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The Advance Organizer Model in Learning: A Systematic Literature Review

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ABSTRACT:

This systematic literature review examines the implementation and effectiveness of the Advance Organizer Model across diverse educational contexts. Grounded in David Ausubel's theory of meaningful verbal learning, the model emphasizes the role of learners' cognitive structures in supporting the acquisition and retention of new knowledge. This review synthesizes empirical studies indexed in major academic databases, including Scopus and Google Scholar, published between 2018 and 2025. The analysis identifies core characteristics of advance organizer implementation, evaluates its effects on learning outcomes, critical thinking, and collaborative learning, and compares variations in effectiveness across educational levels and subject areas. Overall, the evidence indicates that advance organizers enhance conceptual understanding, strengthen long-term retention, and foster meaningful learning by linking prior knowledge with new information. The model appears particularly effective when integrated with collaborative learning strategies and technology-enhanced environments. However, successful implementation is influenced by multiple factors, such as organizer design quality, learner characteristics, and instructional context. This review contributes evidence-based insights for educators and researchers by outlining practical implementation considerations and highlighting gaps for future research. The synthesis suggests that advance organizers remain a relevant pedagogical tool in 21st-century education, adaptable to both traditional and digital learning settings, and supportive of higher-order thinking skills needed in contemporary learning.

Keywords: Advance Organizer; Critical Thinking; Collaborative Learning; Learning Outcome; Meaningful Learning.

ABSTRAK:

Tinjauan literatur sistematis ini mengkaji implementasi dan efektivitas Model *Advance Organizer* dalam pembelajaran di berbagai konteks pendidikan. Berdasarkan teori pembelajaran verbal bermakna David Ausubel, Model *Advance Organizer* menekankan pentingnya struktur kognitif dalam memfasilitasi akuisisi dan retensi pengetahuan. Melalui analisis komprehensif terhadap studi empiris yang terindeks dalam basis data akademik utama termasuk Scopus dan Google Scholar, tinjauan ini mensintesis temuan penelitian tentang penerapan *advance organizer* dalam setting pendidikan yang dipublikasikan antara tahun 2018 hingga 2025. Tinjauan ini mengidentifikasi karakteristik kunci implementasi *advance organizer*, mengkaji dampaknya terhadap hasil belajar, keterampilan berpikir kritis, dan pembelajaran kolaboratif, serta membahas variasi efektivitas di berbagai jenjang pendidikan dan bidang studi. Temuan menunjukkan bahwa *advance organizer* secara signifikan meningkatkan pemahaman konseptual siswa, memperbaiki retensi jangka panjang, dan mempromosikan pembelajaran bermakna dengan menjembatani pengetahuan awal dengan informasi baru. Model ini menunjukkan efektivitas khusus ketika dikombinasikan dengan pendekatan pembelajaran kolaboratif dan lingkungan yang diperkaya teknologi. Namun, keberhasilan implementasi bergantung pada faktor-faktor seperti desain organizer, karakteristik pembelajar, dan konteks instruksional. Tinjauan ini berkontribusi pada bidang ilmu dengan menyediakan wawasan berbasis bukti bagi pendidik dan peneliti terkait strategi implementasi optimal dan mengidentifikasi kesenjangan untuk penelitian masa depan. Sintesis ini mengungkapkan bahwa advance organizer tetap menjadi alat pedagogis yang berharga di abad ke-21, dapat diadaptasi baik untuk lingkungan pembelajaran tradisional maupun digital, dan efektif dalam mengembangkan keterampilan berpikir tingkat tinggi yang esensial untuk pendidikan kontemporer.

Kata Kunci: *Advance Organizer*; Pembelajaran Bermakna; Hasil Belajar; Berpikir Kritis; Pembelajaran Kolaboratif.

INTRODUCTION

Learning requires students to integrate new knowledge with their existing cognitive structures. However, traditional instruction often focuses on information transfer without providing adequate conceptual frameworks, leading to rote memorization, misconceptions, and shallow understanding (Ausubel, 1960; Joyce et al., 2000). This challenge has become increasingly critical in 21st-century education, which emphasizes conceptual understanding, critical thinking, and meaningful learning (Albina et al., 2022; Nofriansyah et al., 2025; Rahayu & Nofriansyah, 2024).

