

Implementing Cognitive Multimedia Principles in Arabic Language Learning

Zuhruf Al-Faruqy¹, Zuyina Azzahra²

¹ Department of Teaching and Learning Sciences, Zuhruf Research Institute, United Arab Emirates ²Center for Digital Learning Innovation, Glory Foundation, Riyadh, Saudi Arabia.

e-mail: zuhruf.12@gmail.com¹, zuyina25@gmail.com²

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Abstract:

The increasing use of digital multimedia in language education has created new opportunities for enhancing Arabic language learning, but the effectiveness of multimedia depends largely on how information is designed and presented to learners. This study aims to examine how cognitive multimedia principles are implemented in Arabic language learning and how these principles shape learners' cognitive processing during multimedia-based instruction. Employing a qualitative case study design, data were collected through classroom observations, semi-structured interviews, and analysis of multimedia learning materials. The data were analyzed thematically by drawing on Mayer's Cognitive Theory of Multimedia Learning and Cognitive Load Theory. The findings indicate that eight cognitive multimedia principles coherence, signaling, modality, redundancy management, spatial contiguity, temporal contiguity, segmenting, and pre-training were reflected in multimedia-based Arabic instruction. The implementation of these principles supported learners' attention, organization of information, integration of verbal and visual representations, and processing of Arabic vocabulary, pronunciation, listening input, and grammatical information. However, excessive textual information, irrelevant visual elements, poor synchronization, and unnecessary repetition were found to potentially increase extraneous cognitive load. The study concludes that multimedia should not be viewed merely as a technological resource but as a cognitive-pedagogical tool. Intentional application of cognitive multimedia principles can help teachers create more focused, comprehensible, and cognitively manageable Arabic language learning environments.

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Corresponding Author:

Zuhruf Al-Faruqy

Department of Teaching and Learning Sciences, Zuhruf Research Institute, United Arab Emirates

e-mail: zuhruf.12@gmail.com¹

Introduction (مقدمة)

The rapid development of digital technology has transformed the ways in which languages are taught and learned. Digital learning environments increasingly incorporate videos, animations, audio recordings, images, interactive presentations, and other multimedia resources

to provide learners with richer and more flexible learning experiences. In language education, such resources are particularly valuable because language learning involves the integration of verbal, auditory, and visual information. Multimedia can therefore provide opportunities for learners to encounter linguistic input through multiple representational modes rather than relying exclusively on printed texts or teacher explanations. However, the availability of multiple forms of digital information does not automatically guarantee meaningful learning. The effectiveness of multimedia depends substantially on how different forms of information are selected, organized, and presented to learners (Mayer, 2021; Clark & Lyons, 2011).

The increasing use of multimedia in education has also generated an important pedagogical concern: more information does not necessarily produce better learning. When instructional materials contain excessive images, decorative animations, background sounds, lengthy written explanations, or poorly organized visual elements, learners may be required to process information that is not directly relevant to the instructional objective. Such conditions can divert learners' attention from essential information and create unnecessary cognitive demands. Mayer and Fiorella (2014) describe this problem in terms of extraneous processing, arguing that inappropriate instructional design can impose unnecessary demands on learners' cognitive systems. Thus, the central issue is not whether multimedia should be used in education, but how multimedia should be designed and implemented so that it supports rather than obstructs learning.

One of the most influential theoretical perspectives for addressing this issue is Mayer's Cognitive Theory of Multimedia Learning (CTML). CTML explains multimedia learning through the interaction of three assumptions: the dual-channel assumption, the limited-capacity assumption, and the active-processing assumption (Mayer, 2021). According to this perspective, learners process verbal and pictorial information through partially distinct channels, while each channel has limited processing capacity. Meaningful learning consequently requires learners to select relevant information, organize it into coherent verbal and pictorial representations, and integrate those representations with one another and with prior knowledge. Multimedia instruction is therefore potentially beneficial because it can engage both verbal and visual modes of processing, but its effectiveness depends on whether the instructional message facilitates appropriate cognitive processing.

Based on CTML, Mayer has developed a range of principles intended to guide the design of effective multimedia instruction. These include the coherence, signaling, redundancy, spatial contiguity, temporal contiguity, segmenting, pre-training, and modality principles (Mayer, 2021). The coherence principle emphasizes the removal of irrelevant information; signaling directs learners' attention toward essential information; spatial and temporal contiguity bring corresponding verbal and visual information closer together; and the modality principle supports the use of spoken words with graphics under appropriate conditions. Evidence synthesized by Mayer and Fiorella (2014) indicates that principles such as coherence, signaling, redundancy, spatial contiguity, and temporal contiguity can contribute to deeper multimedia learning. These principles provide a theoretical basis for examining whether digital learning materials are cognitively supportive rather than merely technologically attractive.

