

Reconstructing Thinking Process Indicators in Learning: An Integrative Synthesis of Vygotsky, Piaget, and Thorndike

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ABSTRACT: Research on thinking processes in learning has developed across theoretical traditions, yet related constructs are often examined separately. This fragmentation makes it difficult to develop an integrated understanding of how learners direct attention, process knowledge, draw inferences, and reflect on and regulate their thinking. This study synthesizes the literature on thinking processes in learning and develops an integrative conceptual framework linking core thinking processes with supporting conditions and developmental and social contexts. A systematic literature review using PRISMA-based selection procedures examined Scopus-indexed articles published between 2021 and 2026. Of 288 identified articles, 11 met the inclusion criteria and were analyzed through data extraction, thematic analysis, and narrative synthesis. The synthesis identifies three core processes: attentional regulation, knowledge processing and inference, and reflection and control. These processes operate within supporting conditions, including prior knowledge, task demands, self-efficacy, learning experiences, language, and social support, and are shaped by developmental and social contexts. The findings distinguish core thinking processes from constructs that function as supporting conditions. The proposed framework conceptualizes thinking as a dynamic system of interrelated processes rather than a fixed sequence of stages. It provides a conceptual basis for developing operational indicators and subsequent empirical validation.

KEYWORDS: thinking processes, integrative synthesis, Vygotsky, Piaget, Thorndike, systematic literature review.

INTRODUCTION

Research on thinking processes in learning highlights the interplay of cognition, social interaction, cultural context, and metacognitive regulation (Mohammed & Kinyó, 2022; Sulla et al., 2023; Tchombe, 2023). Thinking involves processing information, participating in social and cultural activities, and monitoring and evaluating learning. Self-efficacy is associated with cognitive, emotional, and behavioral engagement (Zhang, 2023), while cognitive load and the interaction between working and long-term memory shape the demands of information processing (Krieglstein, 2023; Sweller, 2023). Cultural practices and social interaction contribute to cognitive development (Tchombe, 2023), and language supports social understanding through theory of mind (Bigelow, 2021). These findings portray thinking as a multidimensional process that cannot be adequately explained from a single theoretical perspective.

Despite this diversity, related constructs are often examined within separate traditions. Executive functions, metacognition, self-regulation, and self-regulated learning have overlapping roles in learning, but their relationships remain insufficiently integrated (Theobald et al., 2026). Cognitive development also changes across development, with differences in the characteristics and priorities of thinking (Demetriou, 2022). Metacognition involves planning, monitoring, and evaluating thinking and learning, while attention supports the selection of relevant information and regulation of focus during task performance (Rueda, 2024; Theobald et al., 2026; Zangrilli, 2021). Such distinctions matter for indicator development because constructs associated with thinking do not necessarily represent thinking processes themselves.

The issue also extends to methodological and operational concerns. Developing indicators requires clear connections among construct definitions, theoretical foundations, and validity evidence. A systematic review of measurement in STEM education found that many scales rely primarily on evidence of internal structure and internal consistency (Maric et al., 2023). Broad concepts of thinking and reasoning are likewise difficult to translate into observable learning activities and outcomes (Hačatrjana & Namsone, 2024). Cultural practices and social environments add another layer because the meaning and expression of thinking may vary across learning contexts (Tchombe, 2023). A systematic synthesis is therefore needed to distinguish core thinking processes from supporting conditions and to clarify their conceptual relationships. Systematic literature reviews provide a structured basis for identifying and synthesizing such evidence (Chong et al., 2022).

An integrative synthesis of Vygotsky, Piaget, and Thorndike provides the theoretical basis for reconstructing thinking-process indicators. Vygotsky contributes perspectives on social interaction, language, and cultural mediation; Piaget emphasizes knowledge construction, cognitive structures, and equilibration; and Thorndike explains learning through stimulus–response connections and the strengthening of responses through consequences (Rila & Aziz, 2022; Stoltz et al., 2024). These perspectives offer complementary lenses for examining the conditions and processes involved in learning rather than competing explanations of a single mechanism. Metacognitive processes are considered through evidence concerning the monitoring and regulation of learning (Sulla et al., 2023). The resulting synthesis is intended to clarify which constructs represent core thinking processes, which function as supporting conditions, and how their relationships can be organized into a coherent conceptual framework.

