilities substantially influence the quality of students' engagement in collaborative learning activities. Xu et al. (2023) demonstrate that CPS competence is closely associated with critical and creative thinking, with students capable of multidimensional analysis and flexible cognitive strategies tending to exhibit higher levels of collaborative effectiveness. Similarly, Sun et al. (2020) emphasize the psychosocial mechanisms underlying CPS, arguing that capacities such as active listening, respect for diverse perspectives, and willingness to negotiate function as enabling conditions for the co-construction of shared knowledge. Taken together, these findings suggest that individual factors not only serve as prerequisites for CPS development but also act as mediating variables that shape how students respond to the cognitive and social demands of collaborative learning environments.

At the level of the learning environment, research consistently indicates that pedagogical structures and instructional design exert a direct influence on the development of collaborative problem-solving (CPS) competence. Johnson and Johnson (2007) demonstrate that cooperative learning models foster positive interdependence, individual accountability, and promotive interaction—core elements of collaborative problem solving. Complementing these findings, studies conducted in the Vietnamese context (e.g., Dang Thi Dieu Hien, 2021; Tran Thi Quynh Trang, 2023) show that intentionally designed learning environments, such as project-based learning, WebQuest activities, and experiential learning, not only enhance students' ability to coordinate actions but also support the development of group regulation and monitoring skills throughout the problem-solving process. Collectively, these findings suggest that the learning environment does not merely accompany CPS development but operates as a central mechanism shaping the structure and enactment of collaborative problem-solving competence.

At the level of the social and professional context, processes of digitalization and globalization are profoundly reshaping the demands placed on collaborative problem-solving (CPS) competence. The OECD (2018, 2020) emphasizes that the future workforce must be capable of collaborating across cultures, through digital platforms, and within geographically dispersed teams. Research on digital skills by van Laar et al. (2017) further indicates that CPS in contemporary contexts is inherently intertwined with digital competence, multimodal communication abilities, and the capacity to work effectively in online environments. Accordingly, the social and professional

context does not merely impose new demands on CPS but also creates novel spaces of practice in which collaborative problem-solving is enacted, refined, and further developed.

Synthesizing these three levels of influence highlights that collaborative problem-solving (CPS) competence emerges from dynamic and non-linear interactions among individual learners, instructional environments, and broader social and professional contexts. From this perspective, strategies for fostering CPS competence should adopt a systemic approach that integrates the intentional design of collaborative learning environments, the alignment of assessment practices, and the concurrent development of students' foundational individual competencies.

5. Assessing University Students' Collaborative Problem-Solving Competence

Assessing university students' collaborative problem-solving (CPS) competence constitutes a significant challenge in educational measurement, given the integrative nature of this competence, which encompasses both cognitive problem-solving processes and socially situated collaborative behaviors. Unlike assessments that focus primarily on declarative or procedural knowledge, CPS assessment requires systematic observation and analysis of learners' interaction processes, including communication, negotiation, co-construction of shared understanding, and coordinated action as students respond to complex and ill-structured problem situations within group settings.

From a measurement-theoretical perspective, Nunnally (1978) and Nunnally and Bernstein (1994) argue that competence assessment instruments must simultaneously ensure reliability and validity. This requirement is particularly demanding in the assessment of collaborative problem-solving, as CPS is inherently multi-dimensional and process-oriented, encompassing both individual cognitive operations and socially mediated interactions that unfold over time. As a result, CPS cannot be adequately captured through traditional paper-and-pencil tests that focus solely on isolated outcomes. In response to these challenges, contemporary measurement approaches grounded in item response theory (IRT) (Wilson, 2005; Wright & Linacre, 1994) allow latent competencies to be modeled based on learners' performances across diverse tasks and indicators, thereby enhancing measurement precision and supporting more robust inferences about students' collaborative problem-solving competence.

In the international context, the OECD (2015) developed a framework for assessing collaborative problem-solving (CPS) within the PISA program, conceptualizing CPS as an integrated competence that combines problem-solving processes with collaborative processes. The framework organizes CPS assessment around three core dimensions: (i) establishing and maintaining shared understanding; (ii) taking actions to solve problems; and (iii) organizing and sustaining group activities. Subsequent empirical studies have examined the psychometric properties and construct validity of CPS tasks in PISA 2015, providing evidence that this multidimensional competence can be reliably assessed through computer-based simulation environments (Stadler et al., 2020). In a related vein, Sun et al. (2020) proposed a generalized CPS competence model that places particular emphasis on observable behavioral indicators emerging throughout the collaborative problem-solving process.

