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Cognitive Load of Distance Learners for Sustainable Development

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ABSTRACT

In the present times, cognitive demands arise because of the change in the mode of learning material which possess cognitive load to the distance learners. Interactive learning medium may induce cognitive load to the distance learners and many learners find it difficult to achieve learning gains, thus inhibiting sustainable development. This study attempts to contribute to the study of cognitive load focusing on the online and distance learning based on the basic parameters of cognitive load construct. Keeping in view the existing research, quantitative research method was applied to measure the cognitive load. The sample of the study was composed of the distance learners of the university from three courses at the same level and quantitative research method was used for acquiring precision of results. The data was collected through a questionnaire. The results show that distance learners are facing extraneous load in terms of devices more than that of intrinsic and germane load. This study is significant in the ways that it could provide the insight for the development to attain sustainable cognition by suggesting some techniques that are potentially useful for the management of disparate cognitive load of the distance learners.

Keywords: *Cognitive Load, Sustainability, Development, Cognition.*

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INTRODUCTION

Cognitive Load is based on an instructional theory rooted from human cognition (Sweller, Ayres, &Kalyuga, 2011). Cognitive load theory assumes a limited working memory used to process information, long-term memory used to store knowledge that has been acquired for subsequent use and learning as a positive change in long-term memory. CLT has been used to generate a wide range of instructional procedures. When learning takes place through the use of technology and learners' get learning material through technology, the modality and format of learning material presentation is changed which generate cognitive load among the learners.The cognitive load is divided into three major categories:Intrinsic Load, Extraneous Load and Germane Load. The intrinsic load is imposed by elements in the content information and it is closely related to the complexity of the topic or subject matter. The extraneous load is imposed by the design instructions and is due to instructions design, devices, and noise/interruption. The Germane load is imposed by the cognitive resources that the learners have available for learning and is created by effective instructional strategies. As the population of this world is increasing, people's interest is also increasing in education. Education environment is changing rapidly and universities like to have those students who can bring them better marketing. With growing demands of better life, students are looking for part time job to meet their responsibilities comprehensively. Some students who are living a far distance from their universities look for a way of learning which can be easily managed by them. So, online education system has become a crucial method of learning for such students. Moreover, availability of internet and linkage of educational system to internet has also shifted the trend of teaching learning activity from traditional method to online method(Castro &Tumibay, 2021). Online learning is use of technology based materials (intranet, extranet, internet, video conferencing, satellite broadcast

and computer mediated training) to foster teaching and learning by making better communication between a teacher and a learner. Students, by online learning can get easy and effective access to learning materials of different varieties(O'Doherty et al., 2018). According toSaykili, (2018), and Tanhan et al., (2020) internet based courses, open courses and organized programs are terms which have also been adopted for online learning. All teaching learning approaches based on information and communication are best described by online education term, although other similar terminologies are also used for this purpose(Lee, 2010). Saykili, (2018) has explained distance education with the concept which is used for online education that distance education is actually a technology based bridging between a facilitator and a learner who are at a far distance from each other. But for distance education while using technology there is no need to be online while in case of online education the learner and his facilitator will have to be online at the same time(Doyumgaç, Tanhan, &Kiymaz, 2021). Although online learning has brought e-revolution in education yet its impact can be negative if extra burden is put on the learner. A learner can only handle a specific quantity of burden which does not exceed his cognitive load capacity. It can be explained in terms of cognitive load theory. The cognitive load theory is a frequently used theoretical charter in pragmatic research on instruction and learning. Its basic assumption is working memory capacity can limit the cognitive capacity, however, effective usage of accessible resources can enhance learning of a learner(Korbach, Brunken, & Park, 2018). According to Sweller, Ayres, &Kalyuga, (2011) this theory also works as a framework to analyze cognitive demands during leaning. Cognitive Load Theory finds links with the principles of instructional design based on cognitive architecture theories. These principles focus on working memory and long term memory of learners(Bayraktar, Cosgun, &Altan, 2019). According to this theory, it is working memory which first processes novel information and then

it is stored in long term memory. Capacity and duration are limitations of working memory but long term memory is unlimited(Anmarkrud, Andresen, &Braten, 2019; Sweller, van Merrienboer, &Paas, 2019).Cognitive load can be reduced during learning by using technology teaching methods (Hawlitschek&Joeckel, 2017).Unnecessary information interactions refer to an unnecessary mental load which affect performance of a learner during learning (Wang, Fang, & Gu, 2020).

