The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

ASSOCIATION OF SELF-EFFICACY AND COGNITIVE LOAD IN ONLINE LEARNING AMONG UNDERGRADUATE PHYSICAL THERAPY STUDENTS

Dr. Aleena Mustafa[*1], Dr. Allena Javed[2], Dr. Maryam Kundi[3], Dr. Sheeba Orakzai[4]

*[*1](PT) Lecturer, City University of Science & Information Technology, Peshawar.*
[2](PT) Consultant Physiotherapist, Qamar Hospital Gujrat
[3](PT) Senior Lecturer, Riphah International University, Gulberg Green Campus, Islamabad
[4](PT) Demonstrator, City University of Science and Information Technology, Peshawar.

[*1]aleenamustafa897@gmail.com, [2]aleenajaved630@gmail.com, [3]maryamkhankundi@gmail.com, [4]drsheebaphysio94@gmail.com

DOI: https://doi.org/10.5281/zenodo.15607039

Keywords
Self-efficacy, Cognitive load, Online learning, Physical activity, COVID-19, Physical therapy students

Article History
Received on 29 April 2025
Accepted on 29 May 2025
Published on 06 June 2025

Corresponding Author: *
Dr. Aleena Mustafa

Abstract

Background: *Online education has become increasingly prevalent, offering flexible learning opportunities. However, factors like cognitive load and self-efficacy significantly influence student performance and adaptation in virtual environments.*

Objectives: *This study aimed to examine the relationship between general self-efficacy and cognitive load in online learning among undergraduate physical therapy students. It also explored how COVID-19-related stress and physical activity levels interact with cognitive load.*

Methods: *A cross-sectional study was conducted from October 2021 to July 2022 involving 444 undergraduate physical therapy students from private universities, selected through non-probability convenience sampling. Inclusion criteria required students to have at least six months of online learning experience. Data were collected using the General Self-Efficacy Scale, Cognitive Load Scale, International Physical Activity Questionnaire, and COVID-19 Stress Scale. An online form was distributed, and responses were analyzed using SPSS version 23.*

Results: *Findings revealed a weak positive correlation between cognitive load and general self-efficacy ($r = 0.358$, $p = 0.486$). Additionally, cognitive load showed weak positive correlations with COVID-19 stress ($r = 0.151$, $p = 0.001$) and physical activity ($r = 0.111$, $p = 0.019$). These results indicate that although the associations are not strong, they are statistically relevant in the context of online education.*

Conclusion: *The study suggests that enhancing self-efficacy may help reduce cognitive load among students engaged in online learning. Meanwhile, COVID-19-related stress may contribute to increased cognitive burden. Promoting self-efficacy and addressing stress management could support better learning outcomes in virtual settings.*

INTRODUCTION

Concept of learning under the law The National Education System's number 20 challenges for 2003 is how students connect with teachers and learning resources in a classroom setting. Online learning is instruction that takes place between professors and students without them physically meeting. E-learning, remote learning and video conferences are all ways to learn. Online learning is also referred to by words like e-learning and System Online Learning. Computer-based learning and the Online Learning Model (OLM) (1). With the use of information and communication technology, or e-learning, students may study whenever and wherever they choose. E-learning is a development that may be used in the educational process to modify learners' abilities in a variety of skills in addition to how learning materials are delivered. A technique of teaching and learning known as "e-learning" employs electronic media and the internet as an intermediary throughout the teaching and learning process (2). Learning online during the COVID-19 epidemic was more difficult since it required the student to be independent in their learning and successful completion of the lecturer's assignments. Online learning is obviously different from traditional face-to-face learning, and it can put students under cognitive strain. A psychological theory called the theory of cognitive load looks at the potential and constraints of the human cognitive architecture to anticipate the outcomes of the study (3). “Germane cognitive learning (GCL)”, “extraneous cognitive load (ECL)”, and “Intrinsic cognitive load (ICL)”, make up cognitive load. ICL is influenced by how complex a given piece of content is; the more parts and connections there are, the more sophisticated the information is, and the higher the ICL will be as a result. ECL is dependent on how the subject matter is presented. If the presentation of the content is poor, it can increase ECL; but, if the material is poorly constructed, it can result in cognitive processes that are ineffective and irrelevant. GCL places focus on the procedure or effort used by pupils to resolve issues after learning. The GCL can be impacted by an individual's traits, motivation, attitude toward the content being studied, learning style, experience, and knowledge (4). Self-efficacy, often known as confidence in one's capability to perform, has gotten a lot of attention in the literature on applied psychology (5). The connections between self-efficacy and well-respected conceptions like expectation and the intuitively alluring idea that one's self-confidence might have self-fulfilling implications have caught the attention of practical researchers in a variety of fields (6).