Three research questions guide the review: (RQ1) How are the characteristics, dimensions, and indicators of thinking processes described in the learning literature? (RQ2) How do the contributions and conceptual differences among Vygotsky, Piaget, and Thorndike inform a framework of thinking-process indicators? (RQ3) How can these findings be organized into an integrative framework with potential for operationalization in learning? The questions align the review with the identification of evidence, theoretical interpretation, and conceptual synthesis (Sauer & Seuring, 2023). Qualitative synthesis further supports the examination of patterns and relationships across studies (Maeda et al., 2022). The resulting framework provides a conceptual basis for subsequent indicator development and empirical validation.

METHODOLOGY

Study design

A systematic literature review (SLR) was conducted to identify, evaluate, and synthesize research on thinking-process indicators in learning, with particular attention to the conceptual contributions of Vygotsky, Piaget, and Thorndike. The review followed procedures involving research-question formulation, eligibility criteria, literature searching, study selection, data extraction, and synthesis (Chong et al., 2022; Sauer & Seuring, 2023). The approach was used to identify relationships among constructs and develop an integrative framework of thinking-process indicators (Paul et al., 2024).

Search strategy and eligibility criteria

Scopus was searched using keywords related to cognitive process indicators, Vygotsky–Piaget–Thorndike integration, learning theory synthesis, and cognitive development theories. Eligible publications were Scopus-indexed articles published between 2021 and 2026 and addressing thinking processes, learning, or cognitive theories relevant to the research questions. Titles and abstracts were used for initial screening, followed by full-text assessment for eligibility, study quality, and data extraction.

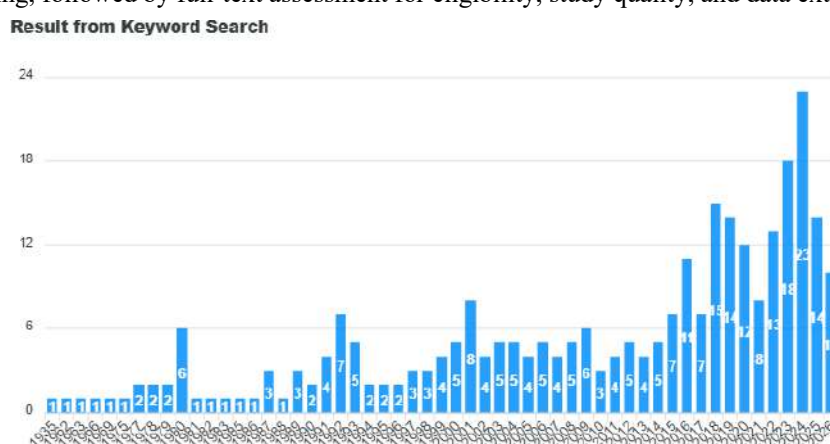


Figure 1. Publication trends based on keyword searches related to thinking processes and learning theories

Study selection

Study selection followed the PRISMA 2020 flow. The initial search identified 288 articles. After preliminary filtering against the specified criteria, 66 articles proceeded to screening. Thirty-seven were excluded, leaving 29 reports for full-text retrieval. Seventeen full texts could not be retrieved, and 12 reports were assessed for eligibility. One report was excluded because it did not meet the eligibility criteria, resulting in 11 articles included in the synthesis.

PRISMA 2020 Flow Diagram: Indicators of Thinking Processes Based on Piaget, Vygotsky, and Thorndike Theories in Mathematics Learning Generated using Watase Uake Tools, based on PRISMA 2020 reporting.

