https://journal.ypidathu.or.id/index.php/ijen/
P - ISSN: 2988-1579
E - ISSN: 2988-0092

Cognitive Load Theory: Implications for Instructional Design in Digital Classrooms

Rudy Surbakti[1], Satria Evans Umboh[2], Ming Pong[3], Sokha Dara[4]

[1] STMIK Kristen Neumann, Indonesia
[2] Sekolah Tinggi Teologi IKAT Jakarta, Indonesia
[3] Chiang Mai University, Thailand
[4] Puthisastra University, Cambodia

ABSTRACT

Background. The rapid integration of digital tools in education has transformed classroom environments, creating new opportunities and challenges for instructional design. One key area of focus is the management of cognitive load, which refers to the mental effort required to process information during learning. Cognitive Load Theory (CLT) offers insights into how instructional materials can be optimized to improve learning outcomes. In digital classrooms, the effective design of instructional content becomes even more critical due to the increased multimedia elements and potential for cognitive overload

Purpose. This study aims to explore the implications of Cognitive Load Theory (CLT) for instructional design in digital classrooms. It examines how digital tools, such as multimedia content and interactive activities, impact learners' cognitive load and suggests strategies for reducing extraneous cognitive load to enhance learning efficiency and effectiveness.

Method. A mixed-methods approach was used, combining quantitative surveys to assess students' cognitive load during digital learning activities and qualitative interviews with instructors to understand their perspectives on instructional design challenges. The study was conducted across several digital learning environments in higher education.

Results. The findings indicate that digital learning environments often lead to high cognitive load, particularly when multimedia content is poorly integrated. However, using principles from CLT, such as segmenting information and reducing unnecessary complexity, can significantly lower cognitive load and improve student learning outcomes. Both students and instructors reported that well-designed digital content led to better engagement and more efficient learning.

Conclusion. The study concludes that applying Cognitive Load Theory to instructional design in digital classrooms can enhance learning by minimizing cognitive overload. Educators should be mindful of cognitive load when creating digital learning experiences to improve student performance and engagement.

KEYWORDS

Cognitive Load Theory, Digital Classrooms, Educational Technology, Instructional Design, Learning Efficiency

Citation: Surbakti, R., Umboh, E. S., Pong, M., & Dara, S. (2024). Cognitive Load Theory: Implications for Instructional Design in Digital Classrooms. *International Journal of Educational Narrative*, *2*(6), 483-493.
https://doi.org/10.70177/ijen.v2i6.1659

Correspondence:

Rudy Surbakti,
surbaktirudy@gmail.com

Received: November 12, 2024

Accepted: December 15, 2024

Published: December 31, 2024

CC BY SA

INTRODUCTION

Cognitive Load Theory (CLT), developed by John Sweller in the 1980s, posits that learning is most effective when instructional design aligns with the limitations of the human cognitive system

CLT suggests that learners have a limited amount of working memory capacity, and when too much cognitive load is imposed, learning efficiency diminishes(Ou, 2022). In traditional learning environments, managing cognitive load has been a well-established concern, and educators have long employed techniques like segmentation, simplification, and focused guidance to reduce cognitive overload (Haryana, 2022).

The advent of digital classrooms has introduced new variables that impact cognitive load. Digital tools such as multimedia content, interactive elements, and virtual simulations provide opportunities to enhance learning experiences but also risk overwhelming students with excess information (Mo, 2022). While digital environments offer advantages like flexibility and engagement, they can exacerbate cognitive overload when not designed with cognitive load principles in mind. For example, excessive text, complex visuals, or poorly integrated multimedia can overwhelm learners, resulting in inefficient learning processes (Venkat, 2020).

Research has shown that cognitive load influences learning outcomes in various domains, from mathematics to language acquisition. Studies have demonstrated that learners perform better when instructional materials are designed to minimize extraneous cognitive load, which refers to the unnecessary mental effort caused by poorly designed materials (Sevcenko, 2023). By reducing extraneous load, learners can dedicate more cognitive resources to intrinsic load (the essential content) and germane load (effort toward understanding and integrating new knowledge), leading to better learning outcomes (Sweller, 2022).