Self-efficacy is a individual's appraisal of their own capacity to do the activity. Self-efficacy encompasses assessments of one's capacity to execute the job and confidence in one's capacity to do so. Self-efficacy is defined in this study's context as the student's assessments and beliefs about her or his ability to grasp and complete the task when studying online (9). According to a research by Isiksal et al (2005), expertise may have an impact on students' self-efficacy in the classroom. Technology offers students a number of advantages by enabling them to "manage the speed of the program, investigate information, and build their own paths through the material," according to Cauble et al (2000) study on the impact of expertise on self-efficacy (10). Expertise "influences their confidence level with the topic and develops a sense of competence in the student area," they conclude. Evidently, prior research has either examined self-efficacy as a dependent variable that is impacted by expertise, (11) or as an independent variable that impacts learning accomplishment (12).

A psychological theory called the theory of cognitive load looks at the potential and constraints of the human cognitive architecture to anticipate the outcomes of the study (20). The idea of cognitive learning places a strong emphasis on the intangible mental processes that humans employ to learn and retain knowledge or new skills (21). Working memory labor required to comprehend information received at a specific time is known as cognitive load (22). The theory of information processing refers to the management or processing of information in human perception. “Long-term memory and Short-term memory” make up the majority of the system memory that is used to process information (23). The system memory's long-term memory is where data is kept when it has to be stored for a while “Short-term memory”, commonly referred to as working memory or working memory, is a type of memory that can temporarily store a limited quantity of information.

Instructional design establishes the capabilities and constraints of the human cognitive architecture in accordance with the concept of cognitive load (24). "Rating scales" have been widely used and recognized for evaluating cognitive load, although there is still debate over whether and how often to use the instrument. In general, two methods have been reported in the literature: "1) measuring cognitive load once, following the completion of the entire learning/problem-solving phase; and 2) assessing cognitive load immediately following each problem-solving step or task and averaging the obtained values to produce an indicator of the overall cognitive load". When Schmeck et al. examined these two approaches, they discovered that the average of delayed evaluations was much greater than that of instant ratings. Van Gog et al, who looked at mental effort as another often used subjective measure of cognitive load, came to similar findings. The question of whether of the two approaches is superior is still open (16).

Definition of education under the law The National Education System's number 20 challenges for 2003 is how students connect with teachers and learning resources in a classroom setting. Online learning is instruction that takes place between professors and students without them physically meeting. E-learning, remote learning and video conferences are all ways to learn. Online learning is sometimes referred to by names like e-learning, System, and Online Learning. Computer-based learning and the Online Learning Model (OLM) (8).

One of Albert Bandura's most noteworthy features of his social-cognitive theory on personality development was the idea of self-efficacy (or social learning theory). According to Bandura's theory, the self is described in terms of cognition as "a set of sub functions for the perception, assessment, and regulation of action" and "cognitive structures that offer reference mechanisms" (56)

As a context-related construct, academic self-efficacy relates to people's perceptions of their own capacities for effectively carrying out a plan of action those results in a desired outcome (80). Albert Bandura's "self-efficacy theory" as a starting point, as well as further research with an emphasis on academic self-efficacy (79), we believe that the following phase necessitates research on students' mental or cognitive strain in relation to their perceptions of their academic abilities, particularly cognitive abilities. It has been demonstrated in several research that academic self-efficacy is a powerful predictor of academic accomplishment. The goal of this study is to investigate the relationship between the motivational and learning variable (self-efficacy) and the cognitive load in online learning among undergraduate students of physical therapy because there are few studies on self-efficacy and cognitive load in Pakistan.

Objectives

1. To determine association between self-efficacy and cognitive load in online learning among undergraduate Physical therapy students.
2. To determine the association of COVID-19 related stress with cognitive load in online learning among undergraduate Physical therapy students.
3. To determine the association of physical activity with cognitive load in online learning among undergraduate Physical therapy students.

Alternate Hypothesis:

1. There is association between self-efficacy and cognitive load in online learning among undergraduate Physical therapy students.
2. There is association of COVID-19 related stress with cognitive load in online learning among undergraduate Physical therapy students.
3. There is association of physical activity with cognitive load in online learning among undergraduate Physical therapy students.