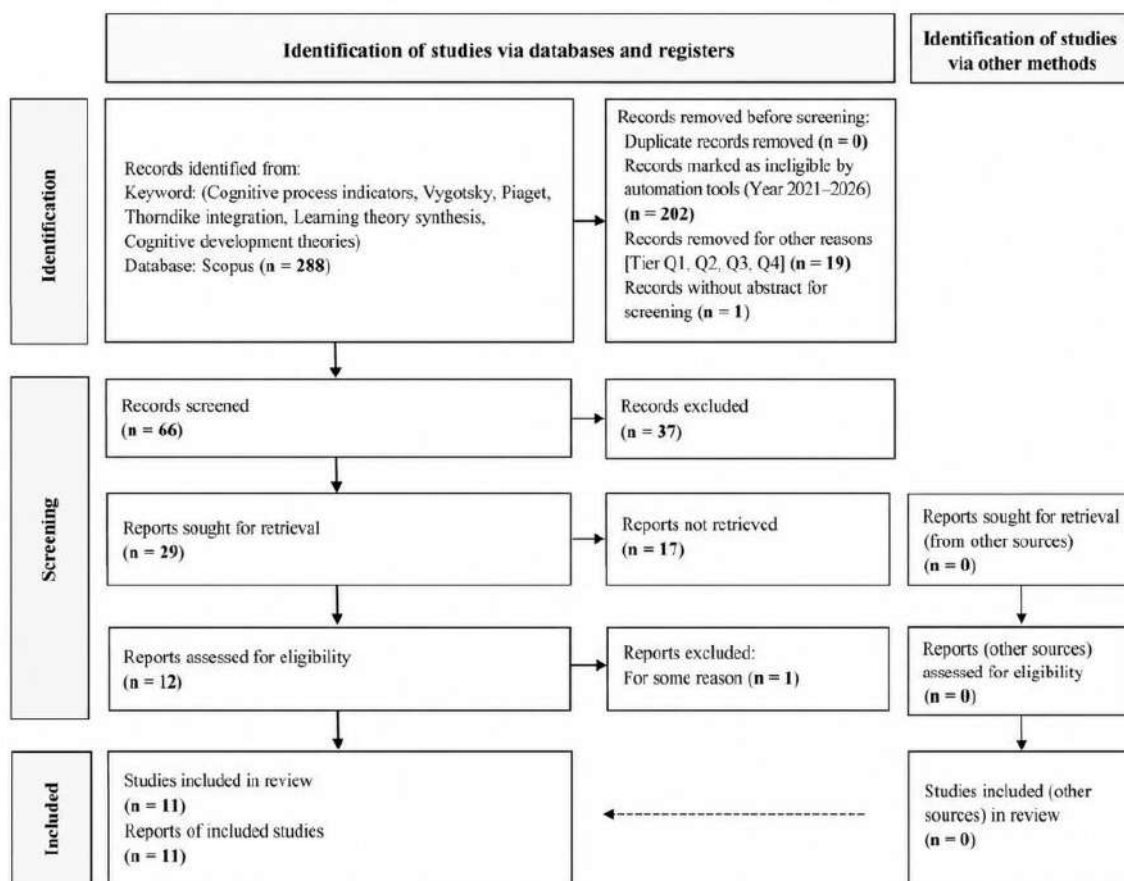


Figure 2. PRISMA 2020 diagram for the selection of articles on indicators of thinking processes in learning.

Data extraction and analysis

Data extraction covered the concepts, dimensions, indicators, theoretical foundations, research methods, main findings, and limitations reported in the selected studies. The extracted data were organized systematically to facilitate comparison across studies. Thematic analysis and narrative synthesis were then used to identify recurring dimensions and relationships among constructs (Bigelow, 2021; Demetriou, 2022; Krieglstein, 2023; Sweller, 2023; Tchombe, 2023; Zangrilli, 2021; Zhang, 2023). The synthesis distinguished cognitive, social, developmental, and metacognitive dimensions and examined how these constructs function as thinking processes or supporting conditions. The resulting relationships were used to construct the integrative framework.

RESULTS

Characteristics of included studies

The search and selection process yielded 11 eligible articles encompassing diverse contexts, methodological approaches, and theoretical foundations. Studies covered Asia, Europe, Australia, Africa, and multinational contexts. Approaches included experimental, mixed-methods, quantitative, qualitative, and theoretical research.

