proceedings

MDPI

Proceeding Paper

Conceptual Framework: Factors Affecting Learner Performance and Cognitive Load in Educational Multimedia Learning †

Khadijah Abdul Rahman [1,*], Siti Aishah Mokhtar [1,*], Noor Arina Md Arifin [1,*], Mohd Nasir Ismail [1] and Tengku Mohd Farid Tengku Abdul Aziz [2]

[1] Faculty of Information Management, Universiti Teknologi MARA Kelantan Branch, Bukit Ilmu, Machang 18500, Kelantan, Malaysia
[2] Academy of Languange Studies, Universiti Teknologi MARA Kelantan Branch, Bukit Ilmu, Machang 18500, Kelantan, Malaysia
* Correspondence: khadijah10@uitm.edu.my (K.A.R.); aishah835@uitm.edu.my (S.A.M.); arina848@uitm.edu.my (N.A.M.A.)
† Presented at the International Academic Symposium of Social Science 2022, Kota Bharu, Malaysia, 3 July 2022.

Abstract: The spread of COVID-19 has compelled educational institutions to make the transition to online communication. It has limited teaching and learning to utilize a fully online learning mode. However, the problem with online learning is that it is entirely dependent on technological devices and the internet: teachers and students with poor internet connections face the problem of access to online learning. These challenges will affect the effectiveness of educational multimedia in the learning process and how students will be able to grasp the educational lesson to remain focused throughout the lesson. Therefore, this study aims to investigate the factors affecting cognitive load and learner performance and proposes a conceptual framework of factors affected in educational multimedia learning underlying the interrelationship between cognitive load and learner performance.

Keywords: learner performance; cognitive load; educational multimedia learning

Citation: Rahman, K.A.; Mokhtar, S.A.; Arifin, N.A.M.; Ismail, M.N.; Aziz, T.M.F.T.A. Conceptual Framework: Factors Affecting Learner Performance and Cognitive Load in Educational Multimedia Learning. *Proceedings* **2022**, *82*, 56. https://doi.org/10.3390/proceedings2022082056

Academic Editor: Mohamad Rahimi Mohamad Rosman

Published: 16 September 2022

1. Introduction

The COVID-19 pandemic has forced the teaching and learning environment to transition to a fully online learning mode. The non-face-to-face teaching made deliverables of academic syllabuses for technical subjects in universities has been a daunting task for educators. Thus, the advancement of internet technology has created opportunities for educators to create educational videos for lesson delivery. However, questions remain on how effective the multimedia learning is. Is the student able to grasp the educational lesson? Can they remain focused throughout the lesson? However, the challenges with online learning is that it is entirely dependent on technological devices and the internet. Both teachers and students with poor internet connections are facing problems with access to online learning. Numerous students, particularly those living in rural areas, lack the high-speed internet connection required for online learning instruction. They had difficulty going live for virtual learning as a result. Some of them had difficulty with technology, as they lack expertise in computers and other forms of technology. There is also a possibility that they did not have a strong internet connection, causing them to have problems downloading some information on the topic. Some students have difficulty managing their time online learning since it is unfamiliar and takes a substantial amount of work. They need to figure out how to schedule their time wisely. Online learning is more flexible than traditional learning; however, some students experience difficulty adjusting to the time required to study online. This study intends to investigate the factors that affect cognitive load and learner performance in educational multimedia learning. The method of the study is a structured literature review, and the expected outcomes of this study is the concep-

tual framework that educators can use in developing educational videos by applying the principles of multimedia learning and reducing the cognitive load in the video.

2. Literature Review

2.1. Modality Principle

One of the principles of multimedia learning is the modality principle. According to Mayer's cognitive theory of multimedia learning, people learn better from visuals and spoken words than visuals and written words. This is because learners can become overwhelmed if there is too much text. According to the modality principle, cognitive load is likely to occur when combined with written–verbal and visual information. Therefore, providing written–verbal information through an auditory channel is preferable when visual information is also available [1]. Ref. [2] stated in their 2019 study that narration is preferable to text according to the modality principle since individuals may focus on visuals while listening to audio. This indicated the modality's effect on cognitive load and learning performance.

