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A Cognitive Load for Online Classrooms in an EFL Context: A Qualitative Study

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ABSTRACT
Cognitive load is the amount of effort the mind makes to process information. When the cognitive load is high or excessive, it leads to consequences such as unwillingness to learn, inability to recall information from long-term memory, and understanding information.The main objective of this study was to consider a cognitive load for online classrooms in an EFL context using a qualitative study. This study made use of qualitative approach through grounded theory (1967). Population were all EFL learners of Tabriz Azad University students among them 16 EFL learners selected as sample size using purposefully non-randomly method who participated in our study voluntary. To gather data, a semi-structured interviews designed with learners to identify the items and components of their cognitive load in online classes. To determine the validity and reliability of interviews process, we made use of Lincoln & Guba (1985) method and kappa coefficient (0.663). Results showed that in general 27 codes were identified as components of cognitive load in online classes which are categorized under 6 core components as learning process, doing tasks, class time, environment, software quality and suitable load. In turn, these core components were categorized as selective components including intrinsic, extraneous and germane cognitive loads.

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1. Introduction

Foreign languages learners, sometimes, are taught more than they can learn; they are overwhelmed by the enormous amount of knowledge. Sweller (1988) claimed that students sometimes are being taught incorrectly because the teaching strategies do not consider how they learn. Beside anxiety and fear in the process of foreign language learning (Bahrami, 2023), according to Sweller, the human working memory capacity is minimal and cannot process a massive amount of information at the same time (Sweller, Van Merrienboer, & Paas, 1998). Therefore, it is of paramount importance for teachers to take into consideration students' cognitive capacities. Otherwise, students will be overwhelmed and the learning outcomes would not comply with the teaching objectives. Consequently, the learning process would fail (Asma & Dallel, 2020).

In attempts to measure the cognitive load, many studies have been conducted including objective tasks such as secondary tasks (Sweller et al., 2011c) and psychophysiological measures such as eye tracking (Zheng & Cook, 2012; Scharinger et al., 2020), electroencephalogram (Makransky et al., 2019a; Baceviciute et al., 2020), and comparing subjective and objective factors of CL (Minkley, Xu & Krell, 2021), and some researchers studied the efficiency of working memory span in the aspects of English language learning (Vosoughi, 2022). However, most of them are developed as self-report scale with single item scale. However, the Covid-19 pandemic and subsequent public health responses had an unprecedented impact on higher education. In March 2020 the world universities, which had then largely delivered in-person classes, announced that they would abruptly transition their classrooms to an entirely online learning environment (Houlden & Valetsianos, 2020). In a matter of a weeks, many offline courses transitioned to an online offering, a trend which continued throughout subsequent terms in 2020 and 2021 (Myrick et al., 2020). Though many university programs transitioned to a formal online offering over the summer of 2020, this transition was undertaken by faculty and students who often had no online learning experience (VanLeeuwen et al., 2021). This transition has reportedly contributed to pervasive negative reactions among students (Besser et al., 2020) and has even taken a toll on many students' mental health (Copeland et al., 2021). Why did it happen this way? Since the widespread adoption of the internet in the 1990s, numerous papers have been reinforcing the need for organizations to introduce online learning and have identified a variety of manageable factors can influence online learning outcomes (Boling et al., 2012, Soleimanifard et.al, 2020). For example, Sun et al. (2008) identified that computer anxiety negatively influences reported online learning satisfaction, while perceived course quality or ease of online learning technology use positively shape it. Similarly, cognitive overload is known to influence online learning outcomes (Mayer, 2009), and steps can be taken to distinguish and limit information or communication overload. Research concerning online learning during the Covid-19 pandemic has identified how

factors such as attitudes towards technology (Aguilera-Hermida, 2020), degree of learner attentiveness (Conrad & Newman, 2021) and effective course design (Orlov et al., 2021) can positively influence online learning outcomes.