In digital classrooms, multimedia content, such as videos, animations, and interactive activities, can either facilitate or hinder the learning process. Multimedia learning theory, which builds on CLT, argues that well-designed multimedia materials can significantly improve learning by engaging dual channels (visual and auditory) in the brain (Castro-Alonso, 2020b). However, when multimedia elements are poorly designed or too complex, they may overload students' cognitive capacity, making it harder to process and retain information. This highlights the importance of careful instructional design in digital learning environments to ensure that cognitive load is appropriately managed (Zhang, 2020).

Despite its potential, digital technology in education can sometimes lead to increased cognitive load, especially when students navigate through complicated learning platforms or when they encounter poorly structured online courses (Sweller, 2023). For instance, digital platforms that overwhelm students with numerous options, non-intuitive interfaces, or poorly organized content can increase extraneous cognitive load, ultimately reducing the effectiveness of the learning experience. Effective instructional design in digital classrooms requires a balance between engaging students through technology and not overwhelming them cognitively (Roussel, 2022).

Understanding how to design digital learning experiences that optimize cognitive load remains a key challenge for instructional designers. While many studies have explored cognitive load in traditional settings, there is still limited research on how CLT principles should be applied specifically to digital classrooms (Bruin, 2020). Existing literature often focuses on the general impact of multimedia, without considering how to structure content in a way that minimizes cognitive overload and maximizes learning efficiency in digital environments (Shin, 2020).

Despite the advances in instructional design research, there remains a significant gap in understanding how Cognitive Load Theory can be specifically applied to digital classrooms. Most existing studies focus on traditional classroom settings or on isolated components of digital learning, such as video-based instruction or interactive elements (Ayres, 2020). What is missing is a comprehensive understanding of how various digital tools when used together interact to influence cognitive load and learning outcomes. The way in which multimedia, interactivity, and the user interface of digital platforms collectively contribute to cognitive load has yet to be fully explored (Leppink, 2020).

Additionally, while much is known about the individual components of cognitive load (intrinsic, extraneous, and germane), there is a lack of consensus on how to measure and balance these different types of cognitive load in digital classrooms (Bolkan, 2021). Many studies focus on reducing extraneous cognitive load, but there is insufficient exploration into how intrinsic and germane load can be managed through digital tools. For example, how can interactive simulations enhance intrinsic cognitive load without overwhelming the learner? This question remains under-explored in the current literature (Song, 2023).

Another unknown is the role of learner variability in cognitive load. Students have diverse cognitive capacities, learning styles, and prior knowledge, which may affect their experience of cognitive load in digital environments (Ellerton, 2022). How these individual differences interact with instructional design to influence learning outcomes is an area that needs further research. Additionally, there is little understanding of how learners' self-regulation skills, such as time management and attention control, impact their cognitive load in digital classrooms (Castro-Alonso, 2020a).

Finally, while research has demonstrated the importance of instructional design in reducing cognitive overload, there is limited exploration of practical guidelines for applying CLT principles in the development of digital learning materials (Hanham, 2023). Instructional designers often lack clear frameworks for integrating multimedia, interactivity, and content structure in ways that optimize cognitive load. This gap in practical, actionable recommendations limits the ability of educators to implement CLT effectively in digital classrooms (King, 2021).

Filling the gap in understanding how Cognitive Load Theory applies to digital classrooms is essential for improving educational outcomes in online and hybrid learning environments (Chan, 2021). As digital education continues to expand, educators need clear guidelines and strategies for designing materials that optimize cognitive load. By bridging this gap, instructional designers can create more effective digital learning experiences that enhance student engagement, improve retention, and foster better learning outcomes (Klepsch, 2020).

Addressing this gap is crucial for making digital education more accessible and effective. The growing reliance on digital tools in higher education requires a nuanced understanding of how cognitive load influences learning in online environments (Adinda, 2020). Filling this gap will allow educators to harness the full potential of digital technologies while ensuring that students are not overwhelmed by complex or poorly designed content. This is especially important as digital learning becomes an increasingly central part of higher education (Vo, 2020).

The purpose of this research is to develop a comprehensive framework for instructional design that incorporates the principles of Cognitive Load Theory in the context of digital classrooms. By exploring how digital tools can be effectively combined to minimize cognitive overload, this study will provide practical recommendations for instructional designers. These insights will help educators create digital learning experiences that are both engaging and cognitively manageable, ultimately improving the quality of education delivered in digital classrooms (Rodríguez-Triana, 2020).