Education plays a crucial role in shaping the quality of human resources, as it enables individuals to develop intellectual potential, skills, and character needed to face the advancement of science and technology (Meirani et al., 2026; Saripah et al., 2025; Nofriansyah et al., 2022; Nofriansyah et al., 2024; Nofriansyah et al., 2025). It also serves as a fundamental foundation for social, economic, and cultural development in modern society (Riyadi et al., 2025; Rahayu et al., 2025; Nofriansyah et al., 2024). In the context of modern education, the learning process is no longer solely oriented toward content delivery but also toward the holistic development of students' competencies, including higher-order thinking skills, problem-solving abilities, and the strengthening of connections between prior knowledge and new knowledge (Supriatna et al., 2025; Rahayu et al., 2025; Nofriansyah et al., 2018; Nofriansyah et al., 2025). Therefore, learning models are needed that can facilitate the systematic structuring of knowledge, enabling students to understand concepts in a deep and sustainable manner.

The Advance Organizer Model, developed by David Ausubel, addresses this challenge by emphasizing the importance of initial organization in helping students understand new material more structurally and meaningfully (Gunawan et al., 2020; Elbyaly et al., 2023). The model is grounded in Ausubel's theory of meaningful verbal learning, which posits that learning occurs when new information is anchored to existing cognitive structures through a process of subsumption (Ausubel, 1968). Advance organizers serve as cognitive bridges, providing an "ideational scaffolding" for new learning material (Ausubel, 1960).

Numerous empirical studies have examined the effectiveness of advance organizers across various subjects and educational levels. Stone (1983) conducted a meta-analysis of 29 reports yielding 112 studies and found that advance organizers were consistently associated with increased learning and retention. More recent reviews by Blown and Bryce (2023) have re-examined Ausubel's theory in light of developments in cognitive neuroscience, suggesting that while the fundamental principles remain valid, our understanding of cognitive structure and memory recall has evolved significantly.

Despite extensive research, findings remain scattered across multiple publications with varying foci, methodologies, and contexts. Some studies demonstrate significant improvements in conceptual understanding and learning outcomes (Hamdanillah et al., 2017; Harjono et al., 2018), while others show context-dependent or limited effects. Research has explored advance organizers in combination with concept mapping (Rahayu & Widodo, 2010), technology integration (Wahyuni, 2017; Elfeky & Elbyaly, 2019), and flipped classroom environments (Elfeky & Elbyaly, 2019). However, systematic syntheses examining the model's effectiveness across diverse contexts remain limited.

This systematic literature review addresses this gap by providing a comprehensive, structured examination of advance organizer research. Unlike previous individual experimental studies

or context-specific investigations, this review synthesizes empirical findings to identify topic trends, implementation characteristics, and emerging patterns in advance organizer research. The review specifically examines three critical areas: (1) the impact of advance organizers on learning outcomes, (2) their influence on critical thinking skills development, and (3) their role in facilitating collaborative learning. By adopting a systematic approach, this study contributes evidence-based knowledge mapping and theoretical insights for both practitioners and researchers.

The research questions guiding this systematic review are: (1) What are the characteristics of research conducted on the Advance Organizer Model in learning? (2) In what educational contexts has the model been implemented, and with what variations? (3) What patterns emerge in research findings regarding the model's effectiveness on learning outcomes, critical thinking skills, and collaborative learning? The findings aim to serve as a reference for educators in understanding the position of the Advance Organizer Model in contemporary learning research and to direct future investigations in this field.

RESEARCH METHOD

Research Design

This study employs a systematic literature review approach to comprehensively examine the application of the Advance Organizer Model in learning contexts. A systematic literature review is a rigorous, transparent, and replicable method for synthesizing research evidence (Kraus et al., 2020). This methodology was selected to provide an evidence-based synthesis of the current state of knowledge regarding advance organizer implementation and effectiveness across diverse educational settings.