Problem Statement

With the advent of technologies, the online learners' are increasing day by day. For optimal and sustainable learning, it is necessary to develop the instructional material is designed in a manner that fits the function of human cognition. Measuring cognitive loads in an instructional process while dealing with distance learners provide valuable information for educators. But the problem is that, there is no trend to explore the cognitive load of the online learners in certain modalities which may hinder for achieving sustainability.

Rationale of the Study

The teaching and learning is rapidly shifting in online mode in which the format of presentation and modality is continuously changing. This increasing shift makes the educators responsible for developing teaching instructions which are compatible for online learners and helpful for construction of sustainable cognition. Therefore, measurement of cognitive load is essential for informed decisions regarding designing and developing instructional material for digital learners.

LITERATURE REVIEW

Online learning is regarded as subfield of machine learning. It includes those techniques which has been devised to learn things in a progressive manner. It has covered many drawbacks of traditional methods of learning. This technique of learning has been extensively used in various fields including data mining, applied math, artificial intelligence etc. (Hoi, Sahoo, Lu, & Zhao, 2021). This term was first adopted in 1995 after development of web based system also called learning management system(Singh & Thurman, 2019). Different terminologies like online education, blended learning e-learning, online courses have been used to describe online learning.Lee, (2017) and Ryan, Kaufman, Greenhouse, She, & Shi, (2016) have defined online learning as a way to connect a teacher to his students by use of web dependent technologies. While discussing core theme of online learning many researchers have pointed out technology as a key element of online learning. They have called it an effective equipment to deliver what was intended to deliver to enhance learning. Some researchers have called it a method of electronic correspondence between a teacher and his students. This chief element (technology) of online learning has been used in term of different ways such as interaction through internet, internet learning environment, information and communication technology, technology mediated teaching learning, CDs, audio-video materials etc., (Singh & Thurman, 2019). As compared to traditional methods, neither time limitation nor space limitations are associated with online learning. Since 2012, online learning method has got massive attention(Wu, 2019). Popularity of online learning can be attributed to its effectiveness against temporal and spatial complications which are primarily associated with traditional methods of learning.

The main purpose of adopting online education is to improve quality of education and learning, and reduce cost of education(Panigrahi, Srivastava, & Sharma, 2018). According to

Jolliffe, Ritter, & Stevens, (2012) online learning can be provided in synchronous and asynchronous ways. The time lag characteristics of asynchronous environment as compared to synchronous environment has advantage that materials are accessible anytime and anywhere. Online learning is not useful in academia but also made significant contribution in industrial field (Chang, 2016). Even a team distributed geographically can improve their skills using online learning method at the same time. Availability of online materials has also been proved beneficial for students who always wished to learn according to their own capacity and pace. No doubt several advantages are associated with online learning some of which are improvement in education and skills, enhanced learning approach, reduced cost and better cost effectiveness of education but retaining presence of students in this learning environment is still a key challenge to be addressed(Perna et al., 2014). In this respect, pioneers have used many strategies like buddying, briefing and feedback to retain students engaged(Nazir, Davis, & Harris, 2015). Moreover, online learning requires disciplined students to get better results(Panigrahi et al., 2018). Learning engagement is key precursor of learning outcome but it is lower in online learning as compared to face to face mode of learning(Hu & Hui, 2012). (Martin, 2017) has also called working memory a chief element of this theory but with time and capacity limitations.

Generally individuals can process only small a quantity of information in given time with the help of working memory and can keep this information retained only for 30 seconds(Adams, Nguyen, & Cowan, 2018). So only useful information will be processed for coding into long term memory rendering other pieces of information ineffective (information exceeding capacity limit). Capacity of working memory can be increased by prior knowledge as expert persons have less load on working memory as compared to inexperienced persons(Feldon, Callan, Juth, &Jeong, 2019). He has also referred cognitive load theory as a framework to understand impact