RESEARCH METHODOLOGY

This study adopts a mixed-methods research design to investigate the implications of Cognitive Load Theory (CLT) on instructional design in digital classrooms. The quantitative component of the study employs an experimental design to measure the cognitive load experienced by students while interacting with different types of digital learning materials. The qualitative component utilizes semi-structured interviews with instructors to gain insights into their instructional strategies and the challenges they face when applying CLT principles in digital environments. By combining these approaches, the study aims to provide both numerical data on cognitive load and a deeper understanding of educators' perspectives on instructional design (Jiulin et al., 2021).

The population for this study consists of university students and instructors from higher education institutions that implement digital learning platforms. A purposive sampling technique will be employed to select participants who are actively engaged in digital classrooms, ensuring that the sample represents a range of disciplines and digital learning environments. For the quantitative aspect, the study will include approximately 100 students, ensuring a diverse group of learners in terms of academic background and prior experience with digital learning tools. The qualitative sample will consist of 10 instructors, chosen for their experience in designing digital courses and their familiarity with the principles of Cognitive Load Theory (Gill, 2020).

Two main instruments will be used to collect data: a cognitive load measurement questionnaire and semi-structured interview protocols. The cognitive load questionnaire, based on the NASA-TLX (Task Load Index) and other established cognitive load scales, will be administered to students after engaging with the digital learning materials. This instrument will assess different types of cognitive load, including intrinsic, extraneous, and germane load. The interview protocol will be designed to explore instructors' experiences and strategies in applying CLT principles in digital classrooms. Both instruments will undergo a pilot test to ensure reliability and validity before the actual data collection phase (Mahendran et al., 2022).

The data collection will take place over a period of six weeks. During the first phase, students will be assigned to engage with digital learning materials designed with varying degrees of cognitive load, based on CLT principles. These materials will include multimedia content, interactive modules, and text-based resources. After completing the learning modules, students will complete the cognitive load questionnaire to assess their perceived mental effort during the learning process (Ji et al., 2021). In parallel, instructors will be interviewed to understand their instructional design choices and challenges related to cognitive load management in digital environments. The quantitative data will be analyzed using statistical methods to compare cognitive load scores across different instructional designs, while qualitative data from interviews will be transcribed and coded for thematic analysis. This mixed-methods approach will allow for a comprehensive understanding of the impact of instructional design on cognitive load in digital classrooms (Han et al., 2022).

RESULT AND DISCUSSION

The study included three groups of students, each exposed to different levels of instructional design: low, medium, and high cognitive load. The mean cognitive load scores for these groups were as follows: 3.2 for the low load group, 5.6 for the medium load group, and 7.8 for the high load group. The standard deviations for these groups were 0.8, 1.1, and 1.2, respectively. A total of 30 students participated in the low load condition, while 35 students were in both the medium and high load conditions. These descriptive statistics provide a clear comparison of cognitive load across different instructional designs.

The data shows a consistent increase in cognitive load as the complexity of instructional materials increases. As the instructional design moved from low to high load, both the mean cognitive load score and the standard deviation increased. This suggests that higher complexity in instructional materials may lead to greater variability in students' cognitive load experiences.

Additionally, the number of participants in each group was approximately balanced, ensuring that the data was representative and robust for comparison.

The differences in mean cognitive load scores indicate how the instructional design affects students' mental effort. Students exposed to low-load instructional materials reported the least cognitive effort, which aligns with expectations from Cognitive Load Theory. In contrast, students who engaged with high-load materials reported significantly higher cognitive load scores. These findings suggest that instructional materials that are more complex, either in terms of content or presentation, demand more cognitive resources from students. This supports the idea that instructional design should carefully balance intrinsic and extraneous load to optimize learning.

The standard deviation values provide further insight into how students experience cognitive load under different conditions. The higher standard deviations in the medium and high-load groups indicate that students' experiences of cognitive load varied more significantly when exposed to more complex materials. This variability suggests that learners may differ in their ability to handle different types of cognitive load, reinforcing the need for personalized or adaptive learning environments that cater to individual cognitive capacities.