Search Strategy and Data Sources

A comprehensive literature search was conducted using multiple academic databases, primarily Scopus and Google Scholar, which provide extensive coverage of peer-reviewed publications in education and related fields. The search strategy employed Boolean operators and specific keywords related to "advance organizer", "meaningful learning", "Ausubel", "learning outcomes", "critical thinking", and "collaborative learning". The search covered publications from January 2018 to December 2025 to capture contemporary research while maintaining relevance to current educational practices.

Inclusion and Exclusion Criteria

Studies were included if they: (1) focused on the Advance Organizer Model or advance organizer strategy in educational settings, (2) reported empirical findings with clear methodologies, (3) were published in peer-reviewed journals or conference proceedings, (4) were written in English or Indonesian, and (5) examined learning outcomes, cognitive skills, or instructional effectiveness. Studies were excluded if they: (1) lacked clear empirical data, (2) focused solely on theoretical discussions without implementation evidence, (3) were duplicate publications, or (4) did not directly address advance organizer implementation or effectiveness.

Data Analysis

Data from selected studies were systematically extracted and analyzed using thematic synthesis. Key information extracted included: study characteristics (authors, year, location, educational level), research design and methodology, participant characteristics, advance organizer implementation details, outcome measures, and main findings. The analysis focused on identifying patterns, trends, and variations in advance organizer implementation and effectiveness across different contexts, subjects, and student populations.

The PRISMA flow diagram (Figure 1) illustrates the systematic search and selection process employed in this review. The initial database search yielded 247 records from Scopus and Google Scholar. After removing 49 duplicates, 198 records were screened based on title and abstract, resulting in the exclusion of 143 records that were either not relevant to advance organizer implementation or were purely theoretical without empirical data. The remaining 55 full-text articles were assessed for eligibility, with 18 articles excluded due to insufficient methodological detail or inadequate quality. The final synthesis included 37 studies that met all inclusion criteria and provided robust empirical evidence regarding advance organizer effectiveness in educational contexts. This rigorous selection process ensures that the review is based on high-quality, relevant research.
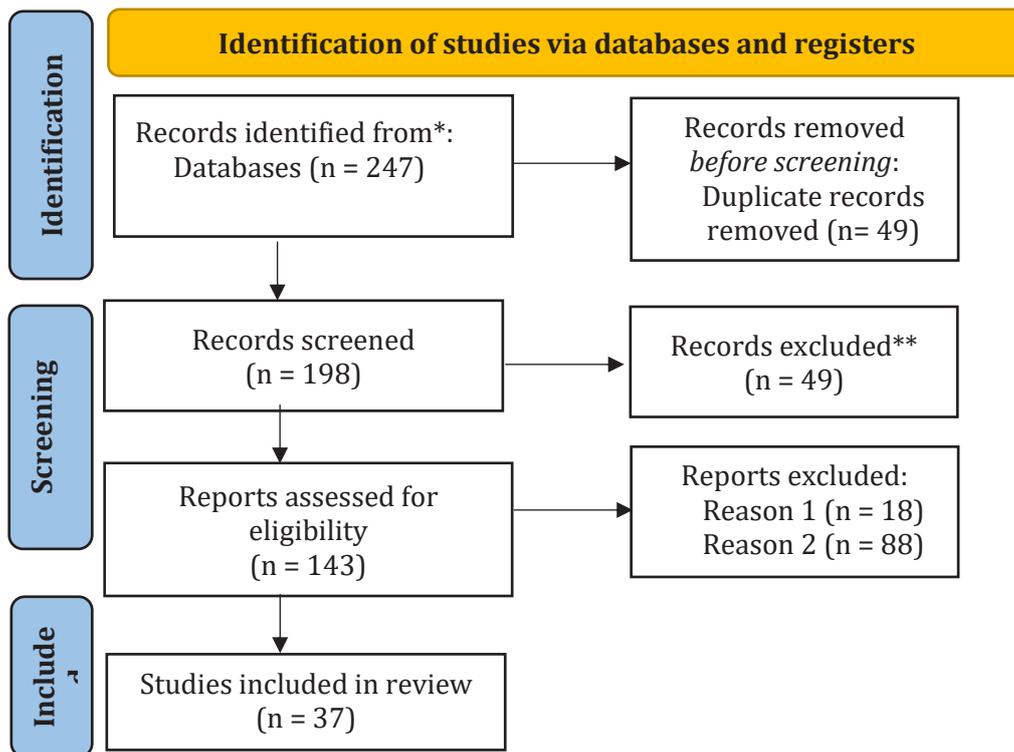