As the pandemic progressed, it became clear that there were additional considerations that affected online teaching success. Online courses still require faculty to provide learning material and communicate directly with students (Swan, 2019), and the change in communication format initially became a source of anxiety for many (VanLeeuwen et al., 2021). However, there are still several gaps in this literature. A main gap in the literature is that there seems to be a need to evaluate the sensitivity of the potential dimensions of EL in online lectures. The other gap is that until now there has been no study in our context that measure the three types of cognitive load differentially, namely intrinsic (ICL), extraneous (ECL), and germane cognitive load (GCL) (Brünken et al., 2010) and their sub-components based on measuring cognitive load of online lectures and this study attempts to fill such theoretical gaps in the literature. Specifically, with the global COVID-19 pandemic, the use of online teaching platforms is quickly increasing (König et al., 2020) and there is evidence that factors such as noise (Servilha & Delatti, 2014) and disturbances from devices including disconnect from the internet (Chen & Yan, 2016) can create cognitive load when learning which should be considered due to the continuation of online education in the country and its possible frequent use in the future, even with the eradication of Covid-19. With attempting to fill theoretical and empirical gaps in the literature related to multi-dimensional cognitive theory, therefore, this study attempts to consider a cognitive load for online classrooms in an EFL context using a qualitative study.

2. Review of Related Literature

Le Cunff et al. (2024) have investigated the neural diversity and cognitive load of students in online classes and online learning and have shown that most students in online classes have high cognitive load and the cognitive load of students with neural diversity is also similar to other students who are almost the same. Bănuț et al. (2023) investigated the cognitive load of students in online education under the lens of learning theories and came to the conclusion that the cognitive load of students in online classes is different from their cognitive load in face-to-face classes. Trilisiana et al. (2023) investigated the cognitive load of students during online learning in the middle of the outbreak of the covid-19 pandemic and showed that due to the newness of the online class experience, students had disturbances and distractions. They have more cognitive load. Andersen & Makransky (2021) validated and further developed the multidimensional cognitive load scale for physical and online lectures (Mcls-pol). Through three studies, they investigated the reliability, and internal and external validity of the MCLS-POL using the Partial Credit Model, Confirmatory Factor Analysis, and differences between students either attending a lecture physically or online (Studies 2 and 3). The results of Study 1 (N = 250) provide

initial evidence for the validity and reliability of the MCLS-POL within a higher education sample, but also highlighted several potential improvements which could be made to the measure. These changes were made before re-evaluating the validity and reliability of the measure in a new sample of higher education psychology students (N = 140, Study 2), and psychological testing students (N = 119, Study 3). Together the studies provide evidence for a multidimensional conceptualization cognitive load and provide evidence of the validity, reliability, and sensitivity of the MCLS-POL and provide suggestions for future research directions. Kastaun et.al. (2021) validated the cognitive load during inquiry-based learning with multimedia scaffolds using subjective measurement and eye movements. In two studies (n = 250), 9th and 11th-grade students experimentally investigated a biological phenomenon. At the beginning of the planning phase, students selected one of four multimedia scaffolds using a tablet (Study I: n = 181) or a computer with a stationary eye-tracking device (Study II: n = 69). The subjective cognitive load was measured via self-reports using a standardized questionnaire. Additionally, they recorded students' gaze data during learning with the scaffolds as objective measurements. Besides the causal factors of cognitive-visual and verbal abilities, reading skills and spatial abilities were quantified using established test instruments and the learners indicated their representation preference by selecting the scaffolds. The results showed that CL decreases substantially with higher grade levels. Regarding the causal factors, they observed that cognitive-visual and verbal abilities have a significant influence on the ECL and GCL in contrast to reading skills. Additionally, there was a correlation between representation preference and different types of CL. Concerning the objective measurement data, they found that the absolute fixation number is predictive of the ECL. Klepsch et.al. (2017) in a study as "development and validation of two instruments measuring intrinsic, extraneous, and germane cognitive load" developed and analyzed two strategies to measure cognitive load in a differentiated way: (1) Informed rating: they trained learners in differentiating the concepts of the cognitive load so that they could rate them in an informed way. They were asked then to rate 24 different learning situations or learning materials related to either high or low intrinsic, extraneous, or germane load. (2) Naïve rating: For this type of rating of cognitive load they developed a questionnaire with two to three items for each type of load. With this questionnaire, the same learning situations had to be rated. In the second study (N D between 65 and 95 for each task), they improved the instrument for the naïve rating. For each study, they analyzed whether the instruments are reliable and valid, for Study 1, they also checked for comparability of the two measurement strategies. In Study 2, they conducted a simultaneous scenario-based factor analysis. The informed rating seems to be a promising strategy to assess the different aspects of cognitive load, but it seems not economic and feasible for larger studies and standardized training would be necessary.