The principles of modality suggest that learning from visuals with spoken text is effective compared to learning from displays with written text [3]. Ref. [4] proved that learning from visuals completed by spoken words is more effective than learning from visuals supplemented by written words. They also argued that learning with visuals alone is not as effective when compared to learning with visuals and spoken words. When learning from visuals alone, it might overload the visual channel; meanwhile, when learning from visuals and narration, both channels are be used to share the load. The modality principles stated learning is at its best when using dual-modal (e.g., text with image) compared to single-modal (text only or image only).

2.2. Spatial Contiguity Principle

The Spatial Contiguity Principle highlighted the concerns with the placement or position of both image and text in an educational video. The image should be placed close to the text explaining the image, rather than being placed separately. An example of spatial contiguity principle in a video is when a caption is explaining an image, its caption should be placed close to the image rather than it being distant. Their experiment showed how this spatial contiguity principle affects cognitive load and learning outcome by presenting he multimedia lesson with printed text at the bottom of each image serving as a caption, and placing the text next to the corresponding part of each image. Spatial contiguity is highlighted when students correspond with the words and visuals are placed close together on the page or screen rather than far apart [5]. As a result, learners are less likely to be able to maintain both in working memory simultaneously. Ref. [3] states that spatial contiguity is the degree to which similar pieces of information are arranged in close physical proximity to simplify processing. It is also about learners learning best when relevant information and visual are physically close together on the screen.

2.3. Segmenting Principle

According to the segmenting principle, multimedia instructions should be delivered in segments rather than as continuous units to maximize learning. For instance, the durations of the chapter 1 video lesson is originally one hour. However, after applying the segmenting principle, the video is divided into five subtopics of 20 min duration each. Ref. [2] study revealed that their experiment groups with segmented clips had higher learning performance than the non-segmented groups. The segmentation principle would allow learners to adapt to the pace of the lesson with cognitive needs. Both studies found that using the segmenting principle also increased knowledge retention and knowledge transfer test marks compared to the lesson presented in the continuous unit. Segmenting is being used as one of the techniques to manage essential processing, which is breaking down a complex lesson into advanced parts under the leaner's control [6]. Segmenting is a technique that gives the learner control over the pacing of an online lesson, such

as instructing the learner to go from one slide to the next of a slideshow by pressing a key [7]. According to [8], there are two main benefits of segmentation that have impact on learning facilitation: a decrease in cognitive overload and the learner better configuring the learning materials.

2.4. Interpolated Assessment

Apart from using these principles, the current trend of measuring effective educational videos is to include the interactivity of the video. In recent years, interactivity of videos has been a subject of research interest in which, as technology evolves, it is now possible for videos to interact with learners. For instance, while a student watches the video lesson, questions that require answers could suddenly pop out. Interpolating assessment in an educational video enables the leaner to interact with the video. Ref. [9] studied the effects on embedded questions in educational videos where there were two versions of the video, one with embedded questions and the other without questions. The author used a comprehension test and self-efficacy as an indicator of effectiveness. He found that the group with embedded questions performed better in assessment scores.

2.5. Cognitive Load

The researchers measured self-efficacy based on Cognitive Load Theory (CLT), and embedded questions also were found to reduce cognitive load. They stated that embedded questions made individuals feel better about themselves, improved confidence, added new information to what they already knew, exercised their memories, and that they learned more. In contrast, the majority of affected variables utilized by previous studies were derived from Sweller's (1988) CLT. There are three main variables: Intrinsic Load (IL), Extrinsic Load (EL), and Germane Load (GL). Extraneous load (EL) is a load that is not required due to unclear instructions. Intrinsic load (ILL) demonstrates the difficulty or complexity of learning materials. As for Germane load (GL), it refers to the effort required to construct knowledge. When a researcher wants to determine how effectively a student learns from a video, they use subjective measurement. In contrast, objective measuring is based on a learner's test scores or final grades. This is significantly different from subjective measuring, based on a leaner's word, ratings, or what he or she saw or heard while studying.