of various instructional materials on success of learners. Most of research of this theory has focused on interrelation of schema construction, demands of working memory and performance with mere or no focus on relationship of cognitive load with motivation in learning.Cognitive load term, derived from mental workload, is related to effect of total load of a learner on his achievements with respect to his specific tasks. If this load exceeds the range of cognitive ability of a learner then it negatively affects his learning interest and outcomes(Paas, Van Gog, &Sweller, 2010). Intrinsic, Extraneous and Germane are three areas of division of cognitive load. Complexity of learning contents and challenges faced during learning of these contents are dealt by intrinsic cognitive load while organization of teaching contents or materials along with curriculum unrelated to learning is dealt by extraneous cognitive load. Cognitive capacity involved in schema construction defines germane load in such a way that the instruction should direct cognitive capacity of a learner to schema construction so that extraneous cognitive load can be reduced(Liao, Chen, & Shih, 2019). Several studies have been carried out to support limited loading of information keeping in range of learner's capacity to handle his tasks. These efforts have made it clear that loading knowledge or information more than capacity can hinder learning(Huang & Huang, 2015; Mayer, 2014).

However, learning is improved by bringing forth proper learning activities which actually reduce cognitive load(Wang, Fang, & Miao, 2018).This strategy of aligning cognitive load with desired learning outcomes will be useful for formulating theory-guided and empirically testable hypotheses, but can be particularly helpful for educators to embrace emerging technologies while minimizing potential extraneous drawbacks (Skulmowski, and Xu,2021).During different learning tasks cognitive load theory revolves around three areas namely intrinsic cognitive load, extraneous cognitive load and germane cognitive load(Sweller et al., 2019). Complexities

involved in learning tasks and results of elemental interactivity form the base of intrinsic cognitive load. Elemental interactivity is the number of elements associated with interacting information for a particular learning task. Complexities of learning tasks have direct proportion with intrinsic cognitive load, however, key role is played by prior knowledge of a learner in this area of cognitive load(Canham &Hegarty, 2010; Park, Korbach, &Brunken, 2015).Construction of mental structures give rise to germane cognitive load(Paas& Ayres, 2014). So, total cognitive load of a learner must not exceed his capacity. Therefore, before using different teaching materials one must analyze those materials keeping in mind capacity of a learner.Korbach, Brunken, & Park, (2017) like other researchers has also regarded cognitive load theory as a framework for study on instruction and learning. For example multimedia learning is a teaching learning technique which can reduce this load with the help of pictures, videos and words (Bayraktar et al., 2019). There are two factors by which one can determine cognitive load. These factors are 1) objectivity and 2) causal relationship. Objectivity denotes reader's own performance while causal relationship finds direct or indirect link between a phenomenon under observation and cognitive load. In addition to these factors cognitive load can also be determined by subjective measure which are linked to cognitive load experienced by a learner during learning(Anmarkrud et al., 2019; DeLeeuw & Mayer, 2008). A restructured model of Cognitive load theory accepts intrinsic and extraneous loads as basic elements. This model finds close relationship between germane load and intrinsic load, thus call germane load as germane resources (Choi, Van Merrienboer, &Paas, 2014; Kalyuga, 2011).

Objectives of the Study

The study was carried out with the following objective/s:

1. To find out the cognitive load of the distance learning students attending online workshops of different courses.
2. To explore the ways of managing cognitive load of the online learners for sustainable learning.

Delimitations of the Study

Due to limited access of resources, the execution of the study was delimited to:

i. The distance learners from the Allama Iqbal Open University.

ii. The distance learning students which were taking workshops online.

iii. The distance learning students were from graduate level courses.

Research Questions of the Study

To achieve the objectives of the study, following research questions were formulated:

1. What level of difference exists between each category of cognitive load of the distance learners?
2. Is there any significant difference exists between the cognitive load of the distance learners?
3. The distance learning students of which educational group exhibit the most cognitive load?

RESEARCH METHODOLOGY

Quantitative research design was used. Survey method was followed.

Population

The university students enrolled in undergraduate level courses taking online workshops from AIOU.

Sample and Sampling Technique

The sample consists of n=157. The sample was conveniently selected as students who are taking online workshops were invited to fill the questionnaire and the participation was voluntary.

Research Instrument

The standardized instrument was used to measure the cognitive load of the learners. The instrument contains two sections, in which the first section was of demographic information and the second section was composed of cognitive load measure. Cognitive load of the learners' were measured through a questionnaire which contains statement regarding intrinsic load, extraneous load and germane load.The instrument contains 15 statements for the measurement of intrinsic load, extraneous load and germane load.The statements were graded through 5-point Likert scale with (strongly disagree=1 to strongly agree=5).The three ranges were developed after reviewing the relevant literature for each category of cognitive load in such a way that below 40th percentile the scores were ranked as low cognitive load, below 70th percentile it was ranked as neutral and above 70th it was ranked as high level of cognitive load.