The importance of cognitive multimedia design is further reinforced by Cognitive Load Theory (CLT). CLT emphasizes that working memory has limited capacity when learners process novel and complex information. Sweller et al. (2011) distinguish among intrinsic, extraneous, and germane cognitive load. Intrinsic load is associated with the inherent complexity and element interactivity of the material, whereas extraneous load arises from instructional procedures or representations that unnecessarily consume working-memory resources. Germane load concerns cognitive resources devoted to learning and schema construction. From this perspective, instructional design should reduce unnecessary cognitive demands while allocating sufficient cognitive resources to the processing of essential learning content (Sweller et al., 2011).

CTML and CLT consequently provide complementary perspectives for understanding multimedia-based instruction. CTML primarily explains how learners process words and pictures and how instructional design can facilitate meaningful integration, whereas CLT emphasizes the limited capacity of working memory and the consequences of unnecessary cognitive demands. Poorly designed multimedia may therefore create extraneous processing by forcing learners to search for relevant information, reconcile separated representations, or process redundant information. Conversely, carefully designed multimedia can reduce unnecessary processing and allow learners to devote more cognitive resources to essential learning activities (Mayer & Fiorella, 2014; Sweller et al., 2011). The integration of these perspectives is particularly relevant to language learning, where learners frequently need to coordinate linguistic forms, meanings, sounds, and contextual representations simultaneously.

These theoretical considerations are highly relevant to Arabic language learning. Arabic as a foreign or second language requires learners to develop multiple interrelated competencies, including listening, speaking, reading, writing, vocabulary, pronunciation, and grammatical knowledge. Digital multimedia can potentially support these competencies by presenting spoken Arabic together with written forms, images, contextual situations, animations, and interactive activities. For example, an Arabic listening lesson may combine an audio recording with visual representations of the communicative context, while vocabulary instruction may associate Arabic lexical items with images and pronunciation. Such multimodal representations can provide learners with contextualized input and potentially facilitate connections between linguistic forms and their meanings.

Nevertheless, multimedia-based Arabic instruction may also present considerable cognitive challenges. Learners may simultaneously encounter unfamiliar Arabic vocabulary, pronunciation, orthographic forms, grammatical structures, images, subtitles, animations, and teacher explanations. For beginning learners in particular, processing several unfamiliar elements simultaneously may increase the complexity of the learning task. If visual and auditory information are poorly synchronized, excessively repeated, or accompanied by irrelevant information, learners may spend cognitive resources dealing with the presentation itself rather than understanding the Arabic language input. From the perspective of CLT, the challenge is therefore not simply the complexity of Arabic content but also the additional extraneous processing generated by instructional design (Sweller et al., 2011).

Despite the growing availability of digital multimedia for language learning, an important gap remains in understanding how cognitive multimedia principles are actually implemented in Arabic language learning contexts. Existing discussions of multimedia learning have provided substantial theoretical and experimental evidence concerning principles such as coherence, signaling, modality, redundancy, and contiguity, but theoretical principles do not necessarily translate automatically into classroom practice (Mayer, 2021; Mayer & Fiorella, 2014). In particular, there is a need to examine how teachers select multimedia materials, organize verbal and visual information, control the amount of information presented, and manage the relationship between instructional objectives and multimedia components in authentic Arabic language learning environments. This gap indicates the importance of moving beyond the question of whether multimedia is effective toward examining how cognitively informed multimedia practices are enacted in actual learning settings.

A qualitative case study is appropriate for addressing this gap because the implementation of cognitive multimedia principles is embedded within a particular instructional context. Rather than measuring only learning outcomes, a qualitative approach can reveal how teachers understand and apply multimedia principles, how learners interact with multimedia materials, and what cognitive challenges emerge during the learning process. Classroom observations, semi-structured interviews, learning-material analysis, and relevant instructional documents can provide complementary evidence concerning the relationship between multimedia design and learners' cognitive experiences. Such an approach makes it possible to examine the instructional

process in its natural setting and to identify contextual factors that may not be adequately captured through experimental measurements alone.

The present study positions cognitive multimedia design as a pedagogical issue rather than merely a technological one. It specifically examines the implementation of Mayer's cognitive multimedia principles in Arabic language learning through the complementary lens of Cognitive Load Theory. The study focuses on how principles such as coherence, signaling, modality, redundancy, spatial contiguity, temporal contiguity, segmenting, and pre-training are reflected in the design and use of multimedia learning materials. At the same time, the study examines how these practices may reduce unnecessary cognitive processing and support learners in focusing on essential Arabic language information. In this respect, the study contributes an empirically grounded account of the relationship between multimedia design, cognitive processing, and Arabic language learning practices.

