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Cognitive reasoning in student learning: an integrative review in higher education

Sumei Sun, Norzihani Saharuddin, Nor Aniza Ahmad
Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia

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ABSTRACT

Cognitive reasoning is an important goal in higher education. However, research often looks at its parts: critical thinking, problem-solving, and decision making separately, which can make it hard to see how they work together. This review integrates 54 articles published between 2015 and 2025, using studies from Scopus, Web of Science, and ERIC, and applies a thematic synthesis approach. It examines how critical thinking, problem-solving, and decision making are connected as parts of cognitive reasoning. The review identifies six main themes: i) teaching strategies that support critical thinking; ii) how collaborative and inquiry-based learning help develop problem-solving; iii) factors that affect decision making skills in university students; iv) how higher-order thinking skills work together as a system; v) new topics such as differences across cultures and the impact of artificial intelligence on reasoning; and vi) ways to assess higher-order thinking in real-world situations. By looking at these areas together, this review offers a clearer understanding of cognitive reasoning and suggests ways to improve teaching and research in higher education.

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Corresponding Author:

Norzihani Saharuddin
Faculty of Educational Studies, Universiti Putra Malaysia
43400 Seri Kembangan, Selangor, Malaysia
Email: norzihani@upm.edu.my

1. INTRODUCTION

Critical thinking, problem-solving, and decision making are important parts of cognitive reasoning in higher education [1]. In general, these cognitive skills can help students succeed in their studies and further prepare them for complex situations outside the classroom [2], [3]. In addition, as artificial intelligence (AI) and learning environments change, students need these abilities even more to keep up [4]. Before reviewing the research, it helps to define these terms. Critical thinking means analyzing, evaluating, and improving one's own thinking [5]. It supports intellectual growth, creativity, and innovation, and helps make informed choices in both school and daily life. Problem-solving involves identifying an issue, generating solutions, weighing options, and using effective strategies [6], [7]. It is particularly important when the answer is not clear and requires thinking beyond the usual steps. Decision-making involves choosing among options in the face of uncertainty or risk [8]. It is closely linked to critical thinking and problem-solving, focusing on weighing options and making choices that turn analysis into action. Although interest in these skills has grown in recent years, research remains scattered due to differences in how they are defined, measured, and taught [9]. Most reviews have examined these skills separately, often within specific subjects or teaching methods [10]. Few studies have explored how critical thinking, problem-solving, and decision-making work together as part of a larger cognitive reasoning system in higher education [11]. Some research concerns problem-solving in certain fields, while others focus on general critical thinking or decision making.

Few examine how these skills connect and their shared role in cognitive reasoning. Collectively, the evidence suggests that many universities graduates struggle with reasoning, evaluating complex information, and making evidence-based decisions, even when they do well academically. This points to ongoing challenges in higher education, such as weak teaching methods, unclear standards, and limited teacher training, which slow the development of cognitive reasoning [12], [13].

Nowadays, higher education faces two main challenges that make the development of integrated cognitive reasoning more urgent. First, graduates need strong reasoning skills for complex jobs, where critical thinking, problem-solving, and evidence-based decisions are important for work and citizenship. Second, as AI tools become more common in education, students who lack reasoning skills may rely too much on automated answers, which can weaken the independent thinking needed for work and lifelong learning. Building integrated cognitive reasoning is not just an educational goal but a real need in higher education today. This highlights the need for a unified framework that brings these three skills together so that curriculum, teaching, and assessment better match the demands of real-world and professional settings. When these skills are taught separately, students may do well on individual tasks but struggle to use reasoning in real interdisciplinary situations. Thus, this study aims to address that gap.

Cognitive reasoning is regarded as an integrated structure. It can help people draw meaningful conclusions even when the information is incomplete, uncertain, or inconsistent [14]. Besides, it is a core cognitive ability that helps people reason in complex, unclear situations. It guides people in interpreting information and forming judgments [15]. Critical thinking, problem solving, and decision-making are the core components of cognitive reasoning [16], [17]. Specifically, critical thinking involves reasoning and evaluating. It helps people interpret information and evaluate evidence [18]. Problem-solving is the process of generating and improving solutions, which are procedural and practical. Decision-making refers to the selection and justification of actions under conditions of uncertainty [14], focusing on selecting outcomes. Underpinning all three components is self-regulated learning, in which metacognitive awareness enables learners to monitor and adjust their reasoning processes [19]. Figure 1 presents the core conceptual framework of cognitive reasoning, integrating critical thinking, problem-solving, and decision-making in higher education. These three processes are not independent; rather, they cooperate and reinforce one another to form a unified system.