Participants and contexts ranged from school-age children to university students and professional groups. This diversity indicates that research on thinking processes extends across educational levels and methodological approaches. Table 1 presents the characteristics and extracted data of the 11 studies.

Table 1. Characteristics and extracted data of included studies

Code	Author and year	Research objective	Research design and context
S01	(Zohrabi Alaei & Zwickl, 2025)	Explain the development of physics students' interest in particular subfields.	Qualitative; 27 interviews with physics students in the United States.
S02	(Akbari et al., 2024)	Develop and validate a resilience-skills questionnaire for healthcare workers.	Instrument development and psychometric testing; 336 healthcare workers in Shiraz, Iran.
S03	(Rueda, 2024)	Explain attentional development using cognitive neuroscience evidence.	Theoretical review of attentional development, particularly in early life.
S04	(Wang & Wang, 2024)	Develop a student leadership evaluation model integrating civic and psychological education.	Model development and quantitative analysis; 246 students across six vocational college programs.
S05	(Zhang, 2024)	Examine leadership development and relationships with students' psychological beliefs and self-efficacy.	Modeling and empirical analysis; 350 university students.
S06	(Kriegelstein, 2023)	Develop and validate a questionnaire measuring types of cognitive load.	Five empirical studies: component analysis, confirmatory factor analysis, and three experiments.
S07	(Sweller, 2023)	Explain cognitive load theory development through replication failures and theoretical integration.	Theoretical essay on the development of cognitive load theory.
S08	(Tchombe, 2023)	Examine cultural practices and children's cognitive development through learning pathways.	Mixed methods; 73 parents and teachers in Cameroon; questionnaires and interviews.
S09	(Demetriou, 2022)	Explain changing developmental priorities in cognitive competence and implications for school learning.	Theoretical synthesis of developmental and learning research.
S10	(Bigelow, 2021)	Test the mediating role of language in cognitive and affective theory-of-mind development.	Developmental study with mediation analysis; 151 children aged 5–12 years.
S11	(Zangrilli, 2021)	Develop a framework categorizing patients' communication about thoughts, feelings, and actions.	Iterative analysis and reliability testing of 29 clinical transcripts: 14 Italian and 15 English.

Dimensions of thinking processes

The synthesis identifies interrelated dimensions of thinking. The cognitive dimension includes working-memory capacity, cognitive load, and knowledge processing. The social dimension includes interaction, communication, language, and understanding others' perspectives. The developmental dimension concerns changes in cognitive abilities and priorities, while the metacognitive dimension includes planning, monitoring, evaluation, and reflection.

Several studies also link self-efficacy, emotional engagement, and behavioral responses to thinking. Thinking is therefore related to social, developmental, affective, and behavioral conditions alongside cognition. Seven main themes were identified: attentional regulation; knowledge processing and cognitive demands; inference and validity checking; language and perspective understanding; reflection and self-regulation; self-efficacy and learning experiences; and social support and context.

Thematic synthesis

The seven themes indicate that constructs occupy different conceptual positions. Attention, processing, inference, and reflection are closely associated with processes occurring during thinking. Prior knowledge, task demands, self-efficacy, learning experiences, and social support function as influencing conditions. Development and social context form a broader background shaping these processes.

Attentional regulation involves information selection and focus control (S03, S09). Knowledge processing and cognitive demands concern knowledge use, working-memory capacity, and task demands (S06, S07, S09). Inference and validity checking involve reasoning and checking information (S09). Language and perspective understanding concern communication and understanding others' viewpoints (S08, S10, S11). Reflection and self-regulation involve awareness, monitoring, and evaluation (S02, S09, S11). Self-efficacy and learning experiences provide motivational support (S01, S02, S05), while social and environmental support influence thinking (S01, S02, S04, S05, S08).