Recent studies have increasingly employed simulated scenarios, online learning environments, and computer-based assessment systems to capture learners' behavioral traces during

collaborative problem-solving activities (Rosen, 2015; O'Neil & Chuang, 2008). Such approaches enable the assessment of not only final task outcomes but also the underlying processes through which learners interact, make decisions, negotiate meaning, and adapt strategies over time. Furthermore, advances in educational technology and learning analytics have made it possible to collect rich, fine-grained interaction data, thereby supporting more sophisticated analyses of the internal structure and developmental dynamics of collaborative problem-solving competence (Rojas et al., 2025).

In Vietnam, research on the assessment of collaborative problem-solving (CPS) competence has predominantly focused on the development of measurement scales and observation criteria targeting students' behaviors in collaborative learning contexts. Tran Thi Quynh Trang (2023) developed and validated an assessment instrument for CPS competence among secondary school students, grounded in a competence framework that includes shared task understanding, communication, group interaction, and coordination in problem-solving activities. In addition, studies by Tran Trung Ninh et al. (2018) suggest that instructional approaches such as WebQuest and project-based learning create conditions in which CPS manifestations become more observable, thereby enabling the assessment of this competence through both students' learning products and their engagement in collaborative processes.

An important issue in the assessment of collaborative problem-solving (CPS) competence concerns the selection of appropriate assessment formats and instruments. Netemeyer, Bearden, and Sharma (2003) recommend combining multiple data sources to enhance the cross-validation and overall validity of measurement instruments. In the context of CPS assessment, this approach can be operationalized through the integration of multiple perspectives, including: (i) students' self-assessment; (ii) peer assessment; (iii) instructor observation; and (iv) the analysis of learning products and group interaction processes. The application of triangulation in educational research (Morse, 1991; Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2009) is particularly valuable for CPS assessment, as this competence is manifested through a combination of cognitive processes, attitudinal dispositions, and observable collaborative behaviors.

However, the assessment of collaborative problem-solving (CPS) competence extends beyond the function of measurement alone; it also plays a formative role in guiding teaching and learning processes. Assessment outcomes enable instructors to identify students' strengths and limitations in both collaboration and problem solving, thereby informing pedagogical decisions such as the adjustment of instructional strategies, the design of open-ended and authentic problem tasks, and the creation of opportunities for deeper academic interaction among learners. Consequently, an assessment approach that emphasizes learners' developmental progress—rather than relying solely on summative grading—is particularly appropriate for complex, multidimensional competences such as CPS.

In summary, the assessment of university students' collaborative problem-solving (CPS) competence should be grounded in a competency-based perspective, combining multiple assessment methods and instruments to ensure reliability and validity, while simultaneously functioning as a pedagogical tool to support and enhance teaching and learning in higher education.

6. Current State of Research on Collaborative Problem-Solving Competence: International and Vietnamese Perspectives

Recent research, both internationally and in the Vietnamese context, has consistently identified collaborative problem-solving (CPS) competence as a core 21st-century skill and a central focus of competency-based educational reforms. However, the depth of theoretical conceptualization, predominant research methodologies, and strategies for pedagogical implementation vary considerably across countries and educational contexts. These differences reflect not only variations in educational systems but also divergent stages of research development and methodological approaches in the study of CPS competence, highlighting the need for a nuanced understanding of international and Vietnamese research trends.

At the international level, research on collaboration and problem solving has developed relatively early and in a systematic manner. Seminal studies by Johnson and Johnson (1989, 1994, 2007) laid the theoretical foundations of cooperative learning, emphasizing key principles such as positive interdependence, individual accountability, and promotive interaction as determinants of effective group learning outcomes. In parallel, research on problem solving progressively focused on complex, ill-structured, and authentic tasks that closely reflect real-world challenges (Polya, 1973; Jonassen, 2011). Over time, the integration of these two research traditions has led scholars to conceptualize collaborative problem-solving (CPS) competence as an integrated socio-cognitive skill, in which cognitive processes are inherently intertwined with social interaction and coordinated group action (OECD, 2015; Sun et al., 2020).

A major milestone in collaborative problem-solving (CPS) research was its inclusion in the OECD's PISA 2015 assessment. The OECD framework (2015, 2017, 2018) not only articulated a comprehensive conceptual structure of CPS competence but also introduced a system of computer-based assessment tasks capable of capturing learners' collaborative behavioral traces throughout the problem-solving process. Subsequent research has focused on evaluating the reliability, construct validity, and measurement properties of these CPS assessment tools (Stadler et al., 2020; von Davier & Halpin, 2013), as well as extending their application across diverse educational contexts, including secondary education, higher education, and vocational training (Rosen, 2015; Ouyang et al., 2021; Rojas et al., 2025). Furthermore, research syntheses and secondary quantitative analyses have provided empirical evidence of the positive effects of CPS on learners' critical thinking and academic achievement (Oliveri et al., 2017; Xu et al., 2023), underscoring the significance of PISA 2015 as a turning point in the international study of collaborative problem-solving competence.