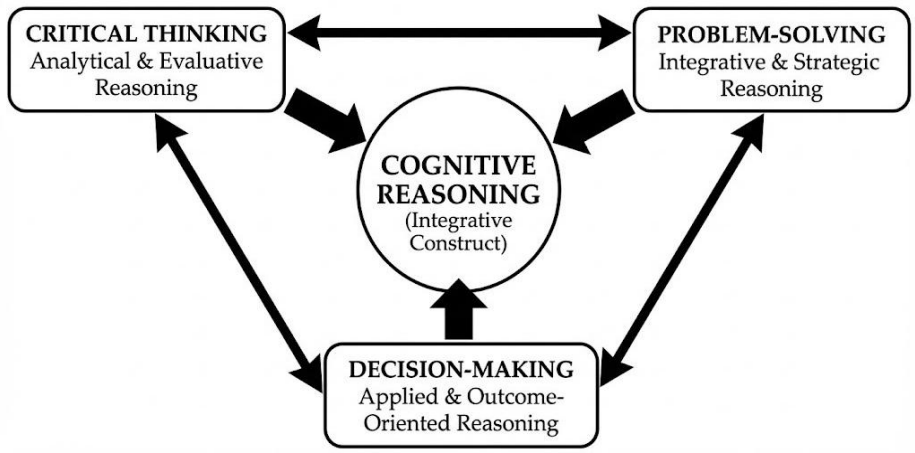


Figure 1. Cognitive reasoning conceptual framework

Cognitive reasoning refers to students' ability to critically analyze information, solve complex problems, and make wise decisions. To understand the development of these skills, Piaget's theory of cognitive development provides a basic perspective [20]. According to Piaget's theory, individuals go through different stages of cognitive development. The formal operational stage is usually reached in adolescence and early adulthood and is characterized by abstract thinking, hypothesis testing, and systematic problem solving. In this review study, although Piaget's theory explains the developmental basis of abstract reasoning, it is not used as a stage model. On the contrary, Piaget's framework is used to explain how college students' cognitive structures are constructed and reorganized when they engage in complex and uncertain academic tasks. Therefore, the concepts of assimilation, accommodation, and equilibrium remain important for understanding the integration of cognitive reasoning in higher education. Bloom's revised cognitive objective classification provides a hierarchical framework for classifying cognitive processes, covering from

low-level skills such as memory and understanding to high-level skills such as analysis, evaluation, and creation [21]. In this review, from an analytical perspective, this classification method is used to identify the positions of critical thinking, problem-solving, and decision-making at the higher cognitive level, thereby clarifying how these concepts are interrelated along the continuum of cognitive complexity.

This review explores how critical thinking, problem-solving, and decision-making affect cognitive reasoning. It has two main goals: i) to provide a clear summary of how critical thinking, problem-solving, and decision making relate to cognitive reasoning in higher education today and ii) to suggest practical ways to use these findings in instructional design and to highlight areas for future research. Furthermore, this study mainly has two contributions. First, it presents a framework that brings together critical thinking, problem-solving, and decision making as connected parts of cognitive reasoning, which previous reviews have not done. Secondly, it combines teaching, assessment, and context to provide a solid foundation for curriculum design and instruction in higher education. This review goes beyond separate views of higher-order thinking by showing how these skills work together in college learning environments. This integrative perspective represents the main novelty of this review. Rather than examining critical thinking, problem-solving, and decision making separately, this review synthesizes evidence across 54 studies to explain how these abilities function together as an integrated cognitive reasoning system in higher education.

2. METHOD

This study employs an integrative review and follows systematic retrieval steps to identify existing research on critical thinking, problem-solving, and decision-making [22], [23]. The integrative review aims to provide a comprehensive overview of these topics under different educational backgrounds and research methods. This method helps this study present a complete picture of these concepts, rather than focusing only on a single intervention or statistical meta-analysis.

2.1. Literature retrieval strategy

We searched three academic databases, including Scopus, Web of Science (WoS), and ERIC. They cover a wide range of social science and educational research. Furthermore, we focused on literature published from 2015 to 2025 to capture recent interest in developing comprehensive reasoning skills in higher education, especially as technology and graduate requirements continue to change. The following search string was applied to the title, abstract, and keyword fields: (Critical Thinking OR Analytical Thinking OR Reflective Thinking) AND (Problem Solving OR Problem Solving) AND (Decision-making OR Decision-making) AND (Higher Education OR Undergraduate OR University OR College). We use Boolean operators to ensure a comprehensive retrieval of research that explores all core conceptual combinations in the context of higher education. Since these criteria were addressed during the subsequent screening process, no additional language or document-type filters were applied.

2.2. Inclusion and exclusion criteria:

The following criteria should be included in the research: i) published in peer-reviewed journals or a collection of papers at peer-reviewed conferences; ii) written in English; iii) the research subjects are undergraduates or higher education groups; iv) involve at least one of three core concepts, including critical thinking, problem solving, or decision-making. Besides, it is related to the development of cognitive reasoning. Exclusion criteria include gray literature, book chapters, editorials, or opinion articles; focusing only on graduate students, professionals, or K-12 groups without mentioning undergraduate groups; or failing to discuss core concepts substantively.

2.3. Screening and selection process

The sequential funnel method is used for screening. A total of 630 records were retrieved in the preliminary database. After removing 58 duplicate records, the remaining 572 records are screened for title and abstract. At this stage, 424 records were excluded because they did not relate to the core concept or higher education background, leaving 148 studies for full review. After evaluating the full texts against the inclusion and exclusion criteria, 94 studies were excluded, and 54 were retained for comprehensive analysis, as shown in Figure 2. Although this study adopted an integrative review approach rather than a systematic review, the literature identification, screening, eligibility assessment, and selection procedures were reported in accordance with the PRISMA 2020 reporting framework to enhance transparency and reproducibility.

It should be noted that the primary screening and selection work are completed by the same reviewer. The main reasons for exclusion at the full-text stage include insufficient attention to the designated core concepts, the research object falling outside the scope of undergraduate or higher education, and a lack of empirical or substantive theoretical contributions related to the objectives of this review. Before screening, clear inclusion criteria and decision-making rules were formulated to ensure consistent inclusion and

exclusion judgments throughout the process. If any ambiguity arose, a conservative inclusion method should be adopted, and the critical record should be retained for full-text review rather than excluded at the title and summary stages. The final review (including the final research screening results) is then reviewed by a tutor and revised according to their feedback. If any ambiguity arises in the inclusion qualification, the inclusion decision is resolved through repeated review of the criteria, and the reasons are recorded to ensure consistency and auditability throughout the screening process.