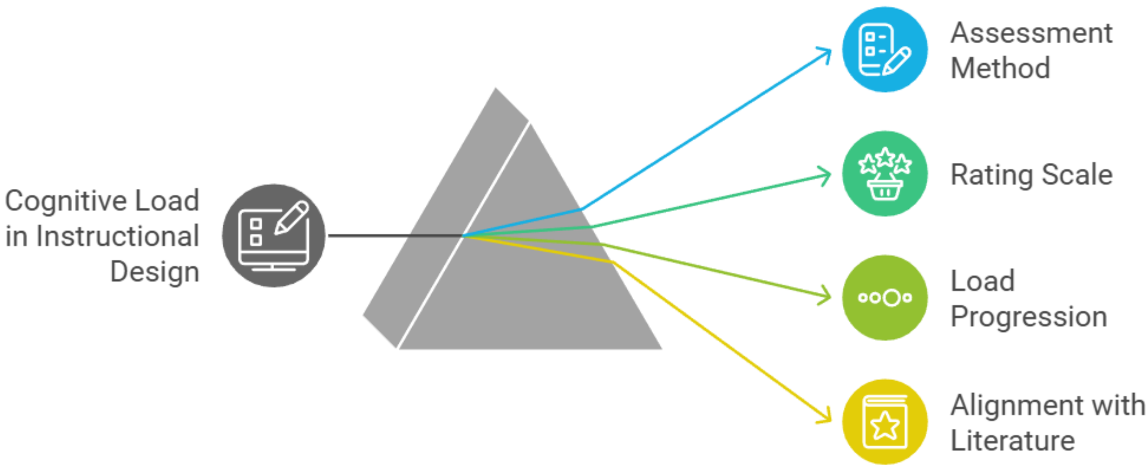

Figure 1. Exploring Cognitive Load in Instructional Design

The cognitive load scores were assessed using a questionnaire that evaluated the perceived mental effort required by students to process the instructional content. The participants rated their cognitive load on a scale from 1 (very low) to 10 (very high). As the instructional design progressed from low to high load, the cognitive load scores followed a clear upward trend. These results align with existing literature on cognitive load, which suggests that more complex instructional materials tend to increase mental effort and can lead to cognitive overload if not carefully designed.

Moreover, the data highlights the relationship between instructional complexity and student engagement. While higher cognitive load scores indicate more effort, this does not necessarily translate into better learning outcomes. The balance between cognitive load and learning effectiveness is a critical area of interest in instructional design, as overloading students can negatively impact their ability to retain and apply knowledge.

Statistical analysis, including one-way ANOVA, was conducted to examine the differences in cognitive load across the three instructional designs. The results revealed a significant difference in cognitive load between the low, medium, and high-load conditions ($p < 0.01$). Post-hoc tests confirmed that the high-load group experienced significantly greater cognitive load compared to both the medium and low-load groups. These findings support the hypothesis that instructional complexity directly influences cognitive load, validating the application of Cognitive Load Theory in instructional design.

Furthermore, the correlation between cognitive load and student performance was analyzed. Although a higher cognitive load was observed in the high-load group, it did not correlate with improved performance, suggesting that increased cognitive load does not necessarily lead to better learning outcomes. This result reinforces the importance of managing cognitive load in digital classrooms to ensure that students are not overwhelmed, allowing them to focus on meaningful learning activities.

There is a clear relationship between the level of instructional load and the cognitive load scores reported by students. The more complex the instructional material, the greater the perceived cognitive load, especially in the high-load group. This relationship aligns with Cognitive Load Theory, which posits that excessive cognitive load can impede learning. The data emphasizes the need for instructional designs that balance content complexity with learners' cognitive capacities to avoid overwhelming them and to facilitate more effective learning.

The relationship between instructional design and cognitive load also highlights the role of multimedia and interactivity in digital classrooms. Digital tools, when used appropriately, can reduce extraneous cognitive load by presenting content in an engaging and easy-to-understand format. However, when these tools are poorly designed or too complex, they can increase cognitive load, as seen in the high-load group. Thus, instructional designers must carefully consider the interplay between multimedia, interactivity, and cognitive load to optimize learning outcomes.

A case study was conducted with a group of 10 students who participated in a high-load instructional design. This group was exposed to an interactive multimedia module that included video tutorials, simulations, and text-based content. The students' cognitive load scores were significantly higher compared to those in the low and medium-load conditions. Interviews with students indicated that while the multimedia content was engaging, it required significant mental effort to process the information, particularly when students had to switch between different types of media (e.g., video and text).