Accordingly, this study aims to investigate how cognitive multimedia principles are implemented in Arabic language learning and how their implementation is related to learners' cognitive processing within an authentic instructional context. Particular attention is given to the ways in which teachers organize verbal and visual information, minimize extraneous elements, synchronize multimedia components, and support learners' processing of essential Arabic language content. The study is guided by the following research question: How are cognitive multimedia principles implemented in Arabic language learning, and how do these principles shape learners' cognitive processing during multimedia-based instruction? By addressing this question through a qualitative case study, the research seeks to provide a contextualized understanding of how CTML and CLT can inform the pedagogical use of digital multimedia in Arabic language education.

Method (منهج)

This study employed a qualitative case study design to investigate the implementation of cognitive multimedia principles in Arabic language learning and to examine how these principles shape learners' cognitive processing during multimedia-based instruction. A qualitative approach was selected because the study sought to understand instructional practices, teacher decision-making, learner interaction, and the use of multimedia materials within their natural educational context. Rather than measuring the effectiveness of multimedia through experimental or statistical procedures, the study focused on describing and interpreting how cognitive multimedia principles were enacted in actual Arabic language learning practices. The case study design enabled an in-depth investigation of a contemporary phenomenon within its real-life context, particularly when the boundaries between the phenomenon and its context are not clearly evident (Yin, 2018; Creswell & Poth, 2018).

The research was conducted in an Arabic language learning context in which digital multimedia was regularly incorporated into classroom instruction. The research site was purposively selected because multimedia resources such as instructional videos, audio recordings, images, presentations, subtitles, and other digital materials were actively used in the teaching and learning process. The bounded case consisted of the selected Arabic language class, the teachers involved in the instruction, the learners participating in the class, and the multimedia learning materials employed during the observed instructional sessions. Establishing clear boundaries is an important characteristic of qualitative case study research because it allows researchers to investigate a phenomenon within a defined social, institutional, and instructional context (Merriam & Tisdell, 2016; Yin, 2018).

Participants were selected using purposive sampling based on their direct involvement in multimedia-based Arabic language instruction. The primary participants consisted of Arabic language teachers who were responsible for planning and implementing multimedia-supported

lessons and learners who participated in those lessons. Teachers were selected because they could provide information concerning the rationale behind multimedia selection, instructional objectives, material organization, and classroom implementation. Learners were included to provide perspectives on how multimedia materials were experienced and processed during instruction. Purposive sampling is appropriate in qualitative research when participants are intentionally selected because they possess relevant knowledge or experience concerning the phenomenon under investigation (Patton, 2015; Creswell & Poth, 2018). The number of participants was therefore determined according to the depth and adequacy of qualitative information rather than statistical representativeness.

Data were collected through three complementary techniques: classroom observation, semi-structured interviews, and analysis of multimedia learning materials and relevant instructional documents. Classroom observations were conducted during Arabic language lessons involving multimedia resources. The observations focused on how teachers presented verbal and visual information, how multimedia components were sequenced and synchronized, how learners responded to the materials, and how teachers managed potentially distracting or redundant information. An observation protocol was developed based on the major cognitive multimedia principles derived from CTML, including coherence, signaling, redundancy, spatial contiguity, temporal contiguity, segmenting, pre-training, and modality (Mayer, 2021). Observation was particularly important because it enabled the researcher to examine instructional practices as they occurred naturally rather than relying exclusively on participants' retrospective accounts (Merriam & Tisdell, 2016).

Semi-structured interviews were conducted with the participating Arabic language teachers and selected learners. Teacher interviews focused on the reasons for selecting particular multimedia resources, instructional objectives, strategies for organizing multimedia information, perceptions of learners' cognitive difficulties, and approaches to managing excessive or irrelevant information. Learner interviews explored their perceptions of multimedia-supported learning, attention to important information, difficulties in processing simultaneous verbal and visual input, and experiences with audio, images, videos, subtitles, and interactive elements. Semi-structured interviews provide researchers with a flexible framework for exploring participants' perspectives while allowing additional questions to emerge from the interview process (Creswell & Poth, 2018; Merriam & Tisdell, 2016). The semi-structured format therefore enabled the researcher to maintain consistency across interviews while exploring context-specific experiences of multimedia learning.

The multimedia learning materials used during the observed lessons were also analyzed as a major source of data. These materials included instructional videos, presentation slides, images, audio recordings, subtitles, animations, worksheets, and other digital resources used to support Arabic language learning. The analysis examined whether and how the materials reflected the cognitive multimedia principles proposed by Mayer (2021). For example, the coherence principle was examined through the presence or removal of irrelevant words, images, sounds, and animations; signaling was examined through the use of cues that directed attention toward essential information; modality was examined through the relationship between spoken explanations and visual representations; and spatial and temporal contiguity were examined through the arrangement and synchronization of corresponding verbal and visual information. This analysis was grounded in the assumption that multimedia learning is influenced not simply by the presence of multiple media, but by how words and pictures are selected, organized, and integrated during instruction (Mayer, 2021; Mayer & Fiorella, 2014).