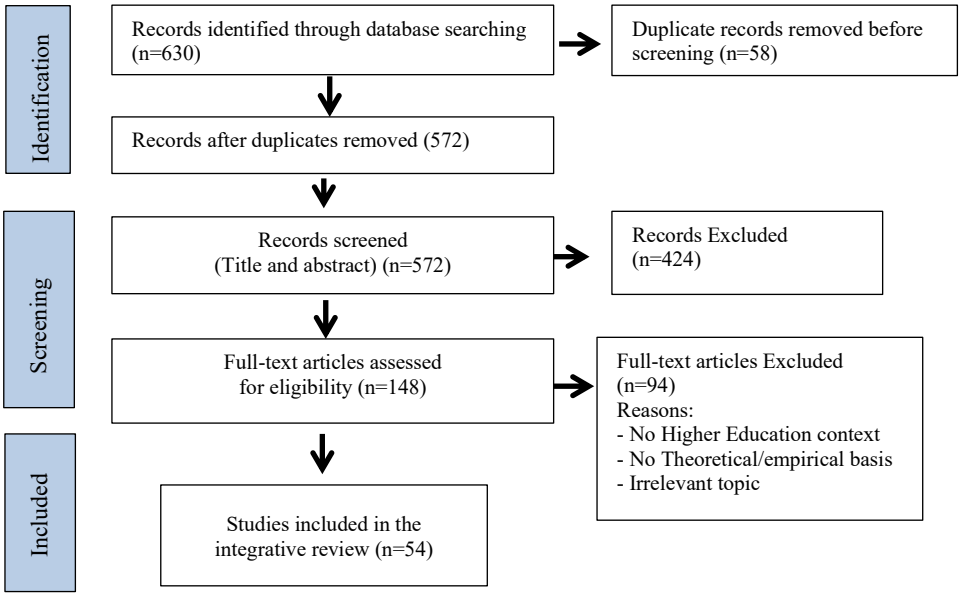


Figure 2. PRISMA 2020 flow diagram of the literature selection process

2.4. Quality appraisal

This study uses an integrative review approach instead of a systematic review or meta-analysis. Methodological considerations were included throughout the process to strengthen the credibility of the findings. The goal was not to estimate effect sizes or prove causal relationships, but to bring together different types of empirical and theoretical evidence about the research topic. A systematic search and screening process was used, following established inclusion and exclusion criteria to ensure transparent and consistent study selection. During screening, studies were assessed for clear methods, relevance to the review goals, and well-described research procedures. Studies lacking sufficient methodological detail or not relevant to the review were excluded.

Formal critical appraisal instruments, such as the Critical Appraisal Skills Programme (CASP), Joanna Briggs Institute (JBI), or mixed methods appraisal tool (MMAT), were not used because the studies included had different research designs. The main goal of this review was to combine theories, not to compare methods or grade quantitative evidence. Still, the review recognizes that differences in methodological quality among the studies could have influenced the results. The section, the coding framework, and the thematic synthesis procedures were reviewed by the supervisory team. However, as the review did not employ a formal quality appraisal framework, the possibility that differences in methodological rigor across included studies may have influenced the synthesis outcomes remains a limitation. This issue is further discussed in the limitations section.

2.5. Data extraction and thematic analysis

A structured data extraction process is used for the 54 included studies. Information is systematically recorded under the following categories: research objectives, research questions, participant groups and educational background, research design and methods, and key findings related to critical thinking, problem-solving, and decision-making. If the study involves multiple core concepts simultaneously, the relationships among them will also be recorded. The data were recorded in a standardized extraction template to facilitate consistent cross-research comparison. Subsequently, a comprehensive thematic analysis was conducted on the included literature to identify patterns, contradictions, and conceptual relationships. The comprehensive analysis follows the three-stage framework proposed [24]. The specific steps are as:

in the first stage, free coding is applied to the findings, discussions, and conclusions of each study to capture key ideas related to critical thinking, problem-solving, and decision-making. In the second stage, through continuous comparison, the relevant codes are iteratively grouped and improved, and finally, a set of descriptive themes is formed, representing the repeated mode of cross-research. In the third stage, descriptive themes are developed into analytical topics that go beyond the findings of a single study and reflect broader conceptual tensions and cross-views in the literature. This coding process is systematically recorded to ensure its auditability and consistency with the theoretical objectives of the review.

3. RESULTS AND DISCUSSION

The key theme of this study is based on four components: cognitive reasoning, critical thinking, problem-solving, and decision making. Overall, there are 54 peer-reviewed journal articles published between 2015 and 2025 from WoS, Scopus, and ERIC. According to the search results, there are numerous relevant studies, including empirical research, cross-national assessments, intervention research, and discipline-specific investigations. Furthermore, these studies highlight the complexity of higher-order cognition by highlighting the pedagogical and background factors that influence students' performance on thinking tasks. Thus, the following section summarizes the literature selection and thematic categorization.

3.1. The process of integrated cognition in higher education

In higher education, critical thinking, problem-solving, and decision-making ability are widely regarded as interrelated components of cognitive reasoning, rather than independent cognitive skills [14], [24], [25]. Although previous studies have often examined these abilities separately, evidence from the empirical and theoretical literature shows that they operate within a broader reasoning system. Critical thinking helps learners interpret evidence and evaluate conflicting views; problem-solving ability enables them to generate and refine possible solutions; and decision-making ability involves choosing among multiple options and defending their choices. Together, these processes improve students' ability to cope with complex and uncertain learning situations.

