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Mental Acts Developed in Deep Learning: A Literature Review

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Abstract

Deep learning refers to an educational approach that prioritizes conceptual comprehension and the development of higher order thinking skills, as opposed to surface learning which emphasizes memorization of facts. In this context, mental acts as described by Harel serve as crucial internal cognitive processes, including comparing, relating, generalizing, and abstracting, which support the meaningful construction of knowledge. This study applies a systematic review of literature, drawing on sources from international journals, nationally accredited journals, academic books, and conference proceedings. The data were examined through thematic analysis to identify the forms of mental acts, the instructional strategies that facilitate their emergence, and their influence on deep learning. The review reveals that while mental acts play an important role in fostering critical, creative, and metacognitive thinking, much of the existing research still concentrates on instructional strategies, with limited attention to affective and metacognitive dimensions. This article contributes a conceptual synthesis that situates mental acts as the central element of deep learning and proposes an integrated framework to strengthen educational practices for the twenty first century.

Keywords: Deep learning, Higher order thinking skills, Mental acts.

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1. Introduction

Deep learning is a pedagogical paradigm that emphasizes meaningful understanding and the interconnectedness of concepts (Mu'ti, 2025). Unlike surface learning, which tends to focus on mechanical and short-term acquisition of information, deep learning requires learners to undergo a transformation in their way of thinking that is more reflective, critical, and able to transfer knowledge into new situations. Mu'ti (2020) emphasize that deep learning occurs when students are actively engaged in constructing meaning, connecting experiences with prior knowledge, and employing higher order thinking strategies in processing information. Thus, deep learning is not merely about academic achievement but represents a cognitive transformation that reshapes how learners comprehend and interpret the world.

Within this framework, the concept of mental acts becomes crucial. According to Harel (2008), a mental act is an internal cognitive activity performed by students when they interact with an object of knowledge. Mental acts are not external actions but mental processes such as comparing, classifying, connecting, generalizing, and abstracting. These activities enable the construction of knowledge, since students do not simply receive information passively but process and internalize it. In other words, mental acts function as an internal mechanism that lies at the core of deep learning.

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Harel distinguishes mental acts from mere mechanical procedures. For example, a student who memorizes a mathematical formula does not necessarily develop a mental act. However, when the formula is used to analyze patterns, compare different approaches, or abstract a general principle from a phenomenon, it is at that point that mental acts are activated. This perspective aligns with constructivist views which argue that knowledge cannot be directly transmitted from teacher to student but must instead be built through the learner's own mental activity.

In educational practice, the urgency of developing mental acts is evident (Akbar et al., 2023). Previous studies indicate that classroom instruction often remains focused on lower order cognitive outcomes, such as remembering and understanding in Bloom's taxonomy. As a result, students are less trained in higher order thinking skills such as analyzing, evaluating, and creating (Li, 2024). Yet, these skills are central to twenty first century education, as reflected in the framework of 21st Century Skills, which highlights critical thinking, creativity, collaboration, and communication. By activating mental acts, learners can achieve deeper conceptual understanding, connect multiple representations of knowledge, and develop more advanced reflective thinking abilities.

Although the literature on deep learning is relatively extensive, specific studies that address mental acts as the internal mechanism underpinning it remain limited. Most existing research focuses on instructional strategies, learning models, or assessment approaches that support deep learning, but few have systematically mapped how mental acts are developed during learning processes and how they contribute to deep learning outcomes. This represents a research gap in the field, as there is a pressing need to integrate the theory of mental acts with deep learning practices in order to gain a more comprehensive understanding of their relationship.

Moreover, prior research has tended to highlight mental acts primarily from a cognitive perspective, while the affective and metacognitive dimensions that often accompany these mental processes have been less explicitly addressed. In fact, emotional engagement, motivation, and learner self-awareness of their own thinking processes are important factors that can enhance the effectiveness of mental acts (Nugroho et al., 2018). In the Indonesian educational context, the implementation of the Merdeka Curriculum also presents distinct challenges. The curriculum emphasizes the strengthening of the Pancasila Student Profile, which prioritizes critical thinking, creativity, and independent learning. However, a more clearly articulated conceptual framework is still required to operationalize how mental acts can be systematically integrated into the implementation of deep learning at schools and universities.

Therefore, this study offers novelty in two key aspects. First, it provides a literature review that specifically focuses on mental acts within the context of deep learning, a field that has not been extensively explored. Second, it proposes a conceptual framework that positions mental acts as a central element of twenty first century learning, encompassing not only cognitive dimensions but also affective and metacognitive aspects in the development of meaningful learning. In this way, the study is expected to contribute theoretically to the advancement of educational scholarship, while also offering practical insights for designing more effective instructional strategies to foster deep understanding among learners.