Null Hypothesis:

1. There is no association between self-efficacy and cognitive load in online learning among undergraduate Physical therapy students.
2. There is no association of COVID-19 related stress with cognitive load in online learning among undergraduate Physical therapy students
3. There is no association of physical activity with cognitive load in online learning among undergraduate Physical therapy students.

Methodology

An Analytical cross Sectional study with sample size of 344 was conducted in Private Sector Universities offering DPT in Peshawar, KPK, to find out association of self-efficacy and cognitive load in online

learning among undergraduate physical therapy students, using Non probability convince sample technique.

Inclusion Criteria:
- Both genders
- Undergraduate Students of PT
- Students taking online classes at least six months 2.6.2

Exclusion Criteria:
Participant failing to fall in this category would be excluded of the study.
- Irregular students
- Students having only clinical rotations

For data collection we used General Self-Efficacy Scale (GSE) , International Physical Activity Questionnaire (IPAQ), Cognitive Load Scale (CLS) and Covid-19 Stress Scale Questionnaire.

After taking approval from Board of advance studies and research, Riphah University, Approval was taken from concerned universities. Students were assessed for eligibility. Those who was willing and meeting our criteria was enrolled and filled different questionnaires namely General Self-Efficacy Questionnaire, COVID-19 stress scale, International physical activity questionnaire, Cognitive Load Scale. All data was collected through online Google forms.

The demographical data was analyzed using the descriptive statistics and presented as mean, standard deviation, frequency and percentages. Pearson correlational coefficient (r) was used for the analysis of correlation between self-efficacy and cognitive load. P value of 0.05 or less than 0.05 was significant.

RESULTS

Table 1 Shows Descriptive Statistics

S.No	Variable	Male	Female	Total
1	Age of the participant in years (Mean±S.D)	21.39±1.88 Years	21.74±1.86 Years	21.55±1.83 Years
2	Gender of participant Frequency (%)	238(53.6%)	206(46.4%)	444(100%)

Table 2: Shows Correlation of Cognitive Load Scale With Gross General Self Efficacy

	General Self Efficacy	
Cognitive Load Scale	**r- value**	**p-value**
Keeping Things in Mind	-0.043	0.364
Task Complexity	0.042	0.379
Understanding the task	-0.049	0.300
Understanding Correctly	-0.030	0.529
Task Comprehension	0.060	0.209
Exhausting Task	0.091	0.055
Inconvenient Task Design	-0.009	0.852
Difficulty in Understanding	0.014	0.762

Table 3: Shows Pearson Correlation of Cognitive Load Scale And General Self-Efficacy (Scale A)

	Keeping in Mind		Things Task Complexity		Understanding the task		Understanding Correctly	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Problem Management	0.35	0.486	0.006	0.902	0.048	0.317	0.001	0.982
Problems Cover-up	**-0.049****	0.361	0.106	0.025	**-0.031****	0.508	0.026	0.592
Goals Accomplishment	0.001	0.990	**-0.041****	0.392	0.027	0.573	**-0.043****	0.369
Dealing Efficiently	**-0.036****	0.447	0.108	0.023	**-0.087****	0.068	**-0.053****	0.269
Handling unforeseen situations	**-0.038****	0.426	0.068	0.023	**-0.030****	0.535	**-0.027****	0.577
Problem Solving	**-0.021****	0.655	**-0.068****	0.155	**-0.031****	0.509	-0.044	0.354
Coping strategies	**-0.093****	0.051	**-0.045****	0.344	0.025	0.605	0.006	0.907

Table 4: shows Pearson Correlation of Cognitive Load Scale and General Self-Efficacy (Scale B)

Solution finding for problems	**-0.036****	0.446	0.002	0.970	**-0.082****	0.086	0.061	0.203
Thinking of solutions in trouble	-0.083	0.081	**-0.073****	0.125	**-0.027****	0.565	0.003	0.946
Dealing with every situation	**-0.015****	0.749	0.398	0.040	0.018	**-0.112****	0.065	**-0.088****