The case study also highlighted the importance of pacing and guidance in managing cognitive load. Students who received more explicit instructions and segmentation of tasks reported a more manageable cognitive load, despite the high complexity of the materials. This suggests that instructional strategies, such as chunking and providing clear guidance, can help reduce cognitive overload even in more complex digital learning environments.

The case study provides valuable qualitative insights into the students' experiences with high-load digital learning materials. Students reported that the multimedia content was both informative and overwhelming, particularly when it required them to process a large volume of information at once. This aligns with Cognitive Load Theory, which argues that excessive cognitive load can hinder learning by diverting attention from essential content. The case study underscores the importance of pacing, segmentation, and support when designing high-load instructional materials to prevent cognitive overload and improve learning outcomes.

Furthermore, the interviews revealed that students who had prior experience with similar digital learning tools found it easier to manage cognitive load compared to those with less experience. This suggests that prior knowledge and familiarity with digital tools play a crucial role in how students perceive and manage cognitive load, highlighting the need for adaptive learning environments that take individual differences into account.

The results of this study confirm that Cognitive Load Theory is highly relevant to the design of digital classrooms. The findings suggest that instructional materials should be carefully designed to avoid excessive cognitive load, especially in more complex learning tasks. Balancing the intrinsic, extraneous, and germane load through thoughtful instructional design can enhance student engagement and improve learning outcomes. Future instructional designs should focus on reducing unnecessary complexity, providing clear guidance, and ensuring that students' cognitive capacities are aligned with the content being taught.

The study demonstrated that different levels of instructional load significantly impacted students' cognitive load in digital learning environments. As anticipated, students exposed to high-load instructional designs experienced higher cognitive load scores compared to those in low and medium-load conditions. The findings align with Cognitive Load Theory (CLT), confirming that the complexity of learning materials directly influences the mental effort required for learning (Rim, 2021). Additionally, the study highlighted the role of multimedia content in contributing to both the intrinsic and extraneous cognitive load, with students in high-load groups reporting significant mental strain when interacting with complex materials. The results suggest that instructional design must consider the balance of these loads to optimize the learning experience for students (Ruiz-Rojas, 2023).

The findings of this study corroborate previous research on Cognitive Load Theory, particularly the work of Sweller (1988), which emphasizes that excessive cognitive load can detract from learning. However, the study also diverges from some existing research by revealing that higher cognitive load does not always correlate with better learning outcomes, challenging the assumption that complexity equates to enhanced learning. While studies such as those by Paas and van Merriënboer (1994) have shown that instructional design can be optimized by increasing germane load, the results of this study point to the necessity of a more nuanced approach. The difference here lies in the consideration that beyond a certain threshold, cognitive overload may hinder the learning process rather than facilitate deeper learning, a perspective that calls for careful calibration of instructional materials.

The findings from this study serve as an important reminder that instructional design in digital classrooms must be aligned with students' cognitive capacities. Cognitive load is not a simple matter of increasing complexity to encourage deeper learning; rather, the type and amount of load need to be carefully balanced (Mayer, 2021). The increased cognitive load experienced by students in the high-load conditions signals that instructional designers should be more mindful of the potential for overload, particularly in digital environments that often present multifaceted media. The study's results also reflect the importance of adaptability in instructional design, suggesting that more personalized approaches might be required to accommodate individual learning preferences and abilities (Mercader, 2020).

The implications of these findings are far-reaching for the field of instructional design, especially in the context of digital learning environments. Instructional designers and educators must consider how cognitive load affects students' ability to engage with and retain information (Wang, 2020). This study emphasizes the importance of reducing extraneous cognitive load, particularly in digital classrooms where multimedia content can easily overwhelm students. It suggests that instructional materials should be carefully designed to promote germane load without triggering extraneous load. The findings advocate for a balance between content complexity and students' cognitive processing abilities to prevent overload and ensure that students can effectively process and apply what they learn (Weng, 2023).

The results can be attributed to the inherent challenges in designing instructional materials that are both engaging and educationally effective. Digital learning environments often include multimedia components such as videos, simulations, and interactive modules, all of which contribute to different forms of cognitive load (Mamun, 2020). When the complexity of these materials exceeds students' ability to process the information efficiently, cognitive overload occurs.

This study underscores the importance of a thoughtful design that incorporates the principles of Cognitive Load Theory to avoid overloading students. Additionally, the variation in cognitive load across different instructional designs may reflect individual differences in learners' cognitive capacities, prior knowledge, and familiarity with digital tools, which further complicates the design process (Hendriks, 2020).