From a theoretical perspective, Piaget's theory of cognitive development and Bloom's revised taxonomy of cognitive objectives provide profound insights into how these reasoning processes operate. Piaget's cognitive adaptation theory shows that when learners encounter information that cannot be integrated into the existing cognitive framework, cognitive imbalances will occur, prompting them to adapt, thus reorganizing their understanding into a more complex structure. Similarly, Bloom's cognitive domain classification framework also points out that effective reasoning requires higher-order operations such as analysis, evaluation, and creation, rather than simple recall [21]. However, these processes are not strictly linear processes, but recursive. Learners will repeatedly return to the previous cognitive stage with the emergence of new information, restrictions, or uncertainties [26].

Collectively, the reviewed evidence suggests that stronger reasoning ability is consistently associated with higher levels of critical analysis, reflective judgment, and adaptive problem-solving, [1], [27], [28]. Problem-solving proficiency constitutes a foundational competency for students engaging with complex disciplinary challenges [29], and scientific reasoning skills have been shown to develop progressively throughout undergraduate education with significant variation across students [30]. One possible theoretical interpretation is that these variations may be associated with underlying cognitive mechanisms. From a cognitive psychology perspective, working memory, metacognitive monitoring, and analogical reasoning have been proposed as mechanisms that may support complex reasoning processes. Although these mechanisms provide a useful theoretical lens for interpreting the reviewed findings, they were not examined consistently across the included studies. Metacognitive monitoring enables students to evaluate the effectiveness of their reasoning strategies and adjust when cognitive conflicts arise. Analogy reasoning further promotes knowledge transfer by helping learners identify structural similarities in different situations. Together, these mechanisms show that improving the reasoning process may have a broader impact on interrelated cognitive functions, not just on isolated skill improvement.

However, the results of subject research show that many undergraduates still face challenges in applying reasoning skills to complex academic tasks. Studies in the fields of chemistry, mathematics, engineering, and social sciences show that students tend to rely on memory, intuitive judgment, or procedural operations rather than systematic analytical reasoning [31], [32]. Measuring the development of these reasoning skills remains methodologically challenging, as standardized instruments often fail to capture the full complexity of students' cognitive processes across diverse institutional contexts [33]. Active learning strategies that engage students in collaborative and inquiry-based tasks have been proposed as one means of addressing this gap [34]. This pattern may be partly due to past educational experiences that emphasize procedural accuracy and test results. When the experience of repeated learning rewards the replication of

knowledge rather than reflective evaluation, students may form rigid cognitive patterns that are difficult to transfer to unfamiliar or unclear situations.

3.2. The influence of teaching and situations on cognitive reasoning

This review primarily shows that cognitive reasoning ability cannot be acquired automatically through subject content alone but requires conscious instructional support and a suitable learning environment. Furthermore, it notes that methods such as inquiry-based learning, problem-oriented learning, the flipped classroom, reflective questions, and structured reasoning skills can help improve students' critical thinking, problem-solving, and decision-making abilities [32], [35], [36]. Moreover, explicit instruction in critical thinking has been shown to produce significant improvements in student reasoning performance when integrated systematically into course design [37]. These methods not only focus on the final proposal but also encourage students to clarify hypotheses, evaluate evidence, consider different schemes, and reflect on their own cognitive processes. Besides, structured-parenthesis teaching is consistent with Vygotsky's theory of the "recent development zone", which is also particularly crucial for helping students transition from guided to independent reasoning [38].

In recent years, the development of technology-enhanced learning has further expanded opportunities for developing reasoning ability [39]. Evidence suggests that a socialized flipped classroom environment and internet-assisted learning mode can effectively promote the development of students' reasoning ability [40]. Taken together, these studies suggest that instructional approaches influence cognitive reasoning primarily by increasing students' cognitive engagement and active participation rather than through the teaching strategy itself [36], [41]. In addition, generative AI technologies can enhance students' ability to apply and integrate higher-order thinking processes to complex tasks [42]. However, the emergence of AI tools has also brought new challenges in recent years. Recent studies included in this review have begun to discuss the potential risks associated with AI-assisted learning. These studies suggest that excessive reliance on AI-generated responses, without critical evaluation, may reduce opportunities for independent reasoning. However, because this remains an emerging research area, further empirical evidence is needed to clarify the long-term cognitive implications.

Excluding these teaching methods, evidence suggests that situational and systemic factors also significantly impact the development of cognitive reasoning ability. Besides, in an educational environment that emphasizes dialogue, collaborative exploration, and reflective judgment, students are usually encouraged to participate more deeply in evidence analysis and to use more complex reasoning strategies. On the contrary, a system that emphasizes rote memorization and test scores may limit opportunities for flexible reasoning and knowledge transfer [43]. Students' identification with their academic discipline and their sense of belonging within the learning community also significantly influence their motivation to persist through cognitively demanding tasks [44]. These findings support the integrative framework proposed in this review by demonstrating that cognitive reasoning develops through the interaction of critical thinking, problem-solving, and decision making within authentic learning environments.