Figure 1. PRISMA 2020 Flow Diagram for Systematic Review
(Source: Page et al., 2021)

RESULTS AND DISCUSSION

Conceptual Framework of the Advance Organizer Model

The Advance Organizer Model is rooted in David Ausubel's theory of meaningful verbal learning, which emphasizes the primacy of cognitive structure in the learning process. Ausubel

defined cognitive structure as an individual's knowledge about a particular subject domain at a specific time, including its organization, clarity, and stability (Ausubel, 1968). The model operates on the principle that the most significant factor influencing learning is what the learner already knows, and instruction should commence accordingly (Ausubel et al., 1978).

Advance organizers are instructional materials presented at a higher level of abstraction, generality, and inclusiveness than the learning task itself (Ausubel, 1960). They serve as cognitive bridges or "ideational anchors" that provide a conceptual framework for integrating new information into existing knowledge structures. Unlike simple introductions or overviews, advance organizers deliberately activate and make explicit the relevant aspects of existing cognitive structure to facilitate the meaningful reception and retention of new material (Joyce et al., 2000).

Research distinguishes between two types of advance organizers: expository and comparative (Ausubel, 1978). Expository organizers are used when learning material is entirely unfamiliar to students, providing new knowledge at a higher level of abstraction to serve as anchoring concepts. Comparative organizers are employed when students have some familiarity with the topic, helping them discriminate between new and existing ideas by highlighting similarities and differences. The selection of organizer type should be based on learners' prior knowledge and the nature of the content to be learned (Mayer, 1979; Joyce et al., 2000).

Contemporary research by Blown and Bryce (2023) has re-examined Ausubel's theory in light of advances in cognitive neuroscience and memory research. They note that while Ausubel's fundamental principles remain valid, our understanding of memory as involving creative, dynamic, and generative processes adds complexity to how we interpret learners' responses and the mechanisms through which advance organizers facilitate learning. This updated perspective suggests that advance organizers may function not only through subsumption but also through schema activation and elaborative processing.

Syntax and Implementation of the Advance Organizer Model

Joyce et al. (2000) identified three distinct phases in implementing the Advance Organizer Model, each serving specific cognitive and instructional functions. Phase One: Presentation of the Advance Organizer involves (1) clarifying the aims of the lesson to establish clear learning expectations, (2) presenting the advance organizer itself, which provides the conceptual framework, and (3) prompting awareness of relevant learner knowledge and experience to activate existing cognitive structures (Joyce et al., 2000). This initial phase is critical as it establishes the cognitive scaffolding upon which new learning will build.

Phase Two: Presentation of Learning Task or Material focuses on delivering the actual content to be learned. Teachers must (1) present the learning material explicitly and in an organized logical sequence, (2) maintain learner attention throughout the presentation, (3) make the organization of the learning material explicit to students, and (4) maintain this logical order consistently (Joyce et al., 2000). Research by Stone (1983) and subsequent meta-analyses have confirmed that the organization and clarity of material presentation significantly influence the effectiveness of advance organizers.

Phase Three: Strengthening Cognitive Organization aims to help learners actively integrate new material into their existing cognitive structures. This phase involves (1) using principles of

integrative reconciliation to help students see relationships between new and prior knowledge, (2) promoting active reception learning through questioning and elaboration, (3) eliciting a critical approach to the subject matter by encouraging students to examine assumptions and contradictions, and (4) clarifying understanding through additional information or application to new situations (Joyce et al., 2000). Contemporary applications have expanded this phase to include collaborative discussion and metacognitive reflection (Sunasuan & Songserm, 2021).