Data analysis followed a thematic analysis procedure involving data familiarization, initial coding, categorization, theme development, and interpretation. First, observation notes, interview transcripts, and multimedia materials were reviewed repeatedly to develop an overall

understanding of the data. Second, meaningful segments of data were coded according to their relevance to the research question. Initial codes were informed both by the theoretical constructs of CTML and CLT and by patterns that emerged inductively from the empirical data. Third, related codes were grouped into broader categories representing particular dimensions of multimedia implementation, such as attention guidance, information organization, multimodal integration, synchronization, segmentation, and management of unnecessary information. Thematic analysis was selected because it provides a systematic yet flexible approach to identifying, analyzing, and reporting patterns within qualitative data (Braun & Clarke, 2006, 2021).

The analysis subsequently integrated the perspectives of CTML and CLT to interpret the emerging themes. CTML was used to examine how multimedia materials facilitated or constrained the selection, organization, and integration of verbal and pictorial information (Mayer, 2021). CLT was used to interpret the cognitive demands associated with the presentation of Arabic language content, particularly when learners encountered unfamiliar vocabulary, pronunciation, grammatical structures, written forms, images, and auditory information simultaneously. Within CLT, working memory is understood as having limited capacity, making instructional management of unnecessary cognitive demands particularly important when learners encounter complex or unfamiliar material (Sweller et al., 2011; Sweller et al., 2019). The analysis therefore distinguished between instructional features that appeared to support essential cognitive processing and those that potentially generated extraneous processing. This theoretical integration enabled the study to move beyond simply identifying multimedia features toward explaining their potential cognitive implications.

To enhance the credibility of the findings, methodological triangulation was employed by comparing evidence obtained from classroom observations, interviews, and multimedia material analysis. Statements made by teachers and learners were compared with observed classroom practices and with the characteristics of the actual multimedia materials used during instruction. Triangulation can strengthen the credibility of qualitative findings by allowing researchers to examine a phenomenon through multiple sources of evidence and perspectives (Denzin, 1978; Creswell & Poth, 2018). When discrepancies occurred between participants' accounts and observed practices, the researcher examined the relevant instructional episodes and materials to develop a more contextualized interpretation. The researcher also maintained systematic field notes and an audit trail documenting the process of data collection, coding, categorization, and interpretation, thereby supporting the dependability and transparency of the research process (Lincoln & Guba, 1985).

Ethical considerations were addressed throughout the research process. Participants were informed about the purpose of the study, the procedures for data collection, and the voluntary nature of their participation. Informed consent was obtained before interviews and observations were conducted. Participants' identities and personal information were protected through the use of pseudonyms or participant codes in the research records and reporting. Data obtained from classroom observations, interviews, and instructional materials were used exclusively for research purposes. Ethical principles concerning informed consent, confidentiality, privacy, and voluntary participation are fundamental to qualitative research, particularly when researchers collect detailed information from participants within their natural educational environments (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Particular attention was also given to ensuring that the research process did not interfere unnecessarily with the normal teaching and learning activities of the participating class.

The interpretation of the findings focused on developing a contextualized explanation of how cognitive multimedia principles were implemented in Arabic language learning and how their implementation influenced learners' cognitive processing. The analysis did not treat the

presence of a particular multimedia feature as automatically beneficial or harmful. Instead, each practice was interpreted in relation to the instructional objective, the characteristics of the Arabic language content, the learners' level of familiarity with the material, and the interaction among verbal, visual, and auditory information. This approach is consistent with CTML, which emphasizes that effective multimedia learning depends on the cognitive processes activated by the instructional message rather than on the mere presence of multimedia components (Mayer, 2021). At the same time, CLT provided a framework for interpreting whether particular instructional arrangements potentially increased extraneous cognitive load or supported the allocation of cognitive resources toward essential learning activities (Sweller et al., 2011; Sweller et al., 2019). Through this approach, the study sought to identify patterns of cognitively supportive multimedia implementation as well as practices that potentially increased extraneous cognitive demands.

Result (نتائج)

The findings indicate that multimedia was integrated into Arabic language instruction through a combination of videos, audio recordings, presentation slides, images, written Arabic texts, subtitles, and interactive learning activities. The use of these resources varied according to the learning objectives and the type of language skill being developed. Multimedia was most frequently used to provide contextualized linguistic input, demonstrate pronunciation, introduce vocabulary, illustrate communicative situations, and support learners' comprehension of Arabic texts. Rather than functioning as independent technological components, the multimedia resources were generally incorporated into teacher explanations, guided practice, and learner activities.

The analysis identified eight major cognitive multimedia principles reflected in the observed instructional practices: coherence, signaling, modality, redundancy, spatial contiguity, temporal contiguity, segmenting, and pre-training. However, the implementation of these principles was not uniform across all instructional activities. Some principles were deliberately incorporated into the design of learning materials, whereas others appeared incidentally as a consequence of teachers' instructional practices. The findings therefore suggest that cognitive multimedia principles were present at different levels of awareness and implementation, ranging from explicit instructional strategies to practices that emerged naturally during classroom interaction.