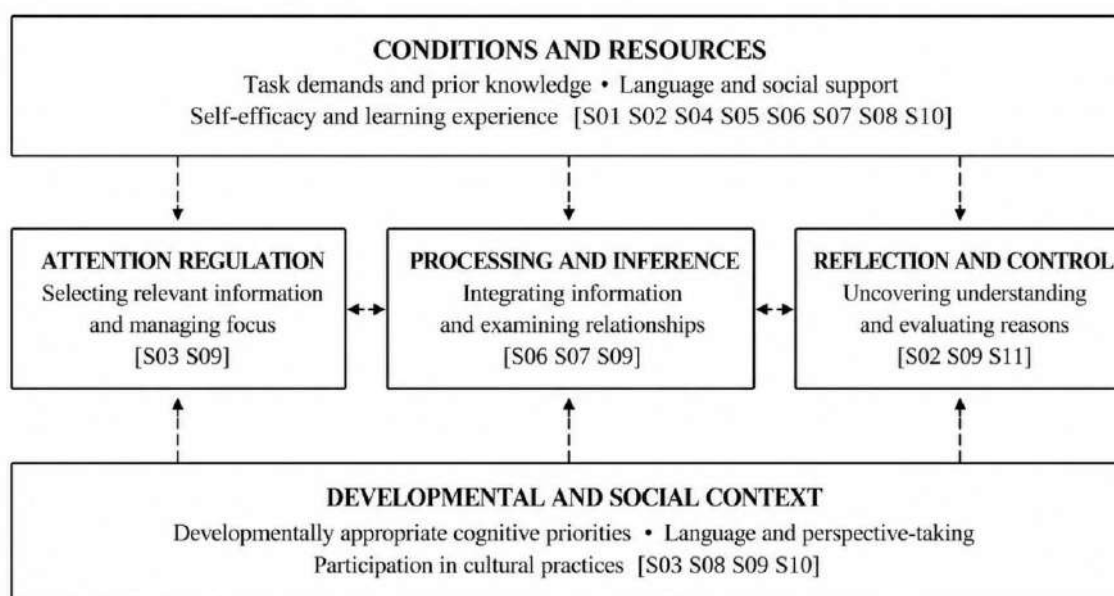
Table 2. Thematic synthesis and study contributions to the thinking-process framework

Synthesis theme	Supporting studies	Synthesis of findings	Conceptual position	Contribution to the framework and observation
Attentional regulation	S03, S09	Information selection and attentional control develop over time and help regulate cognitive activity.	Cognitive process or mechanism.	Basis for attentional regulation. Proposed observations: learners select task-relevant information and redirect focus as needed.
Knowledge processing and cognitive demands	S06, S07, S09	Processing relates to available knowledge, working-memory limitations, task demands, and representational development.	Cognitive processes together with processing resources and conditions.	Basis for examining task-processing relationships. Observe connections between new information and prior knowledge and explanations of conceptual relationships. Measure cognitive load separately.
Inference and validity checking	S09	Inference control and truth or validity checking become important priorities in later thinking development.	Reasoning and cognitive control processes.	Basis for examining reasons. Observe learners providing reasons, checking consistency, and evaluating conclusions against information.
Language and perspective understanding	S08, S10, S11	Language, social participation, and mental-state expressions connect social and cognitive activity.	Representational means, social conditions, and perspective understanding.	Supports interpreting thinking through communication. Observe explanations and responses to others' viewpoints. Clinical categories from S11 require adaptation.
Reflection and self-regulation	S02, S09, S11	Self-regulation, awareness of ability, and mental-state expressions occur in occupational, developmental, and clinical contexts.	Self-regulatory processes and potential verbal evidence; roles differ by context.	Basis for reflection indicators. Observe expressed difficulties, reasons for strategy changes, and evaluations of understanding.
Self-efficacy and learning experiences	S01, S02, S05	Self-efficacy and experience are important constructs in interest, resilience, and leadership research.	Supporting motivational and experiential factors.	Supporting factors in learning activities. Assess self-efficacy separately from the quality of thinking processes.