From a pedagogical perspective, a substantial body of international research has demonstrated that cooperative learning, project-based learning, and online simulation models are effective in fostering collaborative problem-solving (CPS) competence. Seminal studies by Mercer (1996) and Roschelle and Teasley (1995) highlight the central role of academic dialogue and the co-construction of knowledge within group-based learning activities. Building on this foundation, more recent research suggests that appropriately designed scaffolding strategies can further enhance CPS processes, particularly in digitally mediated and technology-enhanced learning environments (Lu & Lin, 2017; Ouyang et al., 2021). Beyond academic contexts, emerging evidence indicates that CPS competence is closely linked to learners' future professional capabilities, including adaptability, teamwork, and complex problem-solving skills required in contemporary labor markets (Levy & Murnane, 2004; OECD, 2020).

In Vietnam, research on collaborative problem-solving (CPS) emerged at a later stage but has shown notable progress over the past decade. Early studies by Le Thai Hung et al. (2016) and Tran Trung Ninh et al. (2018) primarily investigated CPS in secondary education contexts, focusing on instructional approaches such as project-based learning, WebQuest activities, and thematic

teaching. These studies provided initial empirical evidence that CPS competence can be effectively cultivated through the implementation of active learning strategies and the structured organization of collaborative learning environments.

At the higher education level, research on collaborative problem-solving (CPS) in Vietnam has addressed both theoretical and empirical dimensions. Dang Thi Dieu Hien (2021) investigated the development of CPS competence among engineering students through experiential learning, demonstrating the beneficial effects of project-based and hands-on activities on CPS formation. Tran Thi Quynh Trang (2019, 2023) advanced the theoretical foundations and assessment methodology of CPS by developing a structural model of the competence and validating corresponding measurement instruments. Additional studies have explored CPS from the perspective of students' social interactions (Tran Thi Thanh Huyen, 2020) or examined its application within specific disciplines, including chemistry and physics (Tran Trung Ninh & Vu Phuong Lien, 2018; Nguyen Bao Hoang Thanh & Tran Quynh, 2020).

However, compared with the international context, several limitations in CPS research in Vietnam are evident. First, most studies have focused on secondary education, whereas CPS at the university level—where interdisciplinary collaboration and complex problem-solving skills are particularly critical—remains relatively underexplored. Second, a substantial proportion of research has been primarily descriptive or centered on the development of assessment instruments, with integrated theoretical models linking competence structures to influencing factors still scarce. Third, the application of digital technologies, computer simulations, and detailed analyses of group interaction data for CPS assessment is limited, with traditional self-report and observational methods continuing to predominate.

Taken together, the overview indicates that CPS research is progressively shifting from the study of isolated skills toward an integrated competence perspective, from an exclusive focus on outcomes to an emphasis on collaborative processes, and from traditional classroom settings to digitally mediated and online learning environments. In the Vietnamese context, there remains a pressing need to refine the theoretical framework of CPS at the university level, clearly delineate its conceptual structure and influencing factors, and develop assessment instruments that are aligned with the current higher education landscape, thereby providing a foundation for evidence-based instructional design and competence development.

7. Proposed Theoretical Framework for University Students' Collaborative Problem-Solving Competence.

Based on a synthesis of theoretical approaches and empirical findings presented in the preceding sections, a comprehensive theoretical framework for university students' collaborative problem-solving (CPS) competence can be proposed. This framework integrates three interrelated components: (i) the conceptual structure and behavioral manifestations of CPS competence; (ii) a multi-level system of influencing factors; and (iii) an assessment framework for evaluating CPS within the context of Vietnamese higher education.

First, with regard to the conceptual structure of CPS competence, this study draws on the OECD CPS assessment framework (2015) and research by Greiff et al. (2014, 2015) and Sun et al. (2020), while also incorporating the CPS structural model developed by Tran Thi Quynh Trang (2019, 2023) in the Vietnamese context. Accordingly, university students' CPS competence is conceptualized as an integrated socio-cognitive construct, comprising four core components:

1. Problem Identification and Analysis in a Collaborative Context: Involves collectively recognizing and analyzing the problem, clarifying task requirements, and identifying key elements and contextual constraints.

2. Establishing Shared Goals, Planning, and Task Allocation: Entails setting common objectives, developing strategic plans, and distributing responsibilities among group members to ensure coordinated action.