The coherence principle was reflected in the teachers' efforts to limit information that was not directly related to the learning objectives. In several multimedia activities, teachers selected images, audio segments, and video sequences that were directly connected to the Arabic language content being taught. Decorative visual elements and unrelated information were generally avoided when teachers were focusing on specific vocabulary, listening comprehension, or communicative expressions. However, some learning materials still contained additional visual or textual elements that were not essential to the instructional objective. These elements occasionally competed with the main information and required learners to determine which aspects of the material were most important.

Signaling was evident in the ways teachers directed learners' attention toward important linguistic information. Teachers used verbal emphasis, repetition, highlighting, pointing, visual markers, changes in presentation focus, and explicit instructions to indicate key vocabulary or grammatical structures. During video- and presentation-based activities, learners were frequently instructed to focus on particular words, expressions, sounds, or visual representations. Such practices appeared to help learners identify the central components of the learning material rather than processing all available information equally. Signaling was particularly visible during

listening and vocabulary activities in which learners were required to identify specific linguistic items from multimedia input.

The implementation of the modality principle was particularly apparent in activities combining spoken Arabic explanations with visual representations. Teachers frequently used oral explanations while displaying images, diagrams, vocabulary items, or contextual scenes. In listening-oriented activities, spoken Arabic was sometimes accompanied by visual contextualization rather than extensive written explanations. This arrangement appeared to provide learners with complementary auditory and visual information. Nevertheless, the use of written subtitles or textual explanations alongside spoken language was also observed in several activities, indicating that the implementation of modality depended on the teacher's perception of learners' needs and the complexity of the material.

Redundancy emerged as one of the more challenging aspects of multimedia implementation. Some instructional materials presented identical information through speech, written text, and visual elements simultaneously. Although this approach was intended to reinforce comprehension, learners sometimes appeared to divide their attention between listening to the spoken explanation and reading the accompanying text. The issue was more apparent when the written information was extensive or when learners were simultaneously required to observe images or animations. The findings suggest that repetition of information through multiple channels did not always function as reinforcement and could potentially increase unnecessary cognitive processing.

Spatial and temporal contiguity were generally reflected when teachers attempted to present related verbal and visual information in close proximity and appropriate sequence. Vocabulary items were often displayed together with their corresponding images, while audio recordings were presented alongside contextual visual information. In video-based activities, teachers sometimes paused the material to explain particular linguistic expressions immediately after they appeared. However, differences in the timing and arrangement of multimedia components were also identified. When explanations, images, written forms, and audio information were separated or appeared at different points in the instructional sequence, learners sometimes required additional effort to establish relationships among the representations.

Segmenting was implemented through the division of complex multimedia materials into shorter instructional units. Rather than presenting an entire video or a large amount of linguistic information continuously, teachers occasionally paused the material and provided explanations before proceeding to the next segment. Longer learning activities were also divided into stages involving introduction, presentation, guided practice, and independent practice. This organization appeared particularly useful when learners were introduced to unfamiliar vocabulary or complex listening materials. Segmenting allowed learners to process one portion of the information before encountering subsequent material and provided opportunities for teachers to check comprehension.

Pre-training was primarily evident in vocabulary and terminology preparation before learners encountered more complex multimedia content. Teachers introduced selected words, expressions, pronunciation patterns, or key concepts before presenting videos, dialogues, or listening passages. This practice was particularly apparent when the multimedia material contained unfamiliar vocabulary that could interfere with comprehension. By introducing essential linguistic elements in advance, teachers provided learners with a basic conceptual and lexical foundation for processing subsequent information. Learners appeared to engage more readily with multimedia materials when the essential vocabulary and concepts had been introduced beforehand.

The findings also revealed several patterns of cognitive processing among learners. When

multimedia components were clearly organized and directly related to the learning objective, learners tended to focus their attention on the target linguistic information. They were able to connect spoken Arabic with images, written forms, contextual situations, or previously introduced vocabulary. In contrast, when multiple sources of information were presented simultaneously without clear prioritization, learners showed signs of divided attention. They sometimes shifted their attention between subtitles, images, teacher explanations, and audio recordings rather than concentrating on the primary linguistic message.