DATA ANALYSIS

Quantitative analysis was done.SPSS-21 was used. Descriptive analysis of frequencies and percentages wasemployed.Comparison of mean was used. F-test (ANOVA) was carried out in terms of inferential statistics.

Table 1

Descriptive Statistics of Demographic Data

Characteristics		Frequencies	Percentages
Gender	Male	38	24.4
	Female	118	75.6
Educational Program	B. Ed 1.5 years	105	67.7
	B. Ed 2.5 years	46	29.7
	B. Ed 4 years	4	2.6
Total		157	

Table 1 represents that there was 157 students from the graduate level teaching course from three categories including both gender from the AIOU which were taking online workshops for their respective courses and respond willingly to participate in the study.

Table 2

Percentages of Cognitive Load in Ranges

Categories of Cognitive Load	Low	Neutral	High
Intrinsic Load	19.7	48.4	31.8
Extraneous Load	35.7	47.8	83.4
Germane Load	1.9	23.6	74.5
Overall Cognitive Load	16.6	67.5	15.9

This table represents that majority of the students have extraneous load at high level with 83.4% . The overall cognitive load was neutral along with intrinsic load but germane load was also high but not more than extraneous load.

Table 3

Comparison of Means regarding Cognitive Load

Cognitive Load		Sum of Squares	df	Mean Square	F	Sig.
Intrinsic	Between Groups	.994	2	.497	1.033	.359
	Within Groups	73.199	152	.482		
	Total	74.194	154			
Extraneous	Between Groups	6.722	2	3.361	7.227	.001
	Within Groups	70.697	152	.465		
	Total	77.419	154			
Germane	Between Groups	1.020	2	.510	2.178	.117
	Within Groups	35.599	152	.234		
	Total	36.619	154			
Total	Between Groups	1384.688	2	692.344	7.115	.001
	Within Groups	14791.467	152	97.312		
	Total	16176.155	154			

Table 3 illustrates that the extraneous load was significantly high among the groups which makes the groups significantly different from each other at the overall cognitive load.

Table 4

Comparison of Means regarding Categories of Cognitive Load

Cognitive Load		Sum of Squares	df	Mean Square	F	Sig.
Intrinsic	Between Groups	138.532	2	69.266	10.838	.117
	Within Groups	971.443	152	6.391		
Total	Total	1109.974	154			
Extraneous	Between Groups	41.311	2	20.655	2.016	.137
	Within Groups	1557.567	152	10.247		
Instructional	Total	1598.877	154			
Extraneous	Between Groups	58.900	2	29.450	3.586	.108
	Within Groups	1248.171	152	8.212		
Noise	Total	1307.071	154			
Extraneous	Between Groups	44.991	2	22.495	2.256	.030
	Within Groups	1515.551	152	9.971		
Devices	Total	1560.542	154			
Extraneous	Between Groups	425.245	2	212.622	3.392	.036
	Within Groups	9527.465	152	62.681		
Total	Total	9952.710	154			
Germane	Between Groups	33.972	2	16.986	1.879	.156
	Within Groups	1374.066	152	9.040		
Total	Total	1408.039	154			
	Between Groups	1384.688	2	692.344	7.115	.001
Overall	Within Groups	14791.467	152	97.312		
	Total	16176.155	154			

From the table 3 it was found that extraneous load was significantly high among the groups. Table 4 shows that the extraneous load was significantly high due to the devices and the other

categories i.e., noise and instructions were not significantly different among the groups. This means that students while taking online classes have difficulty to search, download, access the learning material and sometimes face difficulty to log in from different devices which increase their extraneous load in terms of devices.

Table 5

Comparison of means for cognitive load regarding Educational Programs

(I) Educational Prog	(J) Educational Prog	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
B.Ed 1.5 years	B.Ed 2.5 years	-1.59317*	.44699	.002	-2.6982	-.4882
	B.Ed 4 years	-4.32143*	1.28788	.004	-7.5052	-1.1377
B.Ed 2.5 years	B.Ed 1.5 years	1.59317*	.44699	.002	.4882	2.6982
	B.Ed 4 years	-2.72826	1.31784	.121	-5.9861	.5295
B.Ed 4 years	B.Ed 1.5 years	4.32143*	1.28788	.004	1.1377	7.5052
	B.Ed 2.5 years	2.72826	1.31784	.121	-.5295	5.9861

* The mean difference is significant at the 0.05 level.