2. Method

This study employs a systematic literature review approach with the aim of identifying, analyzing, and synthesizing previous research related to mental acts in the context of deep learning. The selection of this approach is based on the consideration that the issue of mental acts, although introduced by Harel, has not yet been extensively explored within the framework of contemporary learning. Thus, a literature review serves as an appropriate methodological

strategy to map conceptual developments, uncover interconnections among studies, and highlight the existing gaps in academic discourse. The data sources in this study consist of reputable international journal articles indexed in Scopus, Web of Science, Springer, Taylor & Francis, and ScienceDirect, as well as nationally accredited journals ranked Sinta 1 to Sinta 3. In addition, relevant academic books and conference proceedings are also included to enrich perspectives.

In the literature search process, several keywords were used, such as deep learning in education, mental acts, Harel mental acts, constructivist learning, and higher-order thinking. These keywords were combined with Boolean operators to either broaden or narrow the search results as needed. From this search, a selection process was carried out using inclusion and exclusion criteria. Relevant articles include those that discuss deep learning, mental acts as proposed by Harel, constructivist learning theory, or instructional strategies emphasizing the development of higher-order thinking skills. Conversely, popular non-academic articles, publications that did not undergo peer review, or descriptive works with no relevance to the research theme were excluded from the analysis. The collected data were then analyzed using a thematic analysis approach. Each piece of literature was read thoroughly and coded according to emerging themes, such as the conceptual framework of mental acts, the various forms of mental acts manifested in deep learning, instructional strategies that encourage students' mental engagement, and the relationship between mental acts and critical, creative, as well as metacognitive thinking skills. From this analysis, a synthesis was carried out to identify patterns, similarities, and differences across the findings of previous studies.

To ensure validity and reliability, the selection of literature was carefully conducted with double verification by independent reviewers to confirm the relevance of articles to the research topic. Moreover, the coding of themes was subjected to cross-checking so that the interpretation of findings would not rely solely on the researcher's subjectivity. The final outcome of this procedure is a conceptual map that presents the integration of knowledge regarding mental acts in deep learning, identifies persisting research gaps, and formulates a new conceptual framework expected to provide both theoretical and practical contributions to the development of twenty-first century learning strategies.

3. Results

3.1. Deep Learning as a Framework for Higher-Order Thinking

The rapid process of globalization has transformed the cultural structure and social life of societies. The significant advancements across various fields have driven people to develop life skills that are relevant to the characteristics of the twenty-first century. Distinctive features of life in this century include the acceleration of change, continuous innovation, large-scale shifts, and the deepening integration of technology into everyday life (Erdem et al., 2019; O'Neil, 2001). Crawford (1991) refers to the twenty-first century as the Era of Human Capital. This era underscores the notion that human beings themselves constitute the primary capital or the key factor determining the success of a nation in confronting the major transformations of this century. In Indonesia, the concept of human capital plays a central role in the transition from an agrarian society to an industrial society, which subsequently leads to the formation of a knowledge society. This line of thought explicitly suggests that the paradigm, objectives, governance, and practices of national education, as instruments to produce high-quality human resources, must be aligned with the demands and competencies required by the age. With the growing complexity of social life, individuals are required to master certain competencies in order to adapt to rapid change. These competencies are commonly referred to as twenty-first century competencies.

National Research Council (2012), twenty-first century competencies consist of three main dimensions: the cognitive dimension, the intrapersonal dimension, and the interpersonal dimension. The cognitive dimension encompasses critical thinking, mastery of knowledge, and the development of creativity. The intrapersonal dimension involves intellectual openness, self-awareness, work ethic, and the ability to conduct positive self-evaluation. Meanwhile, the interpersonal dimension focuses on skills in teamwork, collaboration, and leadership. The Organisation for Economic Co-operation and Development (2017) also notes that twenty-first century competencies include critical thinking, creativity, inquiry, initiative, perseverance, information use, systemic thinking, as well as communication and reflection. Furthermore, other essential competencies for global citizens today include creativity, critical thinking, problem-solving, communication, collaboration, and digital literacy (Mutohhari et al., 2021). This argument underscores the importance of preparing students with the skills required to face the challenges of life, work, and citizenship in the twenty-first century. Such skills encompass critical thinking, problem-solving, collaboration and leadership abilities, as well as adaptability and entrepreneurial skills.