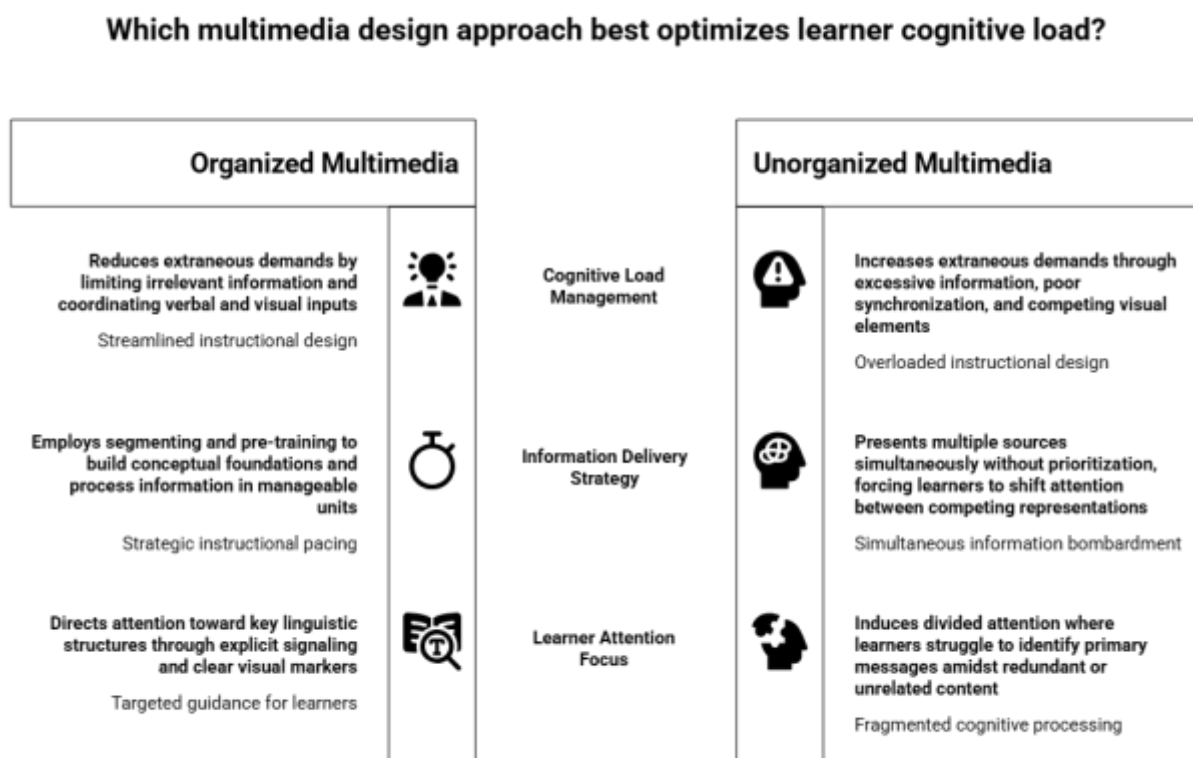


Figure 1: Organized and Unorganized Multimedia

From the perspective of cognitive load, the findings indicate that learners experienced different levels of cognitive demand depending on the organization of multimedia instruction. Intrinsic demands were particularly noticeable when learners encountered unfamiliar Arabic vocabulary, pronunciation, grammatical structures, or listening passages. Extraneous demands emerged when multimedia materials contained excessive information, poorly synchronized components, unnecessary repetition, or competing visual and textual elements. Learners appeared to experience fewer difficulties when teachers reduced irrelevant information, divided complex materials into manageable segments, introduced essential vocabulary beforehand, and explicitly directed attention toward important information.

The findings demonstrate that the pedagogical value of multimedia in Arabic language learning was strongly associated with the way multimedia components were organized rather than with the quantity or technological sophistication of the resources. The implementation of cognitive multimedia principles appeared to support learners when verbal, visual, and auditory information was carefully selected, coordinated, and presented according to instructional objectives. Conversely, multimedia became cognitively demanding when several representations were presented simultaneously without sufficient organization or guidance. The results therefore indicate that effective multimedia-based Arabic instruction depends on the alignment between

multimedia design, cognitive processing, and the linguistic demands of the learning task. The findings further demonstrate that CTML and CLT can be used together to identify both cognitively supportive practices and potential sources of unnecessary cognitive processing in Arabic language instruction.

Discussion (مناقشة)

The findings demonstrate that the implementation of multimedia in Arabic language learning cannot be evaluated merely from the presence or sophistication of digital technologies. Instead, its pedagogical value depends on how multimedia information is selected, organized, synchronized, and presented to learners. The findings indicate that coherence and signaling were among the most prominent principles observed in the instructional practices. Teachers attempted to reduce irrelevant information while directing learners' attention toward essential vocabulary, expressions, pronunciation, and contextual information. This finding supports the central assumption of the Cognitive Theory of Multimedia Learning (CTML) that meaningful learning requires learners to select relevant information from the available instructional message before organizing and integrating it with prior knowledge (Mayer, 2020). Thus, the use of multimedia becomes cognitively meaningful when technology is subordinated to instructional objectives rather than becoming the objective itself.