3.3. Challenges and new models in the development of reasoning

Although higher education has paid greater attention to higher-order thinking in recent years, the literature still has some limitations. A common finding is that the growth of subject knowledge often exceeds the improvement in reasoning ability [43]. Engineering and science students report substantial difficulties adapting to the academic demands of undergraduate programs, particularly when tasks require integrated reasoning beyond procedural knowledge [45]. Therefore, this difference suggests a misalignment between the teaching focus and the development of cognitive skills related to migration. One possible interpretation of the reviewed findings is that students may rely on familiar procedural strategies to reduce cognitive load when facing uncertainty. However, this interpretation should be understood as a conceptual explanation rather than a direct conclusion consistently reported across the reviewed studies. Although procedural methods may help complete short-term tasks, they may also limit exploratory thinking and reduce the opportunity for adaptive reasoning. Therefore, students may propose seemingly reasonable solutions or decisions but cannot explain or argue the reasoning process behind them.

Across the reviewed literature, motivational and emotional factors emerge as consistent conditions that influence students' willingness to engage in cognitively demanding tasks [1], [27], [46]. This pattern suggests that students with higher academic self-efficacy and learning motivation tend to persist longer when faced with cognitive challenges [47]. On the contrary, if students lack confidence, they may rely more on their own intuitive shortcuts and superficial judgments. These findings show that cultivating effective reasoning ability depends not only on cognitive ability but also on learners' motivation and emotional investment. Another emerging trend is the recognition of the limitations of current evaluation practices. Traditional exam-based assessments usually focus more on factual memory rather than on the real reasoning

process. During this process, although students may successfully recall knowledge, this method often fails to provide opportunities to demonstrate comprehensive reasoning in real situations. Besides, performance-based evaluation, including thinking expression, real-world problem situations, and reflective reasoning tasks, seems to better capture how students interpret information, evaluate plans, and make wise judgments [1], [48]. Overall, these research findings mainly emphasize the need for higher education institutions to abandon isolated assessment of cognitive skills and adopt a more comprehensive, context-based approach. Viewed through the proposed integrative framework, these challenges highlight that effective cognitive reasoning depends not only on individual thinking skills but also on interactions among cognitive, motivational, and contextual factors.

3.4. Interaction among the three abilities in learning contexts

This review addresses critical thinking, problem-solving, and decision-making as integral parts of an integrated, dynamic system in cognitive reasoning. In higher education, these abilities are interdependent and mutually reinforcing. Together, they encourage students to participate in complex, poorly structured tasks. The theoretical basis of this integration includes not only Piaget's constructivism, but also Bloom's revised cognitive objective classification [21]. This pattern suggests that critical thinking establishes an analytical basis by enabling students to interpret information, evaluate evidence, and question hypotheses [43]. Subsequently, the problem-solving process enables learners to generate, test, and improve potential solutions [49]. Once these cognitive structures are established, students will make effective decisions by evaluating options and predicting consequences before choosing the most appropriate course of action.

Importantly, this relationship is not linear; decision-making outcomes often prompt people to engage in deeper critical evaluation and refine their problem statements. It reflects the recursive and iterative processes of cognitive reasoning. This recursive dynamic is consistent with Piaget's concept of balance. For example, when a decision creates a new cognitive imbalance or reveals the inadequacy of a previous understanding, learners are forced to reinvest in critical thinking and re-examine the problem-solving process, thereby improving their cognitive organization to a higher level. Overall, the reviewed evidence supports this integrated perspective, although the emphasis placed on each component differs across disciplines and learning contexts [49]. Students' reasoning processes are most prominent across a range of high-level skills, such as critical assessment, strategy generation, and rational decision-making [1]. In addition, transnational research indicates that progress in a given field is often accompanied by improvements in other capabilities [43]. The cognitive basis of these abilities, including working memory, metacognitive monitoring, and analogy reasoning, helps to explain why interventions for one skill tend to have collateral benefits for other skills [1], [43]. From a theoretical perspective, these interrelationships may be understood through these broader cognitive mechanisms. However, these mechanisms were not the primary focus of most studies included in this review and are presented here as an interpretive framework rather than as synthesized findings.

Nowadays, teaching interventions increasingly emphasize the interrelationships among these higher-order thinking skills. This pattern suggests that structured reasoning models have been proven to improve individual skills and their coordinated application, thereby enhancing the accuracy of problem-solving and the quality of decision-making [32]. Targeted instructional interventions focused on mathematical and logical reasoning have similarly demonstrated promise in strengthening the cognitive foundations underlying performance in integrated reasoning [50]. Therefore, these three abilities should not be seen as parallel paths to cognitive development, but as a mutually constitutive and interdependent system in which each component depends on and promotes the others. This is directly significant to teaching design: effective teaching practice should not target critical thinking, problem-solving, and decision-making in separate course units, but should create an integrated learning experience that activates and exercises these three abilities. In general, these research results show that effective higher education practices should integrate these abilities into a coherent learning design to promote high-quality cognitive development, rather than treating them in isolation.