In responding to the challenges of twenty-first century life, Trilling & Fadel (2009) assert that classroom learning approaches must be transformed to meet the demands of twenty-first century competencies. The quality of classroom content and teaching context plays a pivotal role in shaping the future development of a nation. Consequently, improving the quality of classroom instruction should be a top priority for societies oriented toward progress. This perspective emphasizes that the framework of classroom learning should focus on didactic and pedagogical processes that enhance critical thinking, creativity, reasoning, collaboration, and other essential competencies needed by students both in the present and in the future (Demircioglu et al., 2023).

Deep learning is one approach that can facilitate the development of higher-order thinking skills that are indispensable in today's world. This approach emphasizes not only the acquisition of knowledge but also the cultivation of critical and creative thinking, as well as the capacity to adapt and solve problems in diverse real-life contexts (Langer, 1993). Deep learning refers to a profound understanding of the subject matter, which involves more complex cognitive processes such as analysis, elaboration, synthesis, and evaluation. It is not solely oriented toward final outcomes but also toward the learning process itself, enabling students to think critically and reflectively while developing the ability to solve more complex problems. Such learning is highly necessary in the twenty-first century, where both the workplace and society demand individuals who not only possess knowledge but also demonstrate the skills to innovate, collaborate, and think systematically (Sidiq et al., 2021).

Deep learning, which is oriented toward nurturing higher-order thinking abilities, is an essential need because human life consists of interconnected aspects that require comprehensive understanding. Deep thinking processes are necessary for addressing personal challenges, managing disruptive emotions, abandoning detrimental habits, handling finances, fulfilling responsibilities, and planning for the future (Mu'ti, 2025). Furthermore, deep learning contributes to helping individuals reflect upon and strengthen values and beliefs, build positive interpersonal relationships, make sound decisions, and understand the dynamics of politics, opportunities, health, security, and lived experiences. Thus, deep learning not only broadens knowledge but also equips individuals with the cognitive skills to process information incisively, make wise decisions, and act appropriately in complex situations. At the same time, it fosters essential attitudes and values for adapting to social change, making it a strategic approach for preparing a generation capable of facing the challenges of the twenty-first century with skills that are

relevant for both the present and the future.

3.2. Principles of Deep Learning in Education

Three core principles embedded in the deep learning process are mindful, meaningful, and joyful (Kemdikbud, 2025). The first principle, mindful, refers to conducting learning with full awareness. In classroom contexts, mindfulness is reflected in an open learning process where students are given the opportunity and guidance to view issues from multiple perspectives (Mu'ti, 2020). According to Langer (1993), mindfulness is a mental state arising from new understandings, the ability to view information from different angles, and sensitivity to context. It represents an open, creative, and possibility-filled mindset in which individuals can discern differences in seemingly similar things as well as similarities in things previously considered different. Through this process, students can grow into creative individuals.

Mindfulness is the ability to perceive a situation or environment from diverse perspectives. When we are mindful, we recognize that no single perspective is absolutely correct, but that multiple viewpoints exist for the same situation. Mindfulness involves seeing a situation from various angles, aligning with the constructivist theories of Jean Piaget and Lev Vygotsky, who emphasize the importance of active and personal learning in which students actively construct knowledge through experiences and interactions with their environment (Piaget, 1950; Vygotsky, 1978). Mindful learning also includes self-awareness, enabling students to understand their own thought processes and to overcome obstacles that emerge in their learning.

Meanwhile, according to Shapiro & Carlson (2017), mindful learning focuses on enhancing self-awareness and reflection throughout the learning process. They argue that by developing the ability to observe thoughts and feelings during learning, students can become more aware of how they process information and respond to challenges. Mindful learning encourages students to avoid automatic thought patterns and replace them with more reflective approaches, enabling them to identify and critically assess their understanding. This process also involves ongoing self-awareness of how they learn and manage barriers in learning.

The second principle, meaningful, emphasizes the importance of discovering meaning within the learning process and connecting it to real-life situations. It must be recognized that learning is not merely about memorizing facts but about understanding the value of the knowledge acquired and how it can be applied to solve problems relevant to everyday life. Constructivist theories by Piaget and Vygotsky also support this principle, as they argue that knowledge develops through social interaction and continuous reflection, allowing students to connect new knowledge with preexisting cognitive structures.