2.6. Learner Performance

According to [10] study, the online self-regulated learning questionnaire can measure self-regulation and motivation in the student characteristics and learning outcome categories. Other custom-made instruments were employed to assess attitudes, computer skills, workload management, social and family support, satisfaction, knowledge construction, and technology quality, interactions, tools and resources for learning management systems, and face-to-face support. The rubrics can be used to evaluate a student's performance. Rubrics provide students with a description of the performance levels for each criterion dimension that demonstrates what is expected of them in a given task. Also available for self-evaluation are self-assessment papers, checklist, and portfolios. Ref [11] adds that the process evaluating teachers should focus on the following significant indicators: identifying indicators of teacher practice that lead to maximum learner performance; establishing current performance levels; identifying alternative ways to improve performance, and providing feedback on the efficacy of the new strategies.

3. Methodology

This study adopted the structured literature review (SLR) methodology. First, the literature search started with a leading journal relevant to the field of study. Second, a backward search was conducted to identify relevant articles. Third, a forward-search was conducted to identify any news articles that citing the publication.

In the first phase, the study uses online databases to identify and search relevant articles from leading journals. The keywords used are "Learner Performance", "Cognitive Load", and "Principles of Multimedia Learning". In the next stage, the study evaluates the article base and browsed each paper to identify its topics and critical issues. Next, the focus is on the study's introduction, abstract, discussion, and conclusion of the study. Finally, the study identifies potential variables underlying the topic for the development of our proposed conceptual framework.

4. Conceptual Framework

Based on the literature search, this study proposes an integrated framework to illustrate these relationships of identified variables: Modality principle, segmenting principle, spatial contiguity, interpolated assessment cognitive load, and learner performances depicted in Figure 1 below:

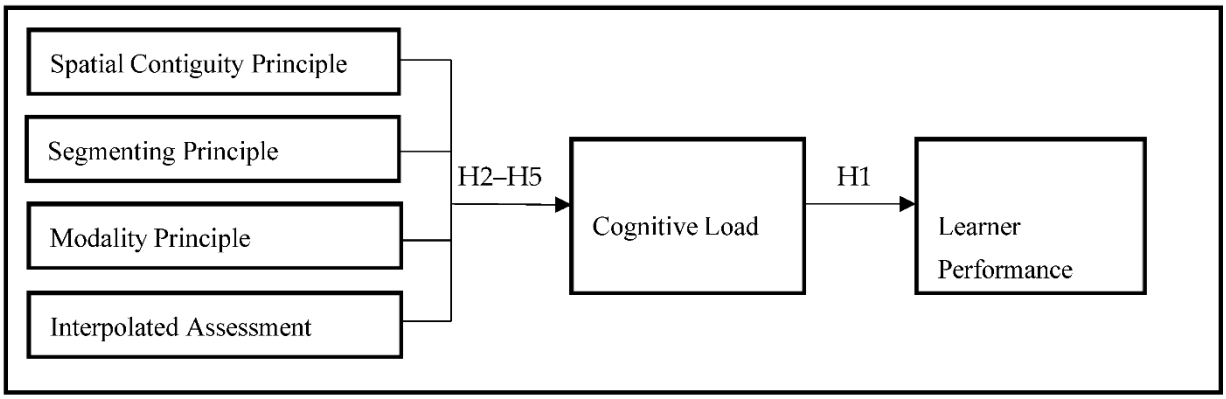

Figure 1. The proposed framework.

H1: *Cognitive load influences learner performance.*

Student performance in university usually measured using test. The test includes a knowledge retention test and a knowledge transfer test. Knowledge Retention tests are designed to test the learner's ability to recall the lesson, while knowledge transfer tests are designed to test the learner's ability to apply the lesson learnt. Using this knowledge retention and knowledge transfer as variables to measure student performance, substantial empirical evidence was found that cognitive load significantly affects student performance. Ref. [2] found a significant positive relationship by conducting pre-tests and post-tests.