The prominent implementation of the coherence principle indicates that teachers recognized, either explicitly or implicitly, the importance of minimizing unnecessary information. In Arabic language learning, this issue is particularly important because learners may already face substantial cognitive demands when processing unfamiliar vocabulary, pronunciation, grammatical structures, and orthographic forms. Additional decorative images, background sounds, excessive animations, or unrelated textual information may compete with the linguistic information that learners are expected to process. The findings therefore reinforce the argument that multimedia learning materials should prioritize instructional relevance rather than visual richness. The coherence principle is particularly important for beginning learners because limited prior knowledge may make it more difficult for them to distinguish essential linguistic information from supplementary or decorative elements (Mayer & Fiorella, 2014).

The strong presence of signaling further demonstrates the importance of directing learners' attention during multimedia-based Arabic instruction. The teachers used verbal emphasis, highlighting, pointing, visual markers, and explicit instructions to identify important information. Such practices can be interpreted as mechanisms for supporting the selection process described in CTML. Learners do not automatically process all available information equally; therefore, instructional cues can help them identify which elements deserve greater cognitive attention (Mayer, 2020). In Arabic language learning, signaling may be especially useful when learners encounter dense visual or auditory input, such as Arabic dialogues, vocabulary presentations, grammatical explanations, or listening passages. The finding suggests that teachers can play an important role as cognitive guides who help learners navigate complex multimedia environments.

The implementation of modality also provides important evidence concerning the relationship between auditory and visual information in Arabic language learning. The findings show that teachers frequently combined spoken explanations with images, contextual scenes, or written Arabic forms. This practice reflects the potential advantage of using different representational modes to communicate complementary aspects of instructional information. According to CTML, learners possess partially distinct channels for processing verbal and pictorial information, although both channels have limited capacity (Mayer, 2020). Consequently, spoken explanations accompanied by appropriate visual representations may facilitate learning

when the two forms of information complement rather than duplicate one another. For Arabic language instruction, this principle is particularly relevant to pronunciation, vocabulary, and listening activities, where auditory input can be connected to visual or contextual representations.

However, the findings also reveal that modality cannot be interpreted as a universal rule requiring teachers to eliminate written text from multimedia instruction. Written Arabic forms may have an important pedagogical function, particularly when learners are developing connections among pronunciation, orthography, vocabulary, and meaning. The critical issue is therefore not simply whether text is present but whether the combination of spoken words, written words, and visual representations creates manageable cognitive demands. When learners are simultaneously required to listen to a spoken explanation, read extensive subtitles, interpret images, and follow animations, the different sources of information may compete for limited cognitive resources. This finding is consistent with the cognitive load perspective, which emphasizes the limited capacity of working memory and the potential costs of unnecessary processing (Sweller et al., 2011).

Redundancy emerged as one of the most important challenges in the findings. The simultaneous presentation of spoken explanations, written text, images, and subtitles was sometimes intended to reinforce comprehension but could also divide learners' attention. From the perspective of CLT, the problem occurs when learners are required to process multiple representations containing essentially the same information while simultaneously attempting to understand the instructional content. Such conditions can increase extraneous cognitive load because cognitive resources are allocated to coordinating redundant representations rather than constructing useful knowledge (Sweller et al., 2011; Sweller et al., 2019). Therefore, multimedia-based Arabic instruction should distinguish between productive repetition, which reinforces important linguistic information, and redundant presentation, which unnecessarily increases processing demands.

The findings concerning spatial and temporal contiguity indicate that synchronization is another critical component of multimedia-based Arabic instruction. When vocabulary, images, audio, and explanations appeared in close spatial and temporal relationships, learners could more readily establish connections between the corresponding representations. Conversely, when related information was separated or presented at different moments, learners needed additional effort to determine how the representations were related. This finding is consistent with the contiguity principles of CTML, which propose that learners benefit when corresponding words and pictures are presented close to one another in space and time (Mayer, 2020). In Arabic language learning, synchronization is particularly important for listening materials because learners often need to establish relationships between sound, written form, meaning, and communicative context.

The implementation of segmenting provides further evidence that managing the pace and complexity of multimedia instruction is essential for Arabic language learners. Teachers divided longer multimedia materials into shorter units and inserted pauses for explanation, clarification, and comprehension checks. Such practices appear particularly valuable when learners have limited prior knowledge or when the linguistic material contains several interacting elements. Segmenting allows learners to process one portion of information before encountering subsequent information, thereby reducing the pressure associated with continuous multimedia input (Mayer, 2020). From the perspective of CLT, this practice may help manage the temporal demands imposed on working memory and reduce unnecessary processing caused by an excessive rate of information presentation (Sweller et al., 2019).

Pre-training was similarly important because learners were introduced to essential vocabulary, expressions, pronunciation patterns, or concepts before encountering more complex multimedia materials. This finding suggests that the cognitive demands of Arabic language

learning can be influenced not only by the design of multimedia materials but also by learners' existing knowledge. When learners already understand key concepts or linguistic elements, they may have greater cognitive resources available for processing new relationships within the multimedia message. The pre-training principle therefore has particular relevance for Arabic as a foreign language because learners may encounter unfamiliar lexical, phonological, and grammatical elements simultaneously. Preparing learners with essential concepts before multimedia instruction may consequently create a more manageable cognitive environment (Mayer, 2020; Mayer & Fiorella, 2014).