Synthesis theme	Supporting studies	Synthesis of findings	Conceptual position	Contribution to the framework and observation
Social support and participation environments	S01, S02, S04, S05, S08	Environment, social support, collaboration, and cultural practices contextualize individual and group activity.	Environmental factors and social participation conditions.	Basis for recording task context, assistance, interaction, and group work when observing thinking.
Development of abilities	S03, S09, S10	Attention, representation, inference, awareness, and perspective understanding change across development.	Developmental context across processes.	Basis for adapting task demands and indicators to learner abilities. The framework does not prescribe uniform indicators for all ages.

Integrative framework of thinking processes

The synthesis informed an integrative framework distinguishing core thinking processes from influencing conditions. Three main processes were identified: attentional regulation, processing and inference, and reflection and control. These are conceptualized as mutually interacting processes rather than linear stages.



Dashed arrows = conceptual relationships proposed by the authors.

Source codes indicate supporting studies; all relationships have not been empirically tested.

Figure 3. Integrative framework of thinking processes in learning

The framework indicates that attentional regulation enables learners to select relevant information and manage their focus. Selected information is processed using available knowledge to establish relationships and draw inferences. Reflection and control enable learners to check understanding, assess reasons, and adjust strategies. These processes operate within conditions comprising prior knowledge, task demands, language, social support, self-efficacy, learning experiences, and developmental and social contexts.

The framework represents a conceptual synthesis of 11 studies rather than a validated instrument. Indicators derived from it require further development and empirical testing.

Variation in findings and limitations

Findings varied by participants, contexts, methods, and theoretical foundations. (Zhang, 2023) links self-efficacy with cognitive, emotional, and behavioral engagement. (Krieglstein, 2023) examines cognitive-load measurement, while (Sweller, 2023) advances cognitive load theory through integration with other theories. (Tchombe, 2023) links cultural practices to cognitive development; (Demetriou, 2022) identifies changing cognitive priorities across development. (Bigelow, 2021) highlights language in theory-of-mind development, and (Zangrilli, 2021) develops a framework related to metacognition.

Study limitations concern specific cultural and participant contexts, sample sizes, design variation, and differences in construct measurement. Some studies are conceptual and have not been tested directly in classroom practice. These differences informed a framework that avoids treating all constructs as thinking processes with identical functions.

Overall, the synthesis of 11 studies indicates that thinking in learning is multidimensional and connects cognitive, social, developmental, and metacognitive aspects. The principal finding distinguishes core thinking processes from supporting or influencing conditions, forming the basis of the integrative framework in Figure 3.

DISCUSSION

Characteristics of thinking processes in the literature

The synthesis of 11 studies shows that thinking in learning is multidimensional, involving cognitive, social, developmental, and metacognitive aspects. Thinking requires learners to select and process information, interact with others, adapt to developmental conditions, and monitor their understanding. Zhang (2023), for example, links self-efficacy with cognitive, emotional, and behavioral engagement. In this synthesis, however, affective conditions and learning experiences are treated as influences on thinking rather than as thinking processes themselves.

The cognitive dimension provides a foundation for these processes. Krieglstein (2023) examines information-processing demands through cognitive load, whereas Sweller (2023) emphasizes the relationship between working and long-term memory. Thus, thinking concerns not only what learners do with information but also the knowledge and processing capacity available to them. Prior knowledge and task demands are consequently positioned as supporting conditions rather than independent indicators of thinking. This interpretation is consistent with Yudianto et al. (2026a), who found that task management and teacher guidance shaped students' spatial structuring during geometric problem solving. Task characteristics and instructional support can therefore influence how learners organize and process information without constituting the thinking processes themselves.

The social dimension adds another layer to this explanation. Tchombe (2023) links cultural practices and social interaction to cognitive development, while Bigelow (2021) identifies language as a mediator in the development of perspective understanding. Thinking is therefore not formed solely through internal activity but is shaped through communication, language, and social experience. Within the proposed framework, these factors function as conditions that support or mediate thinking.