The review of the research literature shows that although the cognitive load of students in online classes has been examined in some previous studies abroad, however no research has been investigated the cognitive load of foreign language learners in online classes, especially in the country after the outbreak of Covid-19 and there is a research gap in this field.

3. Methodology

Method: This study made use of qualitative approach through grounded theory.

Participants: participants were all EFL learners of Tabriz Azad University students among them 16 EFL learners selected as sample size using purposefully non-randomly method who participated in our study voluntary.

Instruments: using a qualitative approach and results of grounded theory approach, we designed a semi-structured interviews with learners to identify the items and components of their cognitive load in online classes. The duration of the interview with each student was about 30-40 minutes. The interview continued until the interviews reach the saturation point, that is the point in time when the collection of new qualitative data no longer changes or changes little. The questions were mainly open-ended questions allowing the participants to express themselves freely on the theme initiated by the interviewer. To determine the validity and reliability of interviews process, we made use of Lincoln & Guba (1985) method and *kappa coefficient (*Kohen, 1960).

Based on Lincoln and Goba's (1985) assessment method, the scientific validity of qualitative studies includes four criteria: validity, transferability, reliability, and verifiability. Therefore, the strategy of review of participants and review of experts was used to determine validity. In order to measure the review of the participants, in addition to returning the statements and experiences of the people during the interviews, the codes, their full text and its classes were also provided to three experts and their views were examined for correction or confirmation. Also, in order to check transferability, the entire text was provided to three members in its entirety along with categories and codes; and finally, regarding the verifiability, an effort was made to record all the activities carefully.

Ethical Considerations: Also, in order to comply with the ethical conditions, we tried to get their consent to participate in the research.

Kappa Coefficient: To measure the agreement between evaluators, we made use of Kappa coefficient (Kohen, 1960):

$Kappa = Pi = (PA_o – PA_E)/ (1 – PA_E)$

In which, PA_0 shows the agreement value between two evaluator and PA_E shows the expected agreement value (Table 1).

Table 1. Results of Kappa Coefficient Test

Agreement level	Kappa	Value	Std.Errors	Approximate T	Sig
		0.663	0.055	10.231	0.000

Table 1 shows the results of Kappa coefficient test. Totally, appropriate coefficient for Cohen's Kappa coefficient is more than 0.6 and in this study and according to results of table 1, Kappa coefficient is more than 0.6 (0.663) and it is significant (P<0.01). Therefore, reliability and validity of the conducted interviews in our study were confirmed completely. Finally, data was coded in three stages including open coding, axial and selective coding.

4. Results and Discussion

Through analyzing of data and categorizing them, results of this study was coded around 27 codes. The primary codes are provided in table 2.

Table 2. Open Coding based on Extracted codes

The Primary codes (open)	Phrases (Content)
1.Long Class Time	I think online learning were long and I could not concentrate until the end of the class and almost half of the class time, I would lose my attention and get distracted. We don't have the opportunity to leave our home during the two hours allowed during the curfew because we have to sit in online classes.
2.Providing uniform lesson content without using info-graphics	In teachers' teaching, figures, diagrams, and images were used very little, and most of the written text was presented, and it was very boring for me, while in traditional classes, the teacher used a variety of teaching methods.
3.Dryness and formality of classes	The professors are not flexible in the virtual class and they talk in one direction throughout the class, and the online classes are very dry and formal.
4.Noise of Environment	There is a lot of noise in the environment. For example, when I participated in the class, my little sister kept making noise and I could not concentrate When I was taking an online class, my family was talking, or the TV was loud. When I was in class, a guest would come and I couldn't really focus on learning in class. The sounds of the environment around me were very annoying during online learning and I felt that my brain did not have the capacity to separate the sounds of the environment and learning.
5.Noise of software	When using the online learning software, there were many problems, for example, the sound of the software was cut off, and sometimes it took half an hour or less to adjust the teacher's voice or our voice to the teacher's, which was nerve-wracking. When using the online learning software, sometimes other sounds came from the software, which disturbed one's concentration.
6.Weak quality of software	The software that was designed for the online class was of poor quality, sometimes it was completely disconnected or the software could not be opened at all due to the low internet speed. Sometimes it would not accept the user's password and you had to try several times before you could log in.