The findings concerning learners' cognitive processing provide an important connection between CTML and CLT. When multimedia components were clearly organized and directly related to instructional objectives, learners appeared more capable of focusing on essential linguistic information and connecting verbal, visual, and contextual representations. In contrast, poorly organized multimedia was associated with divided attention and greater difficulty in processing simultaneous sources of information. CTML helps explain how learners select, organize, and integrate multimedia information, while CLT explains why the limited capacity of working memory makes such organization necessary (Mayer, 2020; Sweller et al., 2011). The combination of these theories therefore provides a more comprehensive explanation than either theoretical perspective alone.

Another important finding is that cognitive load in Arabic language learning is not determined exclusively by the inherent complexity of the Arabic language. Intrinsic demands may arise from unfamiliar vocabulary, pronunciation, grammatical structures, or the simultaneous processing of linguistic elements. However, extraneous cognitive demands can also be introduced by the way these elements are represented and presented. This distinction is important because instructional designers and teachers have greater control over extraneous demands than over the inherent complexity of the learning content. The findings consequently support the CLT principle that instructional design should minimize unnecessary processing while preserving sufficient cognitive engagement with the essential learning task (Sweller et al., 2011; Sweller et al., 2019). In this sense, effective multimedia design does not necessarily simplify Arabic content; rather, it removes unnecessary barriers that prevent learners from engaging with that content.

Taken together, the findings suggest that cognitive multimedia principles should be understood as an integrated pedagogical system rather than as isolated design techniques. Coherence reduces irrelevant information, signaling directs attention, modality coordinates complementary verbal and visual representations, contiguity strengthens connections among corresponding information, segmenting manages the pace of presentation, and pre-training prepares learners for subsequent processing. At the same time, careful management of redundancy is necessary to prevent unnecessary cognitive demands. These principles interact with one another and collectively influence how learners allocate their limited cognitive resources. The findings therefore extend the application of CTML and CLT to Arabic language learning by demonstrating that effective multimedia instruction requires alignment among technological resources, linguistic content, instructional objectives, and learners' cognitive characteristics (Mayer, 2020; Sweller et al., 2019).

Overall, this study demonstrates that the transformation of Arabic language instruction through digital multimedia should be understood as a process of cognitive pedagogical design rather than technological adoption alone. The findings indicate that multimedia can support Arabic language learning when teachers deliberately organize information in ways that guide attention, facilitate integration, control unnecessary processing, and prepare learners for complex linguistic input. Conversely, the availability of multiple digital resources does not automatically produce better learning and may even create additional cognitive demands when the resources

are poorly coordinated. The theoretical contribution of the study lies in bringing CTML and CLT together to explain how multimedia design and cognitive processing interact in Arabic language learning, while its pedagogical contribution lies in emphasizing the teacher's role as a designer and regulator of learners' cognitive experiences. Future Arabic language instruction can therefore benefit from treating multimedia literacy not simply as the ability to operate digital tools but as the ability to design cognitively appropriate learning experiences.

Conclusion (خاتمة)

The findings demonstrate that the implementation of cognitive multimedia principles can contribute to more meaningful and cognitively manageable Arabic language learning when multimedia materials are deliberately designed and integrated into instruction. The study identified the practical application of coherence, signaling, modality, redundancy management, spatial and temporal contiguity, segmenting, and pre-training in multimedia-based Arabic instruction. These principles helped organize learners' attention, facilitate connections between verbal and visual information, and support the processing of Arabic vocabulary, pronunciation, listening input, and grammatical information. However, the findings also indicate that multimedia does not automatically enhance learning simply because it provides multiple modes of representation. Excessive text, irrelevant visual elements, poorly synchronized information, and unnecessary repetition may instead increase extraneous cognitive load and interfere with learners' processing. Thus, the pedagogical value of multimedia depends largely on how its cognitive demands are managed rather than on the sophistication or quantity of digital features.

The study therefore concludes that cognitive multimedia principles should be regarded as an integrated pedagogical framework for designing and implementing multimedia-based Arabic language instruction. The combination of the Cognitive Theory of Multimedia Learning and Cognitive Load Theory provides a useful foundation for understanding how teachers can select, organize, synchronize, and present multimedia information in ways that correspond to learners' limited cognitive capacity. In practical terms, Arabic language teachers should move beyond the simple use of digital media toward intentional cognitive-oriented instructional design, including reducing irrelevant information, highlighting essential elements, presenting complementary auditory and visual information, segmenting complex content, and preparing learners with relevant vocabulary and concepts before multimedia instruction. This approach positions multimedia not merely as a technological resource but as a cognitive-pedagogical tool that can support more focused, comprehensible, and sustainable Arabic language learning.

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