Recent implementations have demonstrated flexibility in adapting the basic three-phase structure to various contexts. Elfeky and Elbyaly (2019) integrated advance organizers into flipped classroom environments, where the organizer was embedded in pre-recorded lectures to guide independent learning. Aziz (2025) incorporated advance organizers into reading comprehension instruction for Madrasa students, adapting the model to align with Islamic pedagogical values while maintaining its core cognitive principles. These adaptations demonstrate the model's versatility and continued relevance in diverse educational settings.

Impact of Advance Organizers on Learning Outcomes

Empirical research consistently demonstrates that advance organizers enhance learning outcomes across diverse educational contexts and subject areas. Stone's (1983) meta-analysis of 112 studies found that advance organizers were associated with increased learning and retention of material, though effect sizes varied depending on organizer design and implementation quality. More recent research has confirmed and extended these findings, particularly in science, mathematics, and language learning domains.

In science education, multiple studies document significant positive effects of advance organizers on learning outcomes. Hamdanillah et al. (2017) found that advance organizer-based video instruction improved physics learning outcomes among grade 11 students. Similarly, Harjono et al. (2018) reported enhanced physics achievement when advance organizers were combined with expository instruction in a lesson study format. Gunawan et al. (2020) demonstrated that inquiry learning combined with advance organizers significantly improved students' problem-solving abilities in physics. These findings suggest that advance organizers are particularly effective in science education, where connecting new concepts to prior knowledge is essential for understanding complex phenomena.

Research in mathematics education reveals similar patterns. Studies examining advance organizers combined with concept mapping have shown enhanced mathematics achievement, particularly in helping students understand the relationships between mathematical concepts and procedures. The integration of visual organizers with mathematical content appears particularly effective in supporting conceptual understanding and procedural fluency (Laurens et al., 2019).

In language learning contexts, advance organizers have demonstrated effectiveness in enhancing reading comprehension and vocabulary acquisition. Aziz (2025) conducted a longitudinal study with Madrasa students and found that a structured advance organizer intervention significantly improved reading comprehension, main idea identification, and inference drawing. The study reported effect sizes indicating substantial improvements in textual understanding. Sunasuan and Songserm (2021) found that advance organizers facilitated meaningful learning of new concepts among ESL learners when combined with collaborative classroom approaches.

The mechanism through which advance organizers enhance learning outcomes appears to involve multiple cognitive processes. Research suggests that organizers: (1) activate relevant prior knowledge, making it available for integration with new information (Ausubel, 1960), (2) provide an organizing framework that reduces cognitive load during learning (Mayer, 1979), (3) facilitate elaborative processing by making relationships between concepts explicit, and (4) support retention through improved encoding and storage of information in long-term memory (Stone, 1983). Neuroscience research cited by Blown and Bryce (2023) suggests that these processes may involve schema activation and modification, consistent with contemporary understanding of memory consolidation.

However, effectiveness varies based on several factors. Rahayu and Widodo (2010) found that the quality of the advance organizer design significantly influenced outcomes, with concept map-based organizers proving more effective than text-based organizers for certain content types. Student characteristics also matter; research indicates that advance organizers are particularly beneficial for learners with limited prior knowledge and those who struggle with information organization (Biswas & Paul, 2018). Implementation fidelity and teacher expertise in using the model also emerged as critical variables influencing outcomes.

Advance Organizers and Critical Thinking Skills Development

A significant body of research examines the relationship between advance organizer use and the development of critical thinking skills. Critical thinking, defined as systematic reasoning and decision-making for evaluating and analyzing information effectively, represents a core competency in 21st-century education. Advance organizers support critical thinking development through several mechanisms, including promoting active reception learning, encouraging integrative reconciliation, and facilitating metacognitive awareness (Joyce et al., 2000).

Aziz (2025) found that advance organizer instruction enhanced students' critical and analytical thinking skills in reading comprehension tasks, with improvements of approximately 27% in measures of inferential reasoning and evaluative judgment. The structured approach to presenting new information encouraged students to move beyond surface-level understanding to deeper analysis of textual relationships and implicit meanings. This finding aligns with Ausubel's (1978) assertion that advance organizers promote a critical approach to subject matter by making conceptual relationships explicit and encouraging students to examine assumptions and contradictions.