3.5. Emerging themes and patterns

A critical, comprehensive analysis of the published literature reveals several important and interrelated themes concerning the roles of critical thinking, problem-solving, and decision making within the broader context of cognitive reasoning in higher education. Taken together, the reviewed studies indicate that these abilities are best understood as interdependent processes that jointly support students' academic achievement and adaptability. Critical thinking, problem-solving, and decision making are not isolated abilities but interrelated processes within a broader cognitive reasoning system. Critical thinking provides an evaluation basis for learners to analyze information and question hypotheses; problem-solving transforms these evaluations into strategic actions; and decision making requires learners to argue and choose possible alternatives. This interaction helps to explain why these abilities are usually developed together rather than independently in a higher education environment. For example, previous research [1], [27] show significant

overlap and integration of these concepts in real teaching environments. In addition, a consistent pattern emerging from the literature is that the development of problem-solving ability depends on students' continuous participation in interrelated decision-making steps. This dynamic connection emphasizes how critical assessment, analytical reasoning, and solution-oriented thinking work together to promote the effective completion of complex reasoning tasks. Therefore, the comprehensive analysis of the subject not only highlights the interrelationship of these skills but also shows that their interaction constitutes an integrated process through which students develop increasingly complex reasoning skills in higher education. Although the reviewed studies consistently support the interconnected nature of these three abilities, the extent of their integration appears to vary across educational contexts. This variation may reflect differences in curriculum design, instructional approaches, and assessment practices across higher education contexts.

The second model emphasizes the increasing reliance on performance-based and task-based assessment methods to assess students' cognitive reasoning abilities. It can be used to evaluate students' cognitive reasoning abilities, typically through real-world situations, simulated tasks, and open-ended problem-solving. These methods are related to the improvement of undergraduate problem-solving ability, experimental design ability, data analysis ability, and evaluation ability [1], [32], [43], [51]–[53]. Studies focusing on specific disciplines such as mathematics and science further confirm that performance-based approaches better capture students' capacity for applied reasoning than traditional recall-based tests [54], [55]. In addition, the reviewed evidence consistently indicates that effective use of learning strategies is a consistent predictor of academic success and reasoning performance among undergraduate students [56]. One possible explanation is that real and open tasks require students to evaluate evidence, formulate solutions, and judge simultaneously under uncertain conditions. Therefore, compared with traditional knowledge-based evaluation, this kind of learning environment may create more favorable opportunities for the emergence of comprehensive reasoning processes. However, critics believe that these assessment methods may focus too much on observable performance and ignore the potential cognitive processes involved in the development of reasoning. These findings suggest that the assessment methods, teaching objectives, and the potential reasoning process that educators aim to cultivate need to be more closely coordinated.

Next, we will discuss the impact of teaching design and the learning environment. The use of metacognitive support, reasoning strategy modeling, and cooperative problem-solving situations can significantly improve students' cognitive participation [57]–[60]. Research across diverse higher education contexts has shown that when instructional environments are explicitly structured to support reasoning development, students demonstrate greater gains in analytical and evaluative thinking [61]–[63]. For example, bracket intervention and collaborative tasks can not only provide metacognitive support, but also provide real problem situations to help students develop and apply effective reasoning strategies [32]. This may be because a clear reasoning framework makes the cognitive process clearer and more structured, so that students can monitor, adjust, and improve their thinking more effectively. Therefore, clear training on reasoning strategies can enhance students' critical analysis ability, problem-solving ability, and decision-making accuracy. While the reviewed studies generally support that cognitive reasoning skills can be transferred across tasks and disciplines, they differ on whether students' cognitive reasoning is strongly influenced by subject norms, assessment formats, and learning environments. This leads to an important question: should cognitive reasoning be understood as a general skill that can be transferred, or a process that depends on the subject and teaching environment, and depends on the situation?

Finally, a consistent pattern emerging from the literature shows that cross-cultural and cross-situational differences are receiving increasing attention [64], [65]. Although the core cognitive process is universally applicable, students' performance in reasoning tasks will be affected by situational factors. In addition, these factors primarily include curriculum design, teaching practice, and sociocultural expectations regarding autonomy and evaluation. The increasing integration of AI and digital technology into higher education represents a particularly important shift that warrants deeper exploration. The popularity of AI tools and their wide application in the academic field have rekindled people's attention to the integration of cognitive reasoning ability. Students may face new and complex challenges beyond the scope of subject knowledge. These challenges include critically assessing the accuracy and reliability of information generated by AI, recognizing the limitations and potential deviations in algorithmic output, and making informed, independent judgments rather than blindly accepting automated feedback.

Against this background, the ability to integrate critical thinking, problem-solving, and decision-making is not only desirable but also crucial. Some recent studies suggest that students with weaker reasoning skills may be more susceptible to over-reliance on AI-generated responses. Nevertheless, because empirical evidence in this area is still emerging, this relationship should be interpreted cautiously. On the contrary, students with strong integrated reasoning ability can use AI tools more strategically and reflectively, and maintain the ability to think independently and evaluate their judgments while making full use of their capabilities. Taken together, this emerging dynamic reinforces the core argument of this review:

cultivating comprehensive cognitive reasoning ability must remain the core priority of higher education, precisely because the increasing popularity of AI in the learning environment makes superficial exposure to knowledge more accessible than ever and may exert a more significant influence. Overall, these findings reinforce the integrative framework by showing that cognitive reasoning should be understood as the coordinated interaction of multiple higher-order thinking processes rather than a collection of isolated skills.

3.6. Gaps and limitations in the literature

Existing studies and reviews mainly examine critical thinking, problem-solving, or decision-making abilities as isolated concepts, and few studies explain how these abilities interact dynamically as an integrated cognitive reasoning system in higher education. Despite the increasing number of studies in this field, there are still some serious shortcomings that restrict the development of theory and practical application. First of all, there is an obvious methodological imbalance. Most reviewed studies rely heavily on performance-based evaluation or standardized reasoning tests [1], [32], [43]. There are relatively few studies on qualitative or mixed methods that can capture the cognitive process behind the observed reasoning performance. Therefore, the existing research results may overemphasize measurable results, while the insights on how students can construct, regulate, and adjust their reasoning process in real learning situations are very limited. In short, these shortcomings show that the existing literature has not fully explained the mechanism of interaction between critical thinking, problem-solving, and decision-making ability in the environment of higher education. Therefore, the existing evidence often only points to the relationship between these concepts and does not adequately explain the causes or conditions for the emergence of these relationships.