Now the groups are compared for extraneous load because extraneous load was significantly high among the groups.Table 5 shows that the B.Ed 1.5 years group was significantly different from B.Ed 2.5 years group and that of 4 years group in terms of extraneous load. But the B.Ed 2.5 years group was not significantly different from 4 years group in terms of extraneous load.

Table 6

Post Hoc Test for mean differences for cognitive load categories regarding Educational Programs in terms of Extraneous Load due to Devices

(I) Educational Prog	(J) Educational Prog	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
B.Ed 1.5 years	B.Ed 2.5 years	-.68012	.50668	.408	-1.9327	.5724
	B.Ed 4 years	-3.57143	1.45984	.053	-7.1802	.0374
B.Ed 2.5 years	B.Ed 1.5 years	.68012	.50668	.408	-.5724	1.9327
	B.Ed 4 years	-2.89130	1.49380	.157	-6.5841	.8015
B.Ed 4 years	B.Ed 1.5 years	3.57143	1.45984	.053	-.0374	7.1802
	B.Ed 2.5 years	2.89130	1.49380	.157	-.8015	6.5841

Table 6 shows that B.Ed 1.5 years group was significantly different from B.Ed 4 years group but not significantly different from B.Ed 2.5 years group in terms of extraneous load due to devices.

Table 7

Post Hoc Test for Comparison of means for Overall Cognitive Load regarding Educational Programs

(I) Educational Prog	(J) Educational Prog	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
B.Ed 1.5 years	B.Ed 2.5 years	-3.30104	1.74421	.170	-7.6128	1.0108
	B.Ed 4 years	-17.31190*	5.02542	.003	-29.7351	-4.8887
B.Ed 2.5 years	B.Ed 1.5 years	3.30104	1.74421	.170	-1.0108	7.6128
	B.Ed 4 years	-14.01087*	5.14233	.027	-26.7231	-1.2987
B.Ed 4 years	B.Ed 1.5 years	17.31190*	5.02542	.003	4.8887	29.7351
	B.Ed 2.5 years	14.01087*	5.14233	.027	1.2987	26.7231

*The mean difference is significant at the 0.05 level.

Table 7 illustrates that B.Ed 1.5 year group was significantly different from the B.Ed 4 years group in terms of overall cognitive load but not significantly different from B.Ed 2.5 years group. Also, B.Ed 2.5 years group was significantly different from B.Ed 4 years group in terms of overall cognitive load.

Discussion

This study measured the cognitive load of distance learners. The undergraduate students has very high extraneous cognitive load. This extrinsic cognitive load can be reduced by load reeducation intervention. Shail Kadir et al. (2023), used this technique and found significant improvement in the reduction of cognitive load in an inquiry based learning. It means a well-

managed teaching method can significantly reduce cognitive load. According to Kalyuga, (2011) and Sweller, (2010) the main focus of instructional design must be minimize unnecessary load of working memory to create more space for processing of online learning related materials which in turn can dismantle limitation of working memory.Germane cognitive load of a distance learners can be induced by planning and organizing teaching materials in a well-defined manner which in turn actually minimizes the extraneous cognitive load. The findings of the study were in line with the findings of PAAS and Ayres, (2014) that extraneous cognitive load gives rise to needles surge in interactional elements.The purpose of such type of studies is to find and devise different techniques which can minimize load of working memory while there was distance learning. Ozcan (2024) also found that using WEI4S instructional approach can effectively reduce cognitive load (CL) through structured stages to solve algebraic equations. The distance learners, usually do not have teacher interaction in formal setting. It can also cause cognitive load to them. However, different strategies can be used to reduce or anage the cognitive load. Wang (2024) investigated biomechanical intervention strategies to manage cognitive load in college students. In its study physical activity, ergonomic adjustments, and mindfulness practices were used for the reduction in cognitive load and improve mental health.

Conclusion

It is concluded that the overall cognitive load of the distance learners was neutral. However, it was found that extraneous load was high. Germane load of distance learners was also high but not significantly different among the groups. The intrinsic load of the distance learners was neutral and also there was no significant difference among the groups in this regard. Moreover, it was found that extraneous load due to devices was significantly high among the groups.