Developmental differences further qualify how thinking occurs. Demetriou (2022) identifies changes in cognitive characteristics and priorities across development, while Zangrilli (2021) highlights reflection, monitoring, and evaluation. These findings support a distinction between the processes performed during thinking and the conditions that enable those processes. A similar distinction is evident in Yudianto et al. (2026b), where mathematical reasoning was traced through anticipatory activity and the coordination, checking, and revision of representations during task solving. Such evidence supports viewing thinking as something expressed through learners' actions as they engage with and regulate information, rather than as a direct reflection of underlying cognitive capacity alone.

These findings answer RQ1. Thinking is multidimensional, but its dimensions do not have equivalent conceptual functions. The synthesis identifies three core processes—attentional regulation, processing and inference, and reflection and control—and distinguishes them from supporting conditions, including prior knowledge, task demands, self-efficacy, language, social support, learning experiences, and development. This distinction is important because related constructs should not automatically be treated as interchangeable indicators of thinking.

Contributions and relationships of Vygotsky, Piaget, and Thorndike

Vygotsky, Piaget, and Thorndike contribute different perspectives to the explanation of thinking and learning. Their contributions are therefore treated as complementary rather than as explanations of identical processes.

Vygotsky provides a basis for understanding how thinking is shaped through social interaction, language, and cultural mediation. The role of language identified by Bigelow (2021) and the influence of cultural practices discussed by Tchombe (2023) support this perspective. Its primary contribution to the framework is explaining how social and cultural interaction supports the development and mediation of thinking.

Piaget, in contrast, emphasizes the development and reorganization of cognitive structures. Demetriou (2022) provides related evidence concerning changes in cognitive characteristics and priorities across development. From this perspective, development helps explain why thinking may differ across individuals and developmental periods, but developmental stages are not treated as direct indicators of thinking processes.

Thorndike provides a perspective on the relationship between experience, responses, and consequences in learning. Zhang (2023) provides relevant empirical context through findings concerning self-efficacy, engagement, and learning experiences. These findings should not, however, be interpreted as direct empirical tests of Thorndike's theory. Rather, Thorndike's contribution is used to conceptualize how experience and consequences may influence response tendencies.

The three perspectives are therefore integrated according to their distinct functions: Vygotsky explains social mediation, Piaget explains cognitive-structural development, and Thorndike addresses learning through experience and consequences. Their integration does not create a single construct by merging theoretically distinct concepts. Sweller (2023) likewise illustrates the value of connecting theoretical perspectives while retaining distinctions among their explanatory functions.

These findings address RQ2 by showing that the three theories are complementary rather than substitutive. No single perspective accounts for the full range of processes and conditions identified in the literature. Their integration provides a broader conceptual basis for examining thinking across cognitive development, social interaction, learning experience, and information processing without assuming that the underlying constructs or mechanisms are identical.

Integrative framework of thinking processes

The central contribution of the synthesis is the distinction between core thinking processes and supporting conditions. Across the 11 studies, three processes recur most consistently: attentional regulation, processing and inference, and reflection and control. These processes should not be interpreted as a fixed sequence. Learners may redirect attention when information conflicts with expectations, reconsider an inference, or change a strategy following reflection.

Attentional regulation involves selecting information relevant to the task and maintaining or redirecting focus. Demetriou (2022) and Rueda (2024) emphasize the role of attention in regulating cognitive activity. The selected information is then processed in relation to available knowledge and task demands, consistent with the role of processing capacity and working-memory resources discussed by Krieglstein (2023) and Sweller (2023).

Processing and inference involve establishing relationships, generating explanations, and checking them against available information. Reflection and control concern evaluating understanding and strategies and making adjustments when necessary. The findings of Zangrilli (2021) concerning reflection, monitoring, and evaluation support this metacognitive component.

The three processes are functionally related rather than independent. Attention determines what information receives processing; processing supports the construction of relationships and inferences; and reflection evaluates the resulting understanding and may redirect attention or strategy. The framework therefore represents thinking as a dynamic system of interacting processes, rather than a linear sequence or a collection of separate indicators.