Secondly, longitudinal research is still lacking, which limits our understanding of how critical thinking, problem-solving, and decision-making ability develop and interact over time. Most of the existing studies are cross-sectional studies, which can only provide a snapshot of students' reasoning ability at a specific point in time, limiting our understanding of the development and changes of different learning stages. Third, although some studies have compared the reasoning ability in different disciplines or national contexts, the impact of social culture, institutional, and teaching factors is limited. Differences between different institutions show that situational factors such as teaching norms, evaluation culture, and expectations of learners' autonomy play an important role in shaping students' cognitive reasoning ability. However, these dynamic factors have not been fully explored, limiting the universality of contemporary cognitive reasoning models in different educational contexts. Fourth, most of the existing literature overemphasizes the cognitive dimension and pays insufficient attention to the emotional and motivational structure. Although a large amount of evidence in educational psychology shows that factors such as self-efficacy, learning motivation, and emotional regulation can affect the way students cope with complex reasoning challenges, few studies have combined these variables to explore reasoning performance. Therefore, students with equivalent cognitive ability still know little about the reasons for differences in problem-solving and decision-making.

Finally, although it is generally recognized that these three abilities are closely related, the integrated theoretical model remains imperfect. A recurring limitation across the reviewed literature is that many studies examine critical thinking, problem solving, or decision-making separately, or focus only on two of them, resulting in a limited understanding of the dynamic interaction between them. These findings suggest that we need a more comprehensive, situational, and theoretically integrated approach to explain how these abilities work together in a complex educational environment. A particularly critical but rarely studied gap is how to evaluate reasoning ability in the higher education system. The current assessment practice mainly relies on examinations that prioritize the recall and retelling of knowledge rather than on real, situation-rich reasoning tasks. These methods fundamentally fail to capture the dynamics and integration of the critical thinking, problem-solving, and decision making described in this article.

When students consistently receive shallow tests rather than evaluations based on performance or on tasks integrated into real situations, the cultivation of their higher-order reasoning ability is neither fully supported nor effectively measured. This disconnects between the assessment design and the goal of cognitive development not only reflects the limitations of teaching but also the systemic shortcomings, which have a significant impact on the degree of preparation of graduates for professional and civic life. Therefore, bridging this gap is not an impressive improvement, but a real problem that higher education institutions, curriculum designers, and policymakers urgently need to solve. We have constructed concept matrix, as shown in Table 1, to integrate key literature on cognitive reasoning and related concepts in higher education. While the concept matrix (Table 1) synthesizes the conceptual relationships among critical thinking, problem-solving, decision-making, and cognitive reasoning, it does not fully capture the overall characteristics of the included studies. To provide a broader overview of the evidence base, Table 2 summarizes the publication trends, research contexts, methodological characteristics, and major insights identified across the 54 included studies.

Table 1. Concept matrix of cognitive reasoning research in higher education

Study	Critical thinking	Problem-solving	Decision making	Higher-order thinking	Cognitive reasoning	Key insight
[27]	✓	✓				CT and reflective thinking relate to students' problem-solving ability [27]
[43]	✓	✓				Cross-country assessment shows variation in students' generic cognitive skills [43]
[1]	✓					Assessment tasks reveal integrated structure of critical thinking [1]
[26]		✓				Engineering students apply structured strategies in problem -solving [26]
[66]	✓	✓				Reflective thinking patterns influence analytical problem- solving [66]
[32]				✓		Instructional design can improve higher-order thinking skills [32]
[31]				✓		Many first-year students struggle with HOTS questions [31]
[67]	✓					Students interpret critical thinking as questioning and reasoning [67]
[68]	✓					Framework for measuring critical thinking skills and dispositions [68]
[34], [53]	✓	✓	✓	✓	✓	Research increasingly integrates thinking skills within cognitive reasoning [34], [53]

Table 2. Summary characteristics of included studies (n=54)

Category	Characteristics	Main insights
Publication period	2015–2025	Increased studies after 2020, showing growing interest in higher-order cognitive skills.
Research context	Higher education	All studies were conducted in higher education.
Methodology	Quantitative/qualitative/mixed methods	Quantitative approaches dominated; qualitative and mixed methods were limited.
Research focus	Critical thinking/problem-solving/ decision-making/cognitive reasoning	Critical thinking was most studied, while decision-making and integrated reasoning received less attention.
Overall evidence	Integrated findings	These competencies are interconnected but often examined separately, suggesting the need for an integrated framework.

3.7. Implications for higher education

Gaps in the literature have important consequences for higher education, especially regarding motivation and emotions. Universities should support student growth by focusing on self-efficacy, feedback skills, and emotional awareness in academic training. Strengthening these non-cognitive skills helps students tackle reasoning tasks with more confidence and persistence. Cognitive reasoning should be recognized as a key graduate skill across all higher education institutions. As AI becomes more common in universities, it is increasingly important for faculty to receive training and for institutions to set clear policies to ensure technology is used ethically, effectively, and fairly to support real-world learning.