3. Communication, Sharing, and Coordination for Solution Implementation: Refers to exchanging ideas, sharing progress, providing mutual support, and coordinating actions to effectively execute the proposed solution.

4. Monitoring, Evaluation, and Adjustment Based on Feedback and Group Outcomes: Involves reviewing progress, evaluating intermediate results, identifying errors, proposing adjustments, and reflecting on lessons learned to improve both the solution and the collaborative process.

These components represent the integration of cognitive processes involved in problem solving with the social interaction processes within the group, constituting the core conceptual structure of CPS competence.

Second, regarding influencing factors, the proposed theoretical framework conceptualizes CPS competence across three contextual levels: individual, learning environment, and socio-digital context.

Individual Level: Foundational knowledge, higher-order thinking skills, learning motivation, communication skills, and students' psychosocial characteristics are considered prerequisites for CPS development and may also act as mediating factors that shape how students engage in collaborative activities (Xu et al., 2023; Sun et al., 2020).

Learning Environment Level: Pedagogical models such as cooperative, project-based, and experiential learning; the organization of problem-based tasks; instructor scaffolding; an academic culture that encourages dialogue and critical feedback; and assessment mechanisms recognizing both individual and group contributions are viewed as direct determinants of the opportunities and quality of CPS practice (Johnson & Johnson, 2007; Dang Thi Dieu Hien, 2021; Tran Thi Quynh Trang, 2023).

Socio-Digital Context Level: Globalization, labor market demands, and the digital transformation of education create new "force fields" for CPS, requiring students to collaborate effectively in multicultural, multimodal, and online environments (OECD, 2018, 2020; van Laar et al., 2017).

These three contextual levels are assumed to interact dynamically, collectively shaping the development and enactment of university students' CPS competence.

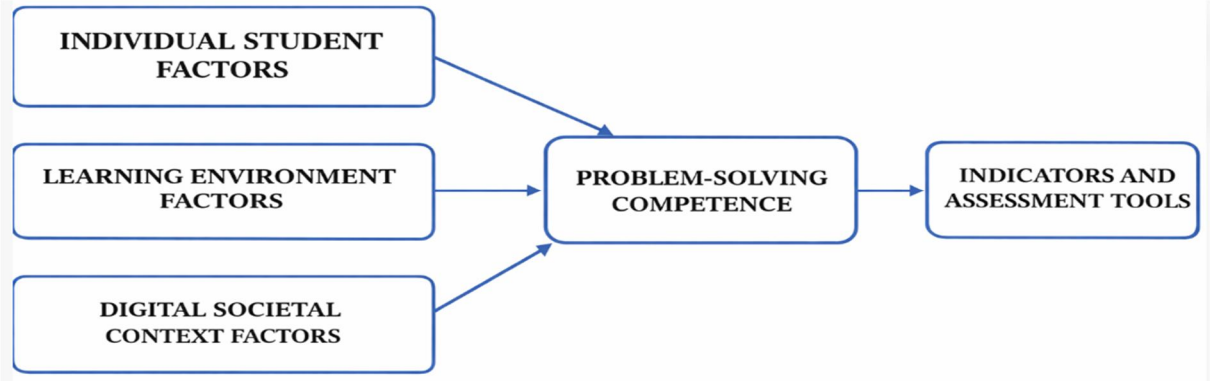
Third, regarding measurement and assessment, this theoretical framework situates CPS within a competency-based assessment paradigm, highlighting the integration of both outcome- and process-oriented evaluation. Conceptually, each component of the CPS structure should be operationalized into specific, observable behavioral indicators within collaborative learning contexts (Wilson, 2005; Netemeyer et al., 2003; Trần Thị Quỳnh Trang, 2023).

Methodologically, the assessment of CPS competence should integrate multiple data sources, including self-assessment, peer assessment, instructor observation, and analysis of group products, in accordance with the principle of triangulation in educational research (Morse, 1991; Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2009). Moreover, digital technologies may be leveraged to capture and analyze interaction traces during collaborative activities, providing richer insights into the structure and developmental level of CPS competence (Rosen, 2015; Stadler et al., 2020).

The proposed theoretical framework can thus be conceptualized as an integrated model in which: (i) university students' CPS competence constitutes the central construct with a multi-component structure; (ii) individual, learning environment, and socio-digital contextual factors

operate as influencing variables across three interrelated levels; and (iii) a system of behavioral indicators and assessment instruments functions as a bridge to translate latent competence structures into observable and measurable behaviors.