The third principle, joyful, highlights the importance of appreciating the achievement of understanding and the application of knowledge. In this approach, students are encouraged to celebrate the process of discovering meaning and recognizing how knowledge benefits society. This concept aligns with self-determination theory by Deci & Ryan (1985), which shows that intrinsic motivation and satisfaction in learning occur when individuals feel they have control over their learning process and experience positive outcomes from their achievements. Through this enjoyable approach, students are not only motivated to learn more effectively but also experience the emotional and social benefits of the knowledge they gain.

The principles of being mindful, meaningful, and joyful in the learning process must be pursued so that they work together and simultaneously. These three principles cannot be viewed separately or partially if deep learning is to function optimally. Deep learning not only encompasses the mastery of academic content but also focuses on the development of students' social, emotional, and cognitive skills. By emphasizing full awareness, the search for meaning,

and an appreciation of the learning process, deep learning creates a more meaningful and holistic educational experience. This approach not only enriches students' understanding of the material but also encourages them to connect it with real-life contexts, making it more relevant, enjoyable, and impactful for their development as individuals and as members of society.

3.3. Deep learning as a constructivist learning practice

Deep learning in the context of education is essentially a direct derivative of constructivist learning theory. As a learning approach, deep learning emphasizes the importance of students' active engagement in constructing knowledge at a deeper level through critical thinking, reflection, and the integration of new material with prior experiences and knowledge. This is consistent with the fundamental assumption of constructivism, which views knowledge not as something passively transferred from teacher to student, but as something actively constructed by individuals through interaction with their environment and learning experiences. Thus, deep learning can be understood as the practical manifestation of constructivist principles that highlight meaningful, collaborative learning oriented toward conceptual understanding rather than mere memorization of facts.

Constructivism is a paradigm about how individuals learn. Constructivism views knowledge as something that can only be acquired through an individual's interaction with the environment. In the context of classroom learning, constructivism regards students as active subjects who must be fully engaged in the construction of knowledge. At its core, constructivism emphasizes that learners build new knowledge based on what they have previously learned (Bada & Olusegun, 2015). It also stresses the importance of individuals constructing their own understanding and knowledge of the world through experiences and reflection on those experiences (Bereiter, 1994). This perspective stands in contrast to the view of learning as a passive transmission of information from one individual to another, where the focus lies on receiving information rather than constructing knowledge.

According to Thampinathan (2022), there are five main principles within constructivist learning theory. The first principle is that knowledge is built upon existing knowledge. Thus, knowledge must evolve through new experiences rather than being passively received. The second principle states that learning occurs through an active process. Students are not empty vessels that merely receive knowledge; instead, they must engage with real-life examples and direct experiences to construct understanding of the subject matter. The third principle highlights that knowledge is acquired as a social construction. This assumption implies that students must be directly involved in social interaction and collaborative activities, both with peers and with teachers.

The fourth principle emphasizes valuing multiple perspectives, recognizing that each learner has different viewpoints. Learning is subjective, with varied interpretations for every individual. This principle is vital in creating a constructivist learning environment, where educators can provide appropriate support tailored to each student's needs. The fifth principle in constructivist theory relates to mental models of learning, where individuals are in a continuous process of growth. Students are constantly building and developing new connections and perceptions of reality. Over time, they gain new experiences and interpret the world in their own unique ways. This enables learners to revise their perspectives with each new experience. Furthermore, students can reflect on new learning materials and connect them with their real-life contexts, thereby helping them develop stronger connections and plan learning more holistically.

Although constructivist classrooms emphasize students' active role in knowledge construction, the constructivist teacher plays a key role in creating classroom situations that stimulate students'

mental activity, allowing learning to occur. Brooks & Brooks (1999) proposed twelve strategies for becoming a constructivist teacher: (1) encouraging and accepting student autonomy and initiative; (2) using raw data and primary sources alongside manipulative, interactive, and physical materials; (3) designing tasks with cognitive terms such as classifying, analyzing, predicting, and creating; (4) allowing student responses to shape lessons, adapting teaching strategies, and adjusting content; (5) asking students about their understanding of concepts before sharing the teacher's own; (6) encouraging student engagement in discussions with both teachers and peers; (7) stimulating curiosity by asking open-ended questions and encouraging students to question one another; (8) asking students to further elaborate on their answers; (9) engaging students in experiences that challenge their initial hypotheses and invite discussion; (10) providing wait time after posing questions; (11) giving students time to build connections and create metaphors; and (12) nurturing students' natural curiosity by frequently using the learning cycle model.