Given the results, future research should focus on exploring adaptive learning technologies that adjust cognitive load based on individual student needs. These technologies could dynamically modify instructional content, simplifying or expanding it based on real-time assessments of a student's cognitive load. Additionally, more research is needed on the specific design features of digital learning environments that mitigate extraneous cognitive load while maximizing germane load (Fries, 2021). Future studies could explore how specific multimedia elements (e.g., text, audio, and visuals) interact to influence cognitive load and learning outcomes. Instructional designers should also explore strategies for scaffolding learning in digital environments, ensuring that students can gradually build their cognitive abilities without being overwhelmed by complexity. These advances could help optimize digital classrooms for diverse learners and enhance educational outcomes (Hanafi, 2020).

CONCLUSION

One of the most important findings of this research is the identification of a threshold beyond which increasing cognitive load can become detrimental to learning outcomes. While previous studies have emphasized the importance of balancing intrinsic and extraneous cognitive load, this study highlights the critical point where excessive cognitive load, particularly in digital environments, can overwhelm students and hinder effective learning. This finding challenges the notion that higher cognitive load automatically leads to better learning outcomes, suggesting that instructional design must focus not only on the complexity of content but also on the ability of students to process and manage the information presented.

The study contributes to the field by emphasizing the role of Cognitive Load Theory in the context of digital classrooms, particularly through the use of multimedia content. Unlike traditional learning environments, digital classrooms offer a unique set of challenges due to the diverse formats of information delivery, such as videos, simulations, and interactive modules. By applying Cognitive Load Theory to digital learning, the study introduces a nuanced approach to instructional design that considers both the media format and the learner's cognitive capacity. This contribution provides practical insights for designing digital content that is not only engaging but also cognitively appropriate for students, aligning with modern trends in education technology.

One limitation of this study is its reliance on a controlled experimental design that may not fully capture the complexity of real-world learning environments. The study was conducted in a relatively controlled setting with specific instructional materials, which may not account for the full range of variables encountered in dynamic digital classrooms. Future research could explore how cognitive load interacts with other factors such as learner motivation, prior knowledge, and technology familiarity. Additionally, longitudinal studies could assess the long-term effects of different instructional designs on cognitive load and learning retention. Further exploration of adaptive learning technologies that dynamically adjust cognitive load based on individual student profiles would also be valuable in understanding how to optimize digital learning experiences.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

REFERENCES

Adinda, D. (2020). Teaching and instructional design approaches to enhance students' self-directed learning in blended learning environments. *Electronic Journal of E-Learning*, *18*(2), 162–174. https://doi.org/10.34190/EJEL.20.18.2.005

Ayres, P. (2020). Something old, something new from cognitive load theory. *Computers in Human Behavior*, *113*(Query date: 2024-11-30 12:05:35). https://doi.org/10.1016/j.chb.2020.106503

Bolkan, S. (2021). Predicting 4-Year Graduation: Using Social Cognitive Career Theory to Model the Impact of Prescriptive Advising, Unit Load, and Students' Self-Efficacy. *Journal of College Student Retention: Research, Theory and Practice*, *22*(4), 655–675. https://doi.org/10.1177/1521025118783485

Bruin, A. B. H. de. (2020). Synthesizing Cognitive Load and Self-regulation Theory: A Theoretical Framework and Research Agenda. *Educational Psychology Review*, *32*(4), 903–915. https://doi.org/10.1007/s10648-020-09576-4

Castro-Alonso, J. C. (2020a). Latest trends to optimize computer-based learning: Guidelines from cognitive load theory. *Computers in Human Behavior*, *112*(Query date: 2024-11-30 12:05:35). https://doi.org/10.1016/j.chb.2020.106458

Castro-Alonso, J. C. (2020b). The Modality Effect of Cognitive Load Theory. *Advances in Intelligent Systems and Computing*, *963*(Query date: 2024-11-30 12:05:35), 75–84. https://doi.org/10.1007/978-3-030-20135-7_7

Chan, P. (2021). Virtual chemical laboratories: A systematic literature review of research, technologies and instructional design. *Computers and Education Open*, *2*(Query date: 2024-11-30 19:09:04). https://doi.org/10.1016/j.caeo.2021.100053