7.What happened in the surrounding environment (reduced focus on the learning)	The events around me completely distracted me and I could hardly maintain my concentration. For example, the doorbell, breaking something in the house, guests coming, family arguments.
8.Smart phone programs including notifications, messages, broadcasting of advertisements in the software	Playing ads on mobile phones while attending class was really annoying. Mobile phone notifications distracted me from learning. When I was in class, my friends' messages, or the messages I received from virtual networks, would distract me.
9.Voice and video calls	Sometimes my phone rang in the middle of class, which completely distracted me. Sometimes my siblings who are in another city would call me in the middle of the class and it would take me a long time to regain my concentration and I would miss a lot of material and it was really annoying.
10.Complexity of online learning compared with traditional learning	To do virtual assignments, I have to keep a lot of things in my head at the same time. In my mind, online homework is complicated compared to traditional homework
11.Weakness of sound from software and difficulty in concentrating	The sound of the software was very low and sometimes, even though the sound was not a problem and was completely established, it was not possible to hear the professor's voice well.
12.Large amount of learning items	The online learning activities that had to rely on the knowledge in memory were more than our memory capacity.
13.Complexity of doing schoolwork	I find it much harder to do online assignments and submit them than the traditional way
14.Internet Outage	Sometimes the internet outage was very liberating During some class exams, the internet outage made me try all kinds of internet features to be able to connect and participate in the exam.
15.keeping a lot of things at the same time	I have to keep a lot of things in my head at the same time
16.Capacity of memory	I feeling that my memory cannot hold all this information at once
17.Lack of familiarity with the technological environment of online learning	We had little familiarity with the Internet and online class technologies, and all of a sudden we had to participate in an online class, which took a lot of time and I felt that my mind did not have the capacity to receive information at once.
18.Complexity of the task and the imposed load	The load imposed on the working memory is caused by the complexity of the task itself.
19.Weak in coordination in learning and multimedia content	I tried not only to understand the details of the text and the multimedia content, but also to understand its general meaning, but I could not make a good harmony between them.

20.More effort to understand correctly in online learning than traditional learning	While doing the virtual assignment, I struggled to understand everything properly, which made me spend more time compared to face-to-face classes, which was very boring.
21.The presence of stimuli that, through supporting elements within the learning material, contribute to deeper processing	While doing the virtual assignment, I tried to get everything right (which indicates trying to get everything right).
22.Being boring to find important information while doing virtual homework	It was frustrating to find important information while doing virtual homework.
23.Difficulty of finding important information while doing virtual homework	The design of this assignment (virtual) was very inappropriate for learning. During the (virtual) task, it was difficult to recognize important information.
24.Difficulty of making connections between important information when doing a virtual task	It was difficult to make a connection between them while doing the (virtual) task
25.The complexity of the methods of presenting school assignments	I think the load imposed on the my working memory is caused by the complexity of the online task presentation methods

Table 2 indicates the open codes related to cognitive load of students on online classes. This table shows that in general 25 open codes were identified and based on we were able to identify three axial or core and selective codes including (a) Intrinsic cognitive load, (b) Extraneous cognitive load, (c) Germane cognitive load.

Intrinsic Cognitive Load Items: The students participating in this research believed that in teachers' teaching, figures, diagrams, and images were used very little, and most of the written text was presented, and it was very boring to them, while in traditional classes, the teacher used a variety of teaching methods. They believed that the professors are not flexible in the virtual class and they talk in one direction throughout the class, and the online classes are very dry and formal. They thought that they have to keep a lot of things in their head at the same time to be able to do virtual assignments. Online homework was complicated compared to traditional homework. The online learning activities that had to rely on the knowledge in memory were more than our memory capacity. It was much harder to do online assignments and submit them than the traditional way. They have to learn a lot of things in at the same time and their memory

cannot hold all this information at once. They had little familiarity with the internet and online class technologies, and all of a sudden they had to participate in an online class, which took a lot of time and they felt that their mind did not have the capacity to receive information at once. The load imposed on the working memory is caused by the complexity of the task itself and It was frustrating to them to find important information while doing virtual homework.