Recommendations

Using Cognitive Load Regulation strategies, the cognitive load of distance learners can be managed using following strategies:

- For better learning, there should be an equation such that germane load should be higher than extraneous load and the intrinsic load gets high when learners' feel difficulty for particular task.
- While distance learning, higher Order information should be presented in small learning packets.
- Information should be provided to distance learners in certain sequence. In this way, learners are able to handle more complex tasks thus, managing intrinsic cognitive load.
- Use weeding to reduce extraneous load of the distance learners.
- Supportive information helps to manage germane cognitive load among distance learners.
- Teachers who are teaching distance learners should continuously survey the learners when orientation or learning cohort was over before new session starts which provides the information to the instructors to improve the design, format and orientation thus better manage the extraneous cognitive load.

References

Adams, E. J., Nguyen, A. T., & Cowan, N. (2018). Theories of working memory: Differences in definition, degree of modularity, role of attention, and purpose. *Language, speech, and hearing services in schools, 49*(3), 340-355.

Anmarkrud, O., Andresen, A., & Bråten, I. (2019). Cognitive load and working memory in multimedia learning: Conceptual and measurement issues. *Educational Psychologist, 54*(2), 61-83.

Canham, M., & Hegarty, M. (2010). Effects of knowledge and display design on comprehension of complex graphics. *Learning and instruction, 20*(2), 155-166.

Castro, M. D. B., & Tumibay, G. M. (2021). A literature review: efficacy of online learning courses for higher education institution using meta-analysis. *Education and Information Technologies, 26*(2), 1367-1385.

Chang, V. (2016). Review and discussion: E-learning for academia and industry. *International Journal of Information Management, 36*(3), 476-485.

Choi, H.-H., Van Merrienboer, J. J., & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: Towards a new model of cognitive load. *Educational Psychology Review, 26*(2), 225-244.

DeLeeuw, K. E., & Mayer, R. E. (2008). A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. *Journal of educational psychology, 100*(1), 223.

Doyumgaç, I., Tanhan, A., & Kiymaz, M. S. (2021). Understanding the most important facilitators and barriers for online education during COVID-19 through online photovoice methodology. *International Journal of Higher Education, 10*(1), 166-190.

Feldon, D. F., Callan, G., Juth, S., & Jeong, S. (2019). Cognitive load as motivational cost. *Educational Psychology Review, 31*(2), 319-337.

Hawlitschek, A., & Joeckel, S. (2017). Increasing the effectiveness of digital educational games: The effects of a learning instruction on students' learning, motivation and cognitive load. *Computers in Human Behavior, 72*, 79-86. doi:

Hoi, S. C., Sahoo, D., Lu, J., & Zhao, P. (2021). Online learning: A comprehensive survey. *Neurocomputing, 459*, 249-289.

Hu, P. J.H., & Hui, W. (2012). Examining the role of learning engagement in technology-mediated learning and its effects on learning effectiveness and satisfaction. *Decision support systems, 53*(4), 782-792.

Huang, Y.M., & Huang, Y.-M. (2015). A scaffolding strategy to develop handheld sensor-based vocabulary games for improving students' learning motivation and performance. *Educational Technology Research and Development, 63*(5), 691-708.

Jolliffe, A., Ritter, J., & Stevens, D. (2012). *The online learning handbook: Developing and using web-based learning*: Routledge.

Kalyuga, S. (2011). Cognitive load theory: How many types of load does it really need? *Educational Psychology Review, 23*(1), 1-19.

Korbach, A., Brünken, R., & Park, B. (2017). Measurement of cognitive load in multimedia learning: a comparison of different objective measures. *Instructional science, 45*(4), 515-536.

Korbach, A., Brunken, R., & Park, B. (2018). Differentiating different types of cognitive load: A comparison of different measures. *Educational Psychology Review, 30*(2), 503-529.

Lee, J.W. (2010). Online support service quality, online learning acceptance, and student satisfaction. *The Internet and Higher Education, 13*(4), 277-283.

Lee, K. (2017). Rethinking the accessibility of online higher education: A historical review. *The Internet and Higher Education, 33*, 15-23.

Liao, C.W., Chen, C.H., & Shih, S.-J. (2019). The interactivity of video and collaboration for learning achievement, intrinsic motivation, cognitive load, and behavior patterns in a digital game-based learning environment. *Computers & Education, 133*, 43-55.

Martin, S. (2017). *A critical analysis of the theoretical construction and empirical measurement of cognitive loadCognitive load measurement and application* (pp. 29-44): Routledge.