***= Statistically Significant Value, **= Negative Correlation**

	Task Comprehension		Exhausting Task		Inconvenient Task Design		Difficulty in Understanding	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Problem Management	0.044	0.359	0.070	0.142	**-0.002****	0.971	0.013	0.789
Problems Cover-up	0.031	0.510	0.096	**0.044***	**-0.067****	0.159	0.005	0.920
Goals Accomplishment	0.058	0.219	0.045	0.348	0.033	0.491	**-0.032****	0.503
Dealing Efficiently	**-0.015****	0.754	0.095	**0.046***	0.044	0.356	0.150	**0.001***
Handling unforeseen situations	**-0.004****	0.927	**-0.056****	0.240	**-0.062****	0.191	0.022	0.637
Problem Solving	**-0.012****	0.807	**-0.044****	0.353	**-0.031****	0.191	-0.070	0.637
Coping strategies	0.047	0.318	0.077	0.104	0.036	0.444	**-0.015****	0.760
Solution finding for problems	0.049	0.303	0.030	0.526	0.002	0.968	**-0.010****	0.823
Thinking of solutions in trouble	0.064	0.176	0.001	0.993	0.010	0.828	**-0.029****	0.543
Dealing with every situation	**-0.003****	0.950	0.097	**0.041***	0.087	0.068	0.094	**0.048***

***= Statistically Significant Value, **= Negative Correlation**

Table 5: shows Pearson Correlation of Cognitive Load Scale and Covid-19 Stress (Scale A)

	Keeping Things in Mind		Task Complexity		Understanding the task		Understanding Correctly	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Risk of Contagion	**-0.151****	**0.001***	0.008	0.864	**-0.159****	**0.001***	**-0.070****	0.141
Social Isolation	**-0.076****	0.109	0.038	0.420	**-0.164****	**0.001***	**-0.081****	0.088
Relationship with relatives	**-0.040****	0.405	**-0.061****	0.203	**-0.048****	0.316	**-0.017****	0.715
Relationship with Colleagues	0.023	0.631	**-0.025****	0.604	0.097	**0.042***	0.037	0.432
Relationship with professors	**-0.001****	0.985	**-0.045****	0.343	0.069	0.149	**-0.032****	0.500
Study Experience	**-0.048****	0.317	**-0.015****	0.753	**-0.024****	0.618	**-0.031****	0.519
Changes in sexual life	**-0.017****	0.728	**-0.040****	0.398	0.059	0.218	0.058	0.225

*= Statistically Significant Value **= Negative Correlation

Table 6: shows Pearson Correlation of Cognitive Load Scale and COVID-19 Stress (Scale B)

	Task Comprehension		Exhausting Task		Inconvenient Task Design		Difficulty in Understanding	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Risk of Contagion	**-0.042****	0.375	0.177	**0.001***	0.139	0.003	0.029	0.546
Social Isolation	-0.009	0.846	0.196	**0.001***	0.149	**0.002***	0.026	0.589
Relationship with relatives	0.009	0.846	0.113	**0.017***	0.088	0.064	**-0.27****	0.572
Relationship with Colleagues	0.051	0.281	**-0.031****	0.508	0.080	0.093	**-0.013****	0.777
Relationship with professors	0.072	0.130	0.093	**0.050***	0.081	0.088	**-0.036****	0.449
Study Experience	0.028	0.556	0.039	0.058	0.133	**0.017***	0.061	0.196
Changes in sexual life	0.029	0.544	**-0.122****	**0.019***	**-0.040****	0.404	**-0.81****	**0.090***

Table 7: shows Pearson Correlation of Cognitive Load Scale and IPAQ (Scale A)

	Keeping in Mind		Things		Task Complexity		Understanding the task		Understanding Correctly	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Vigorous Physical activity	0.028	0.555	0.066	0.168	-**0.014****	0.771	-**0.046****	0.330		
Time Spent on Vigorous activity	0.008	0.873	-**0.123****	**0.009***	-**0.032****	0.499	-**0.021****	0.656		
Moderate physical Activity	-**0.172****	**0.001***	0.016	0.730	-**0.028****	0.561	0.008	0.866		
Time spends on moderate activity	-**0.111****	**0.019***	0.009	0.857	-**0.080****	0.094	-**0.029****	0.539		
Walk for 10 mints	-0.033	0.489	0.108	0.023	-**0.150****	0.001*	-**0.069****	0.149		
Time Spend while walking	0.012	0.799	0.072	0.132	0.019	0.695	-**0.010****	0.839		
Time Spend while sitting	-**0.034****	0.481	-**0.008****	0.863	-**0.011****	0.813	-**0.011****	0.814		

= Statistically Significant Value, **= Negative Correlation

Table 8: shows Pearson Correlation of Cognitive Load Scale and IPAQ (Scale B)