Intrinsic cognitive load is inherent to the topic teachers are teaching and is, basically, how difficult that topic is. This difficulty typically comes from how many connections there are within that topic. For example, in language learning memorizing vocabulary has relatively low intrinsic load (direct connections between words), while grammar has high intrinsic loads (lots of connections) (Frederiksen et.al, 2020). Based on theory related to intrinsic cognitive load, we could categorize providing uniform lesson content without using info-graphics, dryness and formality of classes, complexity of online learning compared with traditional learning, large amount of learning items, complexity of doing schoolwork, keeping a lot of things at the same time, capacity of memory, lack of familiarity with the technological environment of online learning, complexity of the task and the imposed load and being boring to find important information while doing virtual homework as intrinsic cognitive load items.

Extraneous Cognitive of Theory: The students participating in this research thought that online learning were long and they could not concentrate until the end of the class and almost half of the class time, they lost attention and get distracted.They didn't have the opportunity to leave home during the two hours allowed during the curfew because they have to sit in online classes. The professors were not flexible in the virtual class. When using the online learning software, there were many problems, for example, the sound of the software was cut off, sometimes other sounds came from the software, the software that was designed for the online class was of poor quality, sometimes it was completely disconnected or the software could not be opened at all due to the low internet speed. Sometimes it would not accept the user's password and you had to try several times before you could log in. The events around them completely distracted them and they could hardly maintain their concentration. For example, the doorbell, breaking something in the house, guests coming, family arguments. Playing ads on mobile phones while attending class, Mobile phone notifications, friends' messages, and phone rang in the middle of class, voice and video calls were really annoying. The sound of the software was very low and sometimes, even though the sound was not a problem and was completely established, it was not possible to hear the professor's voice well. Sometimes the internet outage was very. It was frustrating to find important information while doing virtual homework. It was difficult to make a connection between them while doing the (virtual) task and the load imposed on their working memory was caused by the complexity of the online task presentation methods.

Extraneous Load (EL) consist of non-intrinsic parts of the learning situation .It means that not all elements of a learning experience enhance the content. Extraneous refers to elements that are not directly relevant to the learning experience (Sweller et al., 2011b). Accordingly, we could categorize the long Class Time, dryness and formality of classes, noise of Environment, noise of software, weak quality of software, what happened in the surrounding environment, smart phone programs including notifications, messages, broadcasting of advertisements in the software, voice and video calls, weakness of sound from software, Internet Outage, difficulty of finding important information while doing virtual homework, difficulty of making connections between important information when doing a virtual task and the complexity of the methods of presenting school assignments as the extraneous cognitive load items in online classes.

Germane Cognitive load: The students participating in this research believed that creating coordination in learning and multimedia content was difficult**,** it was necessary to have more effort to understand correctly in online learning than traditional learning and the presence of stimuli that, through supporting elements within the learning material, contribute to deeper processing. Germane Load (GL) is already existing cognitive resource which can ease the learning e.g., strategies for learning. It means that certain elements of a learning experience can help increase the understanding of a topic. Germane refers to processes that help students' working memory with processing information (Sweller et al., 2011b; Ayres, 2018). Accordingly, we could categorize creating coordination in learning and multimedia content, more effort to understand correctly in online learning and that the presence of stimuli that, through supporting elements within the learning material, contribute to deeper processing as germane cognitive load items. Table 3 shows the process of stages of coding and extracted codes in this study the best.