Mayer, R. E. (2014). Incorporating motivation into multimedia learning. *Learning and instruction, 29*, 171-173.

Mutlu-Bayraktar, D., Cosgun, V., & Altan, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education, 141*, 103618.

Nazir, U., Davis, H., & Harris, L. (2015). First day stands out as most popular among MOOC leavers. *International Journal of e-Education, e-Business, e-Management and e-Learning, 5*(3), 173.

O'Doherty, D., Dromey, M., Lougheed, J., Hannigan, A., Last, J., & McGrath, D. (2018). Barriers and solutions to online learning in medical education–an integrative review. *BMC medical education, 18*(1), 1-11.

Özcan, Z. Ç. (2024). Evaluating the Impact of the WEI4S Instructional Approach on Middle School Students' Algebraic Problem-Solving Skills. *Neveléstudomány*. https://doi.org/10.3390/educsci14010102

Paas, F., & Ayres, P. (2014). Cognitive load theory: A broader view on the role of memory in learning and education. *Educational Psychology Review, 26*(2), 191-195.

Paas, F., Van Gog, T., & Sweller, J. (2010). Cognitive load theory: New conceptualizations, specifications, and integrated research perspectives. *Educational Psychology Review, 22*(2), 115-121.

Panigrahi, R., Srivastava, P. R., & Sharma, D. (2018). Online learning: Adoption, continuance, and learning outcome—A review of literature. *International Journal of Information Management, 43*, 1-14.

Park, B., Korbach, A., & Brünken, R. (2015). Do learner characteristics moderate the seductive-details-effect? A cognitive-load-study using eye-tracking. *Journal of Educational Technology & Society, 18*(4), 24-36.

Perna, L. W., Ruby, A., Boruch, R. F., Wang, N., Scull, J., Ahmad, S., & Evans, C. (2014). Moving through MOOCs: Understanding the progression of users in massive open online courses. *Educational Researcher, 43*(9), 421-432.

Ryan, S., Kaufman, J., Greenhouse, J., She, R., & Shi, J. (2016). The effectiveness of blended online learning courses at the community college level. *Community College Journal of Research and Practice, 40*(4), 285-298.

Saykili, A. (2018). Distance education: Definitions, generations and key concepts and future directions. *International Journal of Contemporary Educational Research, 5*(1), 2-17.

Shaik Kadir, M., Yeung, A. S., Caleon, I. S., Diallo, T. M. O., & Forbes, A.-M. (2023). The effects of load reduction instruction on educational outcomes: An intervention study on hands-on inquiry-based learning in science. *Applied Cognitive Psychology*. https://doi.org/10.1002/acp.4077

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education, 33*(4), 289-306.

Skulmowski, Alexander & Xu, Kate. (2021). Understanding Cognitive Load in Digital and Online Learning: a New Perspective on Extraneous Cognitive Load. *Educational Psychology Review.*

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review, 22*(2), 123-138.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Measuring cognitive load*Cognitive load theory (pp. 71-85): Springer.

Sweller, J., van Merriënboer, J. J. G., & Paas, F. (2019). Cognitive Architecture and Instructional Design: 20 Years Later. *Educational Psychology Review, 31*(2), 261-292.

Tanhan, A., Yavuz, K. F., Young, J. S., Nalbant, A., Arslan, G., Yildirim, M., Çiçek, İ. (2020). A proposed framework based on literature review of online contextual mental health services to enhance wellbeing and address psychopathology during COVID-19. *Electronic Journal of General Medicine, 17*(6), em254.

Wang, C., Fang, T., & Gu, Y. (2020). Learning performance and behavioral patterns of online collaborative learning: Impact of cognitive load and affordances of different multimedia. *Computers & Education, 143*, 103683.

Wang, C., Fang, T., & Miao, R. (2018). Learning performance and cognitive load in mobile learning: Impact of interaction complexity. *Journal of Computer Assisted Learning, 34*(6), 917-927.

Wang, C. (2024). Addressing mental health challenges in college students: A biomechanical approach to mitigating stress and cognitive load through physical intervention strategies. *Molecular & Cellular Biomechanics*, *21*(2), 376. https://doi.org/10.62617/mcb.v21i2.376

Wu, P. L. H. (2019). Does online learning work better than o ine learning in undergraduate medical education? A systematic review and meta-analysis. *Med Educ Online, 4*(1), 1666538.