These processes operate within supporting conditions. Prior knowledge and task demands affect processing capacity (Krieglstein, 2023; Sweller, 2023); language and social interaction support understanding and perspective taking (Bigelow, 2021; Tchombe, 2023); development shapes cognitive characteristics (Demetriou, 2022); and self-efficacy and learning experiences influence engagement (Zhang, 2023). The framework consequently separates mechanisms of thinking from conditions that enable or influence them.

This distinction represents the main conceptual contribution of the synthesis. Rather than simply grouping attention, cognitive load, development, language, metacognition, and self-efficacy as components of thinking, the framework assigns them different functional roles and specifies their relationships. The result is a framework that moves from an inventory of related constructs

toward a relational account of how thinking operates in learning.

These findings address RQ3. The synthesis organizes attentional regulation, processing and inference, and reflection and control as core processes that operate within conditions involving prior knowledge, task demands, language, social support, self-efficacy, learning experiences, and development. The framework remains conceptual and has not yet been empirically validated, but it provides a basis for developing operational indicators and testing the proposed relationships.

Theoretical contributions and implications

The theoretical contribution lies in addressing the fragmentation of thinking-process research. Rather than replacing Vygotsky, Piaget, or Thorndike with a new theory, the synthesis organizes their contributions according to their explanatory functions and relates them to contemporary findings on attention, cognitive load, metacognition, language, and self-efficacy.

This distinction also has methodological implications for indicator development. Indicators should not be selected simply as a list of observable behaviors associated with thinking. Their development should follow the relationships among constructs, process functions, supporting conditions, and available empirical evidence. Conceptual specification should therefore precede instrument construction and empirical validation.

Practically, the framework can help distinguish difficulties in a thinking process from conditions that may contribute to those difficulties. For example, a weak response does not necessarily indicate poor inference; it may reflect limited attention, insufficient prior knowledge, high task demands, or limited opportunities for reflection. The framework thus serves as an analytical basis for examining thinking rather than as a checklist of learner abilities.

Limitations and future research

Several limitations should be considered. First, the search was restricted to Scopus and the specified publication criteria, which may have excluded relevant studies. Second, the included studies varied in participants, cultures, educational levels, and research methods, limiting direct generalization across contexts. Third, the proposed framework is conceptual and has not yet been empirically tested. Fourth, measurement challenges associated with constructs such as cognitive load and metacognition may affect subsequent indicator development.

Future research should test whether attentional regulation, processing and inference, and reflection and control can be empirically distinguished and how their relationships vary across age, learning context, and task characteristics. Supporting conditions should also be examined without conflating them with core processes. Subsequent research can then evaluate individual indicators as well as the functional relationships proposed in the framework.

Overall, the synthesis presents thinking in learning as a multidimensional and dynamic system in which cognitive processes interact with social, developmental, metacognitive, and experiential conditions. The main contribution is not the addition of another list of indicators, but the distinction between what constitutes a thinking process and what supports or influences that process. This distinction provides a clearer basis for subsequent indicator development and empirical validation.

CONCLUSION

The review shows that thinking processes in learning consist of three main processes: attentional regulation, processing and inference, and reflection and control. These processes are influenced by prior knowledge, task demands, language, social support, self-efficacy, learning experiences, and development. The findings therefore answer RQ1 by showing that the indicators reported in the literature do not have the same role. Some describe the thinking process itself, whereas others describe conditions that shape how the process occurs.

Vygotsky, Piaget, and Thorndike contribute different perspectives to this understanding. Vygotsky highlights social interaction, language, and cultural mediation; Piaget explains changes in cognitive structures; and Thorndike emphasizes experience and consequences in learning. Their contributions are not treated as one combined theory, but as complementary perspectives for explaining different aspects of thinking. The resulting framework links the three core processes with their supporting conditions and answers RQ2 and RQ3 by specifying their conceptual relationships.

The framework is still conceptual and requires empirical testing. Further research should develop indicators from the three core processes and examine their validity and reliability across different learners, subjects, and learning contexts. The main contribution lies in separating thinking processes from the conditions that influence them, rather than treating all related constructs as indicators of thinking.

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