This framework not only offers a foundation for the design of instructional activities and the assessment of CPS in higher education, but also provides a roadmap for future empirical research aimed at examining the relationships between contextual influencing factors and the multi-component structure of CPS within specific educational settings.



The author's proposed research model

8. Conclusion and Implications

This study has systematically and comprehensively articulated the theoretical foundations of collaborative problem-solving (CPS) among university students, drawing on both domestic and international research. Based on Weinert's (2001) competency-based approach and the requirements of the Vietnamese National Qualifications Framework (Decision 1982/QĐ-TTg, 2016), CPS is conceptualized as an integrated socio-cognitive competency that closely connects problem-solving and collaboration in the context of increasingly complex learning and professional tasks. Building on the OECD CPS assessment framework (2015; 2017; 2018), international studies (Polya, 1973; Jonassen, 2011; Johnson & Johnson, 1989; 1994; 2007; Sun et al., 2020; Xu et al., 2023), as well as domestic research (Le Thai Hung et al., 2016; Dang Thi Dieu Hien, 2021; Tran Thi Quynh Trang, 2019; 2023; Tran Trung Ninh et al., 2018), this paper proposes a generalized theoretical framework of CPS for university students, including: (i) An internal structure with interwoven cognitive and social components; (ii) A multi-layered system of influencing factors (individual – instructional environment – socio-digital context); and (iii) A measurement and assessment orientation aligned with a competency-based approach.

Based on the above theoretical discussions, several implications can be drawn for improving the quality of higher education. First, from the perspective of curriculum design, collaborative problem-solving (CPS) should be regarded as a core learning outcome, closely aligned with the demands of teamwork, real-world problem solving, and professional adaptability in the digital era. This requires higher education institutions to explicitly operationalize CPS within program- and discipline-level learning outcomes, and to design courses and learning modules that enable students to engage in complex, interdisciplinary, and open-ended tasks that require genuine collaboration rather than superficial task division. The shift from a "knowledge transmission" model to a "competency-based" model can only be meaningful when CPS is systematically integrated throughout the curriculum structure, rather than being treated as a peripheral "soft skill."

From the perspective of instructional organization, synthesized research findings indicate that pedagogical models such as collaborative learning, project-based learning, experiential learning, WebQuest, as well as structured discussion and debate formats, provide favorable

environments for the formation and development of collaborative problem-solving (CPS) competence (Johnson & Johnson, 2007; Mercer, 1996; Roschelle & Teasley, 1995; Dang Thi Dieu Hien, 2021; Tran Trung Ninh et al., 2018). Accordingly, instructors should be conceptualized not only as transmitters of disciplinary knowledge but also as "designers" and "facilitators" of collaborative learning situations. Task design needs to ensure an appropriate level of complexity, create space for diverse perspectives and cognitive conflict, and remain closely connected to issues relevant to students' future professional contexts. At the same time, a classroom culture that encourages dialogue, critical debate, and mutual respect constitutes an indispensable condition for the sustainable development of CPS.

From an assessment perspective, CPS necessitates a shift from approaches that primarily emphasize knowledge-based evaluation to competency-based assessment focused on performance in context. This shift entails the development of behavioral indicators, rating scales, and assessment instruments with appropriate levels of reliability and construct validity (Nunnally, 1978; Nunnally & Bernstein, 1994; Netemeyer et al., 2003; Wilson, 2005). At the higher education level, a feasible approach is to combine multiple assessment methods, including self-assessment, peer assessment, instructor observation, and analysis of group products. Where conditions permit, technology-enhanced tools may also be employed to capture digital traces of interaction during collaborative processes. In this way, CPS assessment serves not only summative classification purposes but also functions as an information-rich feedback mechanism, enabling instructors to refine instructional design and supporting students in identifying their strengths and weaknesses in teamwork and problem-solving.

Finally, from a research perspective, the review indicates that in Viet Nam there remains a substantial gap in systematic investigations of collaborative problem-solving (CPS) at the higher education level, particularly studies that integrate theoretical foundations, competency structure models, influencing factors, and assessment instruments. The theoretical framework proposed in this article may be regarded as a point of departure for subsequent empirical research aimed at: (i) validating the conceptual structure and constituent components of CPS across different student populations and academic disciplines; (ii) examining the relative contributions of individual factors, instructional environments, and socio-digital contexts to the development of CPS; and (iii) developing and standardizing CPS measurement instruments that are appropriate to the Vietnamese higher education context, while accounting for the diversity of educational settings. These research directions not only contribute to strengthening the theoretical and empirical foundations of CPS but also provide a scientific basis for policy formulation, curriculum management, and competency-oriented pedagogical innovation in contemporary higher education.

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