H2: *Spatial contiguity principle influences cognitive load in educational multimedia learning.*

Ref. [3] stated that in multimedia learning research, the spatial contiguity effect enhances learning when written text and visuals are spatially integrated rather than physically separated in multimedia learning studies. In their research, Ref. [12] proposed that the spatial contiguity principle is the most effective way for slow learners. During complex lectures, words are necessary to understand the image, whereas, during interactive multimedia, learners move text physically closer to the diagram. Thus, it shows that spatial contiguity positively impacts learner performance. In a recent meta-analysis, Ref. [13] found strong evidence that increasing spatial contiguity can lead to significant learning improvements. As a result, physical closeness has the potential to impact unconscious as well as cognitive thinking. Therefore, the spatial layout of information representations must be considered, particularly in a learning setting. When related representations are spatially integrated by the designer and nearby to one other, it promotes information processing, integration, and learning [14]. The spatial continuity principle, where learners learn better when text and graphics are close to each other, was supported in the previous research.

Physical closeness can impact learners' performance, where they learn and understand faster than before.

H3: *Segmenting Principle influences cognitive load in educational multimedia learning.*

Segmenting can help to enhance the performance of the learner. A study by [6] indicated that it is more effective to split up a complicated slide into portions that are shown one at a time, as opposed to providing all of the information in a single self-paced slideshow lesson. According to [8], segmenting permits the learner to construct a mental image of one section of the content before going on to the next. It has been demonstrated in previous research (e.g., Mautone and Mayer, 2007, Mayer and Chandler, 2001, Mayer, Dow, and Mayer, 2003, and Sung and Mayer, 2013) that segmenting a slideshow in a variety of ways may improve transfer test performance compared to a continuous presentation.

H4: *Modality Principle influences cognitive load in educational multimedia learning.*

The modality principle also related to the leaners' performance. According to [15] the modality effect can be replicated using extended multimedia instructions on a non-technical toxic such as instructional design. This is demonstrated by the fact that students in the audio group perform just as well as those in the visual group on both the retention and transfer tests. This has been carried out by requiring less mental effort to achieve the same score on the transfer test. The effectiveness of multimedia teachings will only increase if the student cannot determine the pace of the instructions and the narrator sets the pace [15]. According to the study, using a mixed modality to offer the learner materials that can be processed as both text and images simultaneously improves learner performance [3]. When text is replaced with narration, verbal and nonverbal visual inputs that were previously competing are eliminated. Intriguingly, this benefit of storytelling over text remained even when presentations were arranged in chronological sequence.

H5: *Interpolated Assessment influences cognitive load in educational multimedia learning.*

Ref. [16] assert that interpolated assessment can facilitate the learning of a videotaped lecture in several ways. For instance, it can alter the types of ideas people have throughout the lecture, making it easier to understand the lecture's content and making it simpler to connect the lecture's session. Highly driven students may benefit from interpolated evaluations in video-based learning, although the gains are shown in the transfer of knowledge rather than its retention (Ref. [17]). Based on the previous study's findings, it can be deduced that assessment influences cognitive load in educational multimedia learning.

5. Conclusions

This study was conducted with two purposes: first, to investigate the factors affecting cognitive load and learner performance, and second, to propose a conceptual framework of factors affecting educational multimedia learning underlying the interrelationship between cognitive load and learner performance. In order to answer both purposes, a systematic literature review (SLR) methodology was adopted. Subsequently, four multimedia principle factors that will affect the cognitive load and leaner performance were identified: spatial contiguity principle, segmenting principle, modality principle, and interpolated assessment. Next, the study's conceptual model was proposed, and discussions were made on each hypothesis. Future studies to empirically test this framework are encouraged to generalize the findings and further support the theories. The next stage of this research is to validate the conceptual research model in a quantitative study. An instrument will be developed by adapting and adopting the previous instrument. The potential respondents are students from one of the local universities in Malaysia, selected based on demographic information explored via the SLR.