	Task Comprehension		Exhausting Task		Inconvenient Task Design		Difficulty in Understanding	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Vigorous Physical activity	0.001	0985	-0.079**	0.098	-0.043**	0.365	-0.044**	0.355
Time Spent on Vigorous activity	0.037	0.439	-0.005**	0.914	0.036	0.451	-0.054**	0.255
Moderate physical Activity	-0.073**	0.125	0.094	0.047*	0.058	0.221	0.109	0.022*
Time spends on moderate activity	-0.152**	0.001*	0.012	0.799	-0.006**	0.895	0.052	0.276
Walk for 10 mints	-0.068**	0.154	0.184	0.001*	-0.167**	0.001*	0.183	0.001*
Time Spend while walking	0.024	0.614	0.089	0.061	-0.007**	0.878	-0.011**	0.825
Time Spend while sitting	-0.155**	0.001*	0.092	0.052	-0.124**	0.009*	0.026	0.595

*= Statistically Significant Value, **= Negative Correlation

DISCUSSION:

The current study found a weak but positive association between cognitive load and variables like physical activity and general self-efficacy. Several previous studies align with these findings:

Cristian V. et al (2011) examined university students and reported a direct association between self-efficacy and cognitive load, similar to our findings. The difference in strength may be due to sample size or outcome measures used.

A. Pardo et al (2019) also found a significant positive correlation between self-efficacy and cognitive load in students, supporting our results.

David F. Feldon et al (2018) reported an insignificant association between self-efficacy and cognitive load among undergraduate biology students, aligning with our study's weak correlations.

Saied Bishara et al (2021) observed a positive association between cognitive load and self-efficacy in students without learning disabilities, which supports our findings despite variation in participant types.

Santi Wahyuni et al (2020) found that increased self-efficacy reduced cognitive load in online nursing students during COVID-19—similar to our finding of negative correlation in some self-efficacy variables.

Chun-Hao Wang et al (2016) concluded that moderate physical activity improves cognitive functioning, partially supporting our study where moderate activity was negatively correlated with cognitive load.

Jim Horne (2013) found that regular exercise helps reduce cognitive load and improve sleep in aging populations, partially aligning with our findings on physical activity.

Inguna Griskevica et al (2021) reported a significant relationship between cognitive load and self-efficacy in student-directed distance learning, which contrasts with our weak association.

Roman Goenarjo et al (2019) found a strong association between physical activity and cognitive load in athletes, differing from our study's weak correlation among general students.

CONCLUSION:

The findings of this study suggest that engaging in physical activity significantly contributes to the reduction of cognitive load among students during online learning. Furthermore, higher levels of self-efficacy are associated with lower cognitive load, whereas elevated stress levels related to COVID-19 tend to increase cognitive burden. These results underscore the importance of physical and psychological well-being in optimizing students' learning experiences in virtual environments.

REFERENCES

Van Bruggen J. Theory and practice of online learning. Br J Educ Technol. 2005 Jan;36(1):111–2.

Technology EK-TTU of, 2009 undefined. Learning styles and e-learning. Citeseer [Internet]. 2009 [cited 2022 Jul 26]; Available from:

Kirschner PA. Cognitive load theory: Implications of cognitive load theory on the design of learning. Learn Instr. 2002;12(1):1–10.

Paas F, Renkl A, psychologist JS-E, 2003 undefined. Cognitive load theory and instructional design: Recent developments. Taylor Fr [Internet]. 2010 [cited 2022 Jul 26];38(1):1–4. Available from:

Monika M, Manajemen AA-JP, 2017 undefined. Peran efikasi diri dan motivasi belajar dalam meningkatkan hasil belajar siswa sekolah menengah kejuruan. pdfs.semanticscholar.org [Internet]. 2017 [cited 2022 Jul 26];2(2):219–26.

adolescents AB-S beliefs of, 2006 undefined. Guide for constructing self-efficacy scales.

Raskauskas J, Rubiano S, Offen I, Wayland AK. Do social self-efficacy and self-esteem moderate the relationship between peer victimization and academic performance? Soc Psychol Educ. 2015 Jun 11;18(2):297–314.

Wilde N, Hsu A. The influence of general self-efficacy on the interpretation of vicarious experience information within online learning. Int J Educ Technol High Educ. 2019 Dec 1;16(1).

Gottschalk F. Impacts of technology use on children: Exploring literature on the brain, cognition and well-being. 2019 [cited 2022 Jul 26]; Available from: https://www.oecd ilibrary.org/content/paper/8296464e-en

Zheng R, McAlack M, Wilmes B, Kohler-Evans P, Williamson J. Effects of multimedia on cognitive load, self-efficacy, and multiple rule-based problem solving. Br J Educ Technol. 2009;40(5):790–803.