Table 3. Open, Axial and Selective extracted codes from qualitative data

Code Number	Open Codes	Axial Codes	Selective codes
1	Providing uniform lesson content without using info-graphics	Learning Process	Intrinsic Cognitive load
2	Dryness and formality of classes		
3	Complexity of online learning compared with traditional learning		
4	Large amount of learning items		
5	Complexity of doing schoolwork		
6	keeping a lot of things at the same time		
7	Capacity of memory		
8	Lack of familiarity with the technological environment of online learning	Doing tasks	
9	Complexity of the task and the imposed load		

10	Being boring to find important information while doing virtual homework		
11	Long Class Time	Class time	Extraneous Cognitive Load
12	Unsuitable determined time for classes		
13	Noise of Environment	Environment	
14	Noise of software		
15	Weak quality of software		
16	What happened in the surrounding environment (reduced focus on the learning)		
17	Smart phone programs including notifications, messages, broadcasting of advertisements in the software		
18	Voice and video calls		
19	Weakness of sound from software and difficulty in concentrating	Software Quality	
20	Internet Outage		
21	Difficulty of finding important information while doing virtual homework		
22	Difficulty of making connections between important information when doing a virtual task		
23	The complexity of the methods of presenting school assignments		
24	Creating coordination in learning and multimedia content	Suitable Load	Germane Cognitive Load
25	More effort to understand correctly in online learning than traditional learning		
26	The presence of stimuli that, through supporting elements within the learning material, contribute to deeper processing		
27	The virtual learning assignment included elements that helped me understand the assignment		

Table 3 shows the open, axial and selective codes of cognitive load of students in online classes. According to table 3, 27 open codes were identified totally, 6 axial codes and 3 selective codes were identified in general. The aim of this study was to consider the cognitive load of students for online classrooms in an EFL context using a qualitative study. In general, 27 codes were identified and then they were categorized into 3 selective codes as intrinsic cognitive load, extraneous cognitive load and germane cognitive load. At present education system is going through rapid changes due to COVID-19. Most of the students were in transition phase from traditional classes to online classes in turn many technologies came into existence to serve this purpose. Due to emerging technologies coming into effect, education market is becoming bigger and bigger and ultimately resulting in financial costs of parents for their children

education. Going down the lane, somewhere parents are not satisfied with the achievements of their children and leading them to be strict in all or some areas in online classes. This might be one of the reasons having left students to work hard and putting pressure on working memory. In addition to that, teachers are habituated to face to face mode of interaction where they can maximize learning in the students. With the pandemic, they are also trying to teach out to the students using various online platforms. In the process, they use different variations in their teaching for better learning. They use number of assessment techniques through online assignments, quizzes etc. It also adds some more stress on working memory for the students who does not know how to complete the assignments online. There could be many more reasons that contribute cognitive load in the students through online classes.

Furthermore, in online learning through virtual platforms, multiple factors tend to influence the cognitive load on the working memory of students. During the face to face interactions, the educator often uses attention gaining material, or purposeful distractions that break the monotony among the audience. Some extraneous intrusions might impede the development of cognitive schemata during online instruction and serve as negative strategies (De Jong, 2010). We could highlight two effects which would significantly influence the extraneous load: a) environment and its effect on the cognitive load of students. For example, noise of environment such as noise at home, disturbances come from software and smart phone such as voice or video calls, messages, notifications could affect the cognitive load of students in online classes; b) software quality in which net speed, the performance of the software, its sound and internet outage could increase cognitive load of students. Besides that, we should highlight two effects which would influence the intrinsic load: a) Learning process in which dryness and formality of classes, complexity of online learning, large amount of learning items, complexity of doing schoolwork, keeping a lot of things at the same time in the memory and capacity of memory could be considered as things that are affective on the intrinsic cognitive load of students. Finally. This research could identify one effects which would significantly influence the germane load as suitable load.

5. Conclusion

To conclude, cognitive load theory is widely accepted when it comes to web based instruction though it has few loopholes. By the nature, many teachers at different levels of education often feel being provided cognitive load to the learners. This theory may provide clear understanding about how working memory of the learner moves on. It also explains the various effects and consequences of cognitive load in the learners. In the present era, the cutting edge technologies came into education for fulfilling the basic purposes of instruction in online classes. Teachers should not be the slaves of technology, rather the asters of technology. Keeping all the pros and cons in the mind, the instructional design should be made and applied in online classes to make learners active for better learning by reducing cognitive load as much as possible.

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