Research on advance organizers in collaborative settings provides additional evidence of their role in developing critical thinking. Sunasuan and Songserm (2021) documented that advance organizer use in collaborative ESL classrooms facilitated higher-order thinking as students engaged in processes of brainstorming, discussing, explaining, and persuading peers. The organizer provided a shared conceptual framework that enabled more sophisticated discourse and argumentation. Students demonstrated improved ability to identify relationships between concepts, evaluate alternative interpretations, and synthesize information from multiple sources.

The integration of advance organizers with technology-enhanced learning environments appears to amplify their impact on critical thinking. Elfeky and Elbyaly (2019) found that advance organizers embedded in flipped classroom videos promoted development of integrated science process skills, which include hypothesis formation, experimental design, and data interpretation

all components of critical thinking in scientific contexts. The advance organizer helped students approach scientific problems more systematically and analytically.

Widiyowati (2015) examined the relationship between critical thinking ability and student responses to advance organizer-based instruction in chemistry. The study found that students with stronger critical thinking skills showed more sophisticated use of advance organizers, suggesting a reciprocal relationship where organizers both support and are enhanced by critical thinking capabilities. This finding implies that explicit instruction in how to use advance organizers as thinking tools may be necessary to maximize their effectiveness for critical thinking development.

The mechanism through which advance organizers support critical thinking appears to involve both structural and metacognitive elements. Structurally, organizers provide frameworks for systematic analysis by making relationships between concepts explicit and hierarchical. Metacognitively, the process of relating new information to organizers requires students to engage in monitoring, evaluation, and regulation of their own understanding key components of critical thinking (Aziz et al., 2022). Research suggests that the effectiveness of advance organizers for critical thinking development depends on implementation quality, with more effective approaches incorporating explicit guidance on using organizers as analytical tools rather than mere information repositories.

Advance Organizers in Collaborative Learning Contexts

Contemporary research increasingly examines advance organizers within collaborative learning contexts, recognizing that social interaction can enhance the cognitive benefits of both approaches. Collaborative learning, characterized by students working together in small groups to construct knowledge, shares theoretical commonalities with the advance organizer model through their mutual emphasis on active knowledge construction and meaningful learning (Johnson & Johnson, 1989; Cohen, 1994; Slavin, 1995).

Sunasuan and Songserm (2021) conducted an extensive study examining advance organizer implementation in collaborative ESL classrooms. Their findings revealed that the combination proved particularly powerful, with advance organizers providing the conceptual structure necessary for productive collaborative discourse. The shared conceptual framework established by the advance organizer enabled students to engage in more sophisticated peer interaction, including questioning, explaining, and elaborating on each other's ideas. Students demonstrated higher engagement, improved communication skills, and greater achievement compared to collaborative learning without advance organizers.

The research identified several mechanisms through which advance organizers enhance collaborative learning. First, organizers establish common conceptual ground, reducing miscommunication and enabling more efficient knowledge construction within groups (Brown, 2001). Second, they provide reference points for peer teaching and explanation, as students can explicitly refer to organizer components when helping group members understand new concepts. Third, organizers support equitable participation by providing all group members with access to the conceptual framework, reducing achievement gaps that might otherwise limit some students' contributions (Jones, 1995).

Research also highlights challenges in implementing advance organizers in collaborative contexts. Ansari & Natalia (2020) noted that in ESL settings, poorly organized collaborative tasks combined with inadequate advance organizers created stressful learning environments, particularly for students with limited language proficiency. This finding underscores the importance of careful instructional design that coordinates the complexity of the advance organizer with students' language abilities and the demands of collaborative tasks. Well-designed integration, however, can mitigate language barriers by providing visual and conceptual supports for communication.