Author Contributions: Conceptualization, N.A.M.A. and K.A.R.; methodology, S.A.M. and K.A.R.; resources, N.A.M.A.; writing—original draft preparation, N.A.M.A., K.A.R., S.A.M., M.N.I. and T.M.F.T.A.A.; writing—review and editing, N.A.M.A., K.A.R. and S.A.M.; project administration, M.N.I.; funding acquisition, T.M.F.T.A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research as funded by Research management Centre (RMC) of Universiti Teknologi MARA Kelantan Branch 600-TNCPI 5/3/DDN (03) (006/2021).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Kozan, K.; Erçetin, G.; Richardson, J.C. Input modality and working memory: Effects on second language text comprehension in a multimedia learning environment. *System* **2015**, *55*, 63–73. [CrossRef]
2. Chen, C.Y.; Yen, P.-R. Learner control, segmenting, and modality effects in animated demonstrations used as the before-class instructions in the flipped classroom. *Interact. Learn. Environ.* **2019**, *29*, 1–15. [CrossRef]
3. Moreno, R.; Mayer, R.E. Cognitive Principles of Multimedia Learning: The Role of Modality and Contiguity. *J. Educ. Psychol.* **1999**, *91*, 358–368. [CrossRef]
4. Castro, J.C.; Sweller, J. The Modality Effect of Cognitive Load Theory. *AHFE 2019* **2020**, *963*, 75–84. [CrossRef]
5. Mayer, R. *Multimedia Learning*, 3rd ed.; Cambridge University Press: Cambridge, UK, 2020.
6. Mayer, R.E. Evidence-based principles for how to design effective instructional videos. *J. Appl. Res. Mem. Cogn.* **2021**, *10*, 229–240. [CrossRef]
7. Mayer, R.E.; Wells, A.; Parong, J.; Howarth, J. Learner control of the pacing of an online slideshow: Does segmenting help? *Appl. Cogn. Psychol.* **2021**, *33*, 930–935. [CrossRef]
8. Spanjers, I.A.E.; Gog, T.V.; Merrienboer, J.J.G.V. A theoretical analysis of how segmentation of dynamic visualizations optimizes students' learning. *Educ. Psychol. Rev.* **2010**, *22*, 411–423. [CrossRef]
9. Tweissi, A. The Effects of Embedded Questions Strategy in Video Among Graduate Students at a Middle Eastern University. Ph.D. Thesis, Ohio University, Athens, OH, USA, 2016.
10. Barnard, L.; Lan, W.Y.; To, Y.M.; Paton, V.O.; Lai, S. Measuring self-regulation in online and blended learning environments. *Internet High. Educ.* **2009**, *12*, 1–6. [CrossRef]
11. Rockwood School District Committee. *Teacher Evaluation Instrument*; Rockwood School District Committee: Rockwood, TX, USA, 2014.
12. Mayer, R.E.; Fiorella, L. *Principles for Reducing Extraneous Processing in Multimedia Learning: Coherence, Signaling, Redundancy, Spatial Contiguity, and Temporal Contiguity Principles*; Florida Atlantic University: New York, NY, USA, 2014.
13. Ginns, P. Integrating Information: Meta-Analyses of the Spatial Contiguity and Temporal Contiguity Effects. *Learn. Instr.* **2006**, *16*, 511–525. [CrossRef]
14. Clark, R.C.; Mayer, R.E. *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*, 2nd ed.; John Wiley & Sons: Pfeiffer, Germany, 2008.
15. Tabbers, H.K.; Martens, R.L.; Van Merrienboer, J.J.G. The modality effect in multimedia instructions. *Proc. Annu. Meet. Cogn. Sci. Soc.* **2001**, *23*. Available online: https://conferences.inf.ed.ac.uk/cogsci2001/pdf-files/1024.pdf (accessed on 16 March 2022).
16. Jing, H.G.; Szpunar, K.K.; Schacter, D.L. Interpolated Testing Influences Focused Attention and Improves Integration of Information During a Video-Recorded lecture. *J. Exp. Psychol. Appl.* **2016**, *22*, 305–318. [CrossRef] [PubMed]
17. Yang, J.; Zhang, Y.; Pi, Z.; Xie, Y. Students' achievement motivation moderates the effects of interpolated pre-questions on attention and learning from video lectures. *Learn. Individ. Differ.* **2021**, *91*, 102055. [CrossRef]