In addition, curriculum designers should integrate teaching designs such as critical thinking, strategic problem solving, and reflective judgment into real and discipline-specific learning tasks. There is evidence that students can develop a stronger reasoning structure when dealing with open-ended questions that require the use of these abilities simultaneously [1], [27]. Integrating such tasks into the whole curriculum system, rather than limiting them to general education or elective modules, can make reasoning-centered learning a core academic requirement. Such activities can include case studies, scenario analyses, collaborative projects, and reflective decision-making exercises that require students to use multiple reasoning processes simultaneously. In addition, structured support, such as clear demonstrations of reasoning strategies, guided questions, and metacognitive support, has been proven to improve students' reasoning ability significantly. Therefore, teachers should integrate reflective and meta-cognitive components into the curriculum and guide students to monitor hypotheses, evaluate evidence, and make argumentative decisions.

In addition to classroom teaching practice, the results of this research are highly significant for curriculum development, graduate employment, and broader educational transformation. Colleges and universities should break down disciplinary barriers, build an integrated interdisciplinary curriculum, treat critical thinking, problem-solving, and decision-making as the core competencies of graduates, and adjust learning outcomes, evaluation methods, and teaching strategies accordingly. In view of the growing demand in society for graduates who can use evidence-based reasoning to meet complex reality challenges, the cultivation of comprehensive reasoning ability should be systematically integrated into all stages of higher education, rather than regarded as an isolated component. At the institutional and policy levels, we must

increase investment in teacher development, a reasoning-centered evaluation system, and educational policies to ensure that emerging technologies, such as AI, support rather than replace students' independent cognitive development. In addition, with the increasing integration of AI tools into higher education, colleges and universities must actively respond to the design of learning experiences that can clearly cultivate students to critically evaluate the content generated by AI, resist blind dependence on automated output, and use comprehensive reasoning skills to judge the relevance, accuracy, and ethical impact of technical information. It is important that students continue to participate in learning experiences that include uncertainty, challenges, and independent judgment, because these conditions provide opportunities for deeper development of reasoning ability. The curriculum framework should not regard AI as a substitute for reasoning ability but should be positioned as a situation that actively exercises and tests advanced cognitive skills.

In short, these revelations emphasize the need to make structural commitments in the curriculum system to cultivate cognitive reasoning ability and establish it as a basic quality for higher education graduates. These findings further demonstrate the value of the proposed integrative framework, which conceptualizes cognitive reasoning as a dynamic interaction among critical thinking, problem-solving, and decision-making rather than as separate cognitive abilities. This comprehensive reasoning system can support students' academic development and long-term adaptability in an increasingly complex learning environment.

4. CONCLUSION

This review shows that critical thinking, problem solving, and decision-making are interconnected dimensions of cognitive reasoning in higher education. These processes do not operate independently, but as a dynamic system to support students in dealing with complex tasks and making informed judgments in academic and real situations. The synthesized evidence suggests that cognitive reasoning develops through the interaction of individual capabilities, instructional practices, and contextual factors. From a theoretical perspective, this study develops an integrated conceptual framework that conceptualizes cognitive reasoning as a recursive, situation-sensitive process shaped by instructional, motivational, and contextual factors. This perspective extends traditional interpretations of cognitive development by highlighting the dynamic and contextual nature of higher-order reasoning in higher education. From a practical perspective, the findings highlight the importance of integrating reasoning-oriented learning opportunities into teaching design and assessment practices. Higher education institutions should consider critical thinking, problem solving, and decision-making as interconnected competencies that require continuous development across disciplines and academic stages.

There are some limitations to this review. It considered only English-language publications from Scopus, WoS, and ERIC between 2015 and 2025. As a result, studies in other databases or languages might have been missed. Another limitation is that no formal quality appraisal tool was applied to the included studies. Also, since this is an integrative review, the findings are derived from thematic synthesis rather than a quantitative meta-analysis. Because of this, the conclusions should be seen as conceptual interpretations, not as direct evidence of cause and effect. Future research should also explore technology-enhanced learning environments and emerging challenges associated with AI to better understand how higher education can support students' reasoning capabilities in changing social and professional contexts.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Sumei Sun	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	
Norzihani Saharuddin	✓	✓		✓	✓	✓		✓		✓		✓		
Nor Aniza Ahmad	✓	✓		✓						✓		✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this study as no new data were created or analyzed.

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BIOGRAPHIES OF AUTHORS



Sumei Sun is a Ph.D. candidate in Educational Psychology at the Faculty of Educational Studies, Universiti Putra Malaysia (UPM). She holds a master's degree in Education and has an academic background in educational psychology and management. Her research focuses on the intersection of self-efficacy and cognitive reasoning in higher education, with a particular interest in students' academic development and problem-solving processes. She can be contacted at the email address GS69248@student.upm.edu.my or s9033107@gmail.com.



Norzihani Saharuddin is a senior lecturer at the Department of Language and Humanities Education, Faculty of Educational Studies, Universiti Putra Malaysia (UPM). She holds a Ph.D. in Moral Education from International Islamic University Malaysia (IIUM), a Master of Science in Moral Education, and a Bachelor of Education in Guidance and Counseling from UPM. Her research interests include moral education, curriculum and instruction, narrative-based teaching, and educational psychology. She can be contacted at email: norzihani@upm.edu.my.



Nor Aniza Ahmad is an associate professor at the Department of Foundations of Education, Faculty of Educational Studies, Universiti Putra Malaysia (UPM). She holds a Ph.D. in Educational Psychology from Universiti Kebangsaan Malaysia. Her research interests focus on educational psychology, including emotional intelligence, psychological capital, self-efficacy, and student development in educational contexts. She can be contacted at email: nor_aniza@upm.edu.my.