Technology-mediated collaborative learning presents new opportunities for advance organizer use. Studies examining virtual classrooms and online collaboration platforms demonstrate that digital advance organizers can effectively scaffold group work in asynchronous and synchronous online environments. The persistent availability of digital organizers in online platforms allows students to reference them throughout collaborative activities, potentially enhancing their utility compared to one-time presentations in traditional classroom settings.

The synthesis of research on advance organizers in collaborative contexts reveals several implications for practice. First, advance organizers should be designed with collaborative activities in mind, including elements that explicitly support group interaction and discourse. Second, teachers need to provide explicit instruction on how to use advance organizers as collaborative tools, not merely as individual learning aids. Third, assessment should examine both individual understanding and collaborative knowledge construction, recognizing that advance organizers serve both functions. Finally, the integration of advance organizers with collaborative learning appears most effective when implemented systematically throughout instruction rather than as isolated interventions.

Contemporary Applications and Technological Integration

Contemporary research demonstrates significant evolution in how advance organizers are implemented in 21st-century learning environments. Digital technologies have enabled new forms of advance organizers and novel integration approaches that extend beyond Ausubel's original conceptualization while maintaining fidelity to core theoretical principles (Wahyuni, 2017).

Flipped classroom implementations represent a particularly promising context for advance organizers. Elfeky and Elbyaly (2019) examined advance organizer integration in flipped classrooms delivered through learning management systems, finding significant improvements in students' integrated science process skills. The advance organizer embedded in pre-recorded lectures provided students with conceptual frameworks for independent learning, addressing a common challenge in flipped instruction where students may struggle to make sense of content without teacher guidance. This research suggests that advance organizers can effectively scaffold autonomous learning in technology-enhanced environments.

Interactive digital advance organizers represent another innovation. Unlike static text or image organizers, interactive digital versions allow students to explore relationships between concepts dynamically, access additional information on demand, and even modify organizers to reflect their developing understanding. While research on these advanced implementations remains limited, preliminary studies suggest potential benefits for engagement and personalized learning. However,

the risk of cognitive overload from complex interactive features requires careful instructional design (Mayer, 2003).

Video-based advance organizers have gained prominence, particularly in online and hybrid learning contexts. Hamdanillah et al. (2017) found that video presentations incorporating advance organizer principles effectively improved physics learning outcomes. The multimodal nature of video allows for integration of verbal explanations, visual representations, and animations, potentially addressing diverse learning preferences while maintaining the conceptual structuring function of advance organizers. Research suggests that video organizers are most effective when brief, clearly structured, and accompanied by opportunities for active processing.

Virtual classroom environments present unique considerations for advance organizer implementation. Alhalafawy et al. (2024) examined advance organizer use in virtual classrooms for graduate students, finding that organizers helped overcome spatial and temporal constraints by providing persistent conceptual frameworks accessible throughout learning activities. The ability to record and replay advance organizer presentations in virtual environments offers advantages for learner-paced instruction, though research suggests that initial real-time interaction with organizers may be important for establishing shared understanding in group contexts.

Mobile learning applications incorporating advance organizer principles represent an emerging area. While systematic research remains limited, preliminary studies suggest that mobile-accessible organizers can support just-in-time learning and knowledge retrieval in authentic contexts. The challenge lies in designing organizers that function effectively on small screens while maintaining sufficient detail and relationships to serve their cognitive structuring function.

CONCLUSION

This systematic literature review demonstrates that the Advance Organizer Model remains an effective pedagogical approach in contemporary education, significantly enhancing learning outcomes, critical thinking, and collaborative learning across diverse contexts. The model proves most effective when designed to match learners' prior knowledge, implemented following the three-phase syntax, combined with active learning strategies, and integrated thoughtfully with technology. Educators should view advance organizers as cognitive tools requiring systematic implementation and proper training in meaningful learning theory. Future research should investigate moderating variables, long-term retention effects, integration with other instructional strategies, and implementation in emerging contexts such as competency-based and personalized learning systems. This review contributes by synthesizing empirical evidence affirming the model's theoretical foundations and demonstrating its adaptability to evolving educational technologies, offering a theoretically grounded approach for helping students construct deep understanding by systematically connecting new material with prior knowledge.

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