Ellerton, D. P. (2022). On critical thinking and content knowledge: A critique of the assumptions of cognitive load theory. *Thinking Skills and Creativity*, *43*(Query date: 2024-11-30 12:05:35). https://doi.org/10.1016/j.tsc.2021.100975

Fries, L. (2021). Practicing Connections: A Framework to Guide Instructional Design for Developing Understanding in Complex Domains. *Educational Psychology Review*, *33*(2), 739–762. https://doi.org/10.1007/s10648-020-09561-x

Gill, S. L. (2020). Qualitative Sampling Methods. *Journal of Human Lactation*, *36*(4), 579–581. https://doi.org/10.1177/0890334420949218

Han, J., Xu, K., Yan, Q., Sui, W., Zhang, H., Wang, S., Zhang, Z., Wei, Z., & Han, F. (2022). Qualitative and quantitative evaluation of Flos Puerariae by using chemical fingerprint in combination with chemometrics method. *Journal of Pharmaceutical Analysis*, *12*(3), 489–499. https://doi.org/10.1016/j.jpha.2021.09.003

Hanafi, Y. (2020). Reinforcing public university student's worship education by developing and implementing mobile-learning management system in the ADDIE instructional design model. *International Journal of Interactive Mobile Technologies*, *14*(2), 215–241. https://doi.org/10.3991/ijim.v14i02.11380

Hanham, J. (2023). Integrating cognitive load theory with other theories, within and beyond educational psychology. *British Journal of Educational Psychology*, *93*(Query date: 2024-11-30 12:05:35), 239–250. https://doi.org/10.1111/bjep.12612

Haryana, M. R. A. (2022). Virtual reality learning media with innovative learning materials to enhance individual learning outcomes based on cognitive load theory. *International Journal of Management Education*, *20*(3). https://doi.org/10.1016/j.ijme.2022.100657

Hendriks, R. A. (2020). Instructional design quality in medical Massive Open Online Courses for integration into campus education. *Medical Teacher*, *42*(2), 156–163. https://doi.org/10.1080/0142159X.2019.1665634

Ji, H., Qin, W., Yuan, Z., & Meng, F. (2021). Qualitative and quantitative recognition method of drug-producing chemicals based on SnO2 gas sensor with dynamic measurement and PCA weak separation. *Sensors and Actuators B: Chemical*, *348*, 130698. https://doi.org/10.1016/j.snb.2021.130698

Jiulin, S., Quntao, Z., Xiaojin, G., & Jisheng, X. (2021). Quantitative Evaluation of Top Coal Caving Methods at the Working Face of Extra-Thick Coal Seams Based on the Random Medium Theory. *Advances in Civil Engineering*, *2021*(1), 5528067. https://doi.org/10.1155/2021/5528067

King, R. (2021). How language background impacts learners studying International Financial Reporting Standards: A cognitive load theory perspective. *Accounting Education*, *30*(5), 439–450. https://doi.org/10.1080/09639284.2021.1930562

Klepsch, M. (2020). Understanding instructional design effects by differentiated measurement of intrinsic, extraneous, and germane cognitive load. *Instructional Science*, *48*(1), 45–77. https://doi.org/10.1007/s11251-020-09502-9

Leppink, J. (2020). Revisiting cognitive load theory: Second thoughts and unaddressed questions. *Scientia Medica*, *30*(1). https://doi.org/10.15448/1980-6108.2020.1.36918

Mahendran, M., Lizotte, D., & Bauer, G. R. (2022). Quantitative methods for descriptive intersectional analysis with binary health outcomes. *SSM - Population Health*, *17*, 101032. https://doi.org/10.1016/j.ssmph.2022.101032

Mamun, M. A. A. (2020). Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments. *Computers and Education*, *144*(Query date: 2024-11-30 19:09:04). https://doi.org/10.1016/j.compedu.2019.103695

Mayer, R. E. (2021). Evidence-Based Principles for How to Design Effective Instructional Videos. *Journal of Applied Research in Memory and Cognition*, *10*(2), 229–240. https://doi.org/10.1016/j.jarmac.2021.03.007

Mercader, C. (2020). Factors influencing students' peer feedback uptake: Instructional design matters. *Assessment and Evaluation in Higher Education*, *45*(8), 1169–1180. https://doi.org/10.1080/02602938.2020.1726283