3.4. Fundamental Principles of Designing Didactic Situations

Steffe's (1991) exposition provides an illustration that in order to acquire knowledge, students must pass through a series of progressive and interconnected situations. In this context, the teacher plays a crucial role in modifying situations so as to stimulate students' mental actions. Practically, in the learning process, Suryadi (2010) argues that the process of instruction should begin with the presentation of a problem that challenges students and thereby generates mental activity. Such problems may relate to the discovery of concepts, procedures, problem-solving strategies, or mathematical rules. It is important to note that in the stage of presenting problems, teachers must be careful in selecting problems so that they can stimulate students' cognitive development. Brousseau (2002) emphasizes that problems given by teachers to students should be contextualized and personalized. In this regard, (Vygotzky, 1978) offers the framework of the zone of proximal development (ZPD), which represents the difference between what students can do independently and what they can accomplish with the assistance of others. Thus, problems that are able to trigger students' mental actions are those situated within the ZPD, i.e., problems that can be solved by students through guidance from others.

As Steffe & Ulrich (2020) state, since students must pass through a sequence of progressive situations, a dynamic and systematic environment is required to enable students to engage with situations aligned with the predetermined goals of mathematics learning. In other words, a well-structured situation should not only stimulate students' mental activity but also direct it toward specific objectives. To achieve this aim, teachers must anticipate students' possible responses by employing scaffolding techniques in order to create situations consistent with didactic sequences and students' cognitive structures (Akbar et al., 2025). Such scaffolding can help reduce learning obstacles, guide students' thinking along the expected learning trajectory, provide further challenges so that desired mental actions may occur, or support students when such mental actions fail to emerge (Suryadi, 2010; Steffe, 1991).

Moreover, another principle relevant to the framework of ZPD and scaffolding is the Theory of Didactic Situations (TDS). TDS is a framework developed by Brousseau (1997) that focuses on how learning situations can be designed to effectively facilitate the teaching of mathematics. This theory emphasizes the interaction between teachers, students, and learning materials within didactic contexts. In TDS, learning mathematics is regarded as a process whereby students actively construct knowledge through their engagement in specific situations (both didactic and adidactic). TDS categorizes didactic situations into five phases: devolvement, action, formulation, validation, and institutionalization.

In practice, the teacher's role is crucial in supporting students throughout the learning

process. This is due to the fact that the flow of TDS often experiences disruptions during instruction (Hortelano & Prudente, 2024). Such disruptions frequently arise from variations in students' responses to the didactic situations created during the learning process (Steffe, 1990). Indeed, the validation phase was carried out after the institutionalization phase to measure student learning at the end of a lesson, serving as an assessment component within lesson planning and offering an alternative approach to implementing the phases and structuring mathematics lesson sequences.

In addition to the didactic situation framework, another important aspect that teachers must consider in lesson planning is the presence of learning obstacles (Silo et al., 2021). Learning obstacles are categorized into ontogenic, didactic, and epistemological obstacles. Ontogenic obstacles refer to difficulties experienced by students due to psychological factors, particularly their mental readiness. Students who have not yet reached a certain age or developmental stage tend to encounter learning difficulties. Didactic obstacles may also occur, caused by errors in the presentation of instructional material. Such errors can lead to student misconceptions, often stemming from inappropriate or inaccurate delivery of concepts that do not match students' levels of readiness. On the other hand, epistemological obstacles arise when students lack comprehensive understanding of a concept, perceiving it only from the perspective of its origins. This type of obstacle aims to identify areas in the learning process that require adjustment in order to enhance students' productive capabilities as intended.

4. Conclusion

This research affirms that deep learning is a direct derivation of constructivist learning theory which emphasizes meaningful learning through the active involvement of learners in the construction of knowledge. The principles of mindful, meaningful, and joyful learning are identified as essential foundations that must work simultaneously in order for the learning process to produce not only mastery of academic content but also the development of social, emotional, cognitive, and metacognitive skills.

The review of literature demonstrates that mental actions such as comparing, connecting, generalizing, and abstracting hold a central role in fostering the ability to think critically, creatively, and reflectively. Nevertheless, previous studies have largely concentrated on the instructional dimension, while the affective and metacognitive aspects have not yet been explored in sufficient depth. Based on these findings, this study concludes that deep learning should be conceptualized as an integrative pedagogical practice which incorporates cognitive, affective, and social dimensions. This perspective is highly relevant to the demands of twenty first century competencies and simultaneously provides a conceptual framework that places mental action at the very core of the learning process. In practical terms, the development of instructional strategies rooted in deep learning needs to be directed toward the creation of contextual, collaborative, and transformative learning experiences that enable learners to construct meaningful knowledge while connecting it with real life contexts.

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