Bleicher RE, Lindgren J. Success in science learning and preservice science teaching self-efficacy. J Sci Teacher Educ. 2005 Aug;16(3):205–25.

Isiksal M, Askar P. The effect of spreadsheet and dynamic geometry software on the achievement and self-efficacy of 7th-grade students. Educ Res. 2005 Nov;47(3):333 50.

Zu T, Munsell J, Rebello NS. Subjective Measure of Cognitive Load Depends on Participants' Content Knowledge Level. Front Educ. 2021 May 10;6.

Zhou M, Instruction PW-L and, 2012 undefined. Modeling academic achievement by self-reported versus traced goal orientation. Elsevier [Internet]. [cited 2022 Jul 26];

Winne PH. Leveraging big data to help each learner and accelerate learning science. Teach Coll Rec. 2017;119(3).

Schmeck A, Opfermann M, van Gog T, Paas F, Leutner D. Measuring cognitive load with subjective rating scales during problem solving: differences between immediate and delayed ratings. Instr Sci. 2015 Jan 1;43(1):93–114.

Lust G, Elen J, Behavior GC-C in H, 2013 undefined. Students' tool-use within a web enhanced course: Explanatory mechanisms of students' tool-use pattern. Elsevier [Internet]. 2013 [cited 2022 Jul 26]; 9

Nakagawa S, evolution HS-M in ecology and, 2013 undefined. A general and simple method for obtaining R2 from generalized linear mixed-effects models.

Jovanović J, Dawson S, Gašević D, Whitelock-Wainwright A, Pardo A. Introducing meaning to clicks: Towards traced-measures of self-efficacy and cognitive load. ACM Int Conf Proceeding Ser. 2019;(March):511–20.

Goenarjo R, Bosquet L, Berryman N, Metier V, Perrochon A, Fraser SA, et al. Cerebral oxygenation reserve: The relationship between physical activity level and the cognitive load during a stroop task in healthy young males. Int J Environ Res Public Health. 2020;17(4):1–14.

Tofel-Grehl C, Feldon DF. Cognitive Task Analysis–Based Training: A Meta-Analysis of Studies. http://dx.doi.org/101177/1555343412474821

Martin S. A Critical Analysis of the Theoretical Construction And Empirical Measurement Of Cognitive Load. Cogn Load Meas Appl. 2019 Mar 14;29–44.

Al-Hunaiyyan A, Bimba A, ... NI-I, 2017 undefined. A cognitive knowledge-based framework for social and metacognitive support in mobile learning. search.ebscohost.com [Internet]. [cited 2022 Jul 26]; Available from:

Curum B, Khedo KK. Cognitive load management in mobile learning systems: principles and theories. J Comput Educ. 2021 Mar 1;8(1):109–36.

Cornelisz I, Assisted C van K-J of C, 2018 undefined. Student engagement with computerized practising: Ability, task value, and difficulty perceptions. Wiley Online Libr [Internet]. 2018 Dec 1 [cited 2022 Jul 26];34(6):828–42. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/jcal.12292

Fincham E, Gašević D, ... JJ-IT on, 2018 undefined. From study tactics to learning strategies: An analytical method for extracting interpretable representations. ieeexplore.ieee.org [Internet]. [cited 2022 Jul 26]; Available from: https://ieeexplore.ieee.org/abstract/document/8331946/

Li N, Kidziński L, Jermann P, Dillenbourg P. MOOC video interaction patterns: What do they tell us? Lect Notes Comput Sci (including Subser Lect Notes Artif Intell Lect Notes Bioinformatics). 2015;9307:197–210.

Kalyuga S, Kalyuga S. Cognitive Load Theory: How Many Types of Load Does It Really Need? Educ Psychol Rev 2011 231 [Internet]. 2011 Jan 14 [cited 2022 Jul

Sweller J, Sweller J. Element Interactivity and Intrinsic, Extraneous, and Germane Cognitive Load. Educ Psychol Rev 2010 222 [Internet]. 2010 Apr 23 [cited 2022 Jul 26];22(2):123–38. Available from: https://link.springer.com/article/10.1007/s10648 010-9128-5

institutions RC-F change in, environments undefined, and undefined, 2014 undefined. Resistance to change: Unconscious knowledge and the challenge of unlearning. taylorfrancis.com [Internet]. [cited 2022 Jul 26]; Available from.