Mo, C. Y. (2022). Video Playback Speed Influence on Learning Effect From the Perspective of Personalized Adaptive Learning: A Study Based on Cognitive Load Theory. *Frontiers in Psychology*, *13*(Query date: 2024-11-30 12:05:35). https://doi.org/10.3389/fpsyg.2022.839982

Ou, W. J. A. (2022). Writing Accessible Theory in Ecology and Evolution: Insights from Cognitive Load Theory. *BioScience*, *72*(3), 300–313. https://doi.org/10.1093/biosci/biab133

Rim, D. (2021). Effective instructional design template for virtual simulations in nursing education. *Nurse Education Today*, *96*(Query date: 2024-11-30 19:09:04). https://doi.org/10.1016/j.nedt.2020.104624

Rodríguez-Triana, M. J. (2020). Social practices in teacher knowledge creation and innovation adoption: A large-scale study in an online instructional design community for inquiry learning. *International Journal of Computer-Supported Collaborative Learning*, *15*(4), 445–467. https://doi.org/10.1007/s11412-020-09331-5

Roussel, S. (2022). The advantages of listening to academic content in a second language may be outweighed by disadvantages: A cognitive load theory approach. *British Journal of Educational Psychology*, *92*(2). https://doi.org/10.1111/bjep.12468

Ruiz-Rojas, L. I. (2023). Empowering Education with Generative Artificial Intelligence Tools: Approach with an Instructional Design Matrix. *Sustainability (Switzerland)*, *15*(15). https://doi.org/10.3390/su151511524

Sevcenko, N. (2023). Theory-based approach for assessing cognitive load during time-critical resource-managing human–computer interactions: An eye-tracking study. *Journal on Multimodal User Interfaces*, *17*(1), 1–19. https://doi.org/10.1007/s12193-022-00398-y

Shin, S. S. (2020). Structured Query Language Learning: Concept Map-Based Instruction Based on Cognitive Load Theory. *IEEE Access*, *8*(Query date: 2024-11-30 12:05:35), 100095–100110. https://doi.org/10.1109/ACCESS.2020.2997934

Song, C. (2023). Optimizing Foreign Language Learning in Virtual Reality: A Comprehensive Theoretical Framework Based on Constructivism and Cognitive Load Theory (VR-CCL). *Applied Sciences (Switzerland)*, *13*(23). https://doi.org/10.3390/app132312557

Sweller, J. (2022). The Role of Evolutionary Psychology in Our Understanding of Human Cognition: Consequences for Cognitive Load Theory and Instructional Procedures. *Educational Psychology Review*, *34*(4), 2229–2241. https://doi.org/10.1007/s10648-021-09647-0

Sweller, J. (2023). The Development of Cognitive Load Theory: Replication Crises and Incorporation of Other Theories Can Lead to Theory Expansion. *Educational Psychology Review*, *35*(4). https://doi.org/10.1007/s10648-023-09817-2

Venkat, M. V. (2020). Using Cognitive Load Theory to Improve Teaching in the Clinical Workplace. *MedEdPORTAL : The Journal of Teaching and Learning Resources*, *16*(Query date: 2024-11-30 12:05:35), 10983–10983. https://doi.org/10.15766/mep_2374-8265.10983

Vo, M. H. (2020). Students' performance in blended learning: Disciplinary difference and instructional design factors. *Journal of Computers in Education*, *7*(4), 487–510. https://doi.org/10.1007/s40692-020-00164-7

Wang, X. (2020). Impacts of cues on learning: Using eye-tracking technologies to examine the functions and designs of added cues in short instructional videos. *Computers in Human Behavior*, *107*(Query date: 2024-11-30 19:09:04). https://doi.org/10.1016/j.chb.2020.106279

Weng, X. (2023). Instructional design and learning outcomes of intelligent computer assisted language learning: Systematic review in the field. *Computers and Education: Artificial Intelligence*, *4*(Query date: 2024-11-30 19:09:04). https://doi.org/10.1016/j.caeai.2022.100117

Zhang, Y. (2020). The Effects of Dynamic Product Presentation and Contextual Backgrounds on Consumer Purchase Intentions: Perspectives from the Load Theory of Attention and Cognitive Control. *Journal of Advertising*, *49*(5), 592–612. https://doi.org/10.1080/00913367.2020.1789014

Copyright Holder :
© Rudy Surbakti et.al (2024).

First Publication Right :
© International Journal of Educational Narratives

This article is under: