# Comparing Perceived Cognitive Load while Learning Online with AI Chatbots, Pre-recorded Videos, and Live Lectures

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**Abstract:** The Cognitive Load Theory provides an important perspective for observing learning with different online learning technologies. Since more and more professional development programs are carried out online for in-service teachers, it is crucial to explore their perceived cognitive load brought by different online technologies during online learning. This study aimed to examine the Extraneous Cognitive Load (ECL) and Germane Cognitive Load (GCL) of teachers when learning with three online learning technologies (AI chatbot, pre-recorded videos, and live lecture). Altogether 220 teachers from different areas and schools participated in the study by enrolling on the 21-day online learning training about visual thinking tools. The participants reported they perceived ECL and GCL using a self-reported scale. The results showed that they perceived significantly lower ECL during learning with pre-recorded videos than with AI chatbots and live lectures. Meanwhile, no significant differences appeared in the GCL among these three online learning technologies.

**Keywords:** Online Learning, Professional Development, ECL, GCL, AI Chatbot

## 1. Introduction

Technology has changed how we learn and teach. Initially, it was the pre-recorded video lecture represented by MOOC domain the highland of online learning. During the COVID-19 pandemic, live lectures represented by Tencent Meeting and ZOOM have become the mainstream form of teaching. Recently, there is a new way of teaching using AI chatbots, which are like talking robots. However, different online learning methods have different effects on learners. This study looks at how these methods affect teachers' thinking and learning. To understand this effect, we employ the Cognitive Load Theory (CLT).

The CLT theory says that when we learn something, our brain has to deal with three kinds of load: Intrinsic, Extraneous, and Germane(F. Paas et al., 2003). Intrinsic load is how hard the content is. Extraneous load is how hard the method is. Germane load is how well we can use what we learn. The theory says that we should try to lower the extraneous load and increase the germane load to learn better (Sweller et al., 2019). Many researchers have used this theory to study online learning problems(Anmarkrud et al., 2019).

Online learning methods give teachers more choices, but they also need more skills. Teachers have to know how to use different methods for different situations,develop engaging and effective online activities and manage their own thinking and learning with the help of technological tools. This study measures how live lectures, pre-recorded videos, and AI chatbots affect teachers' extraneous and germane load.

## 2. Literature Review

### *2.1 Online Learning and Technologies*

Distance education has become popular, and its effectiveness has continuously improved with technological development. Among the existing online learning technologies, pre-recorded videos and live lectures are currently the most common online teaching technologies. The effectiveness of pre-recorded videos and live lectures has been proven in previous research studies(Bertsch et al., 2007; Islam et al., 2020; Shqaidef et al., 2021). Nevertheless, students could not get an opportunity to ask questions and get feedback promptly while learning through pre-recorded videos. With the advancement of technology, live lectures emerged and addressed this weakness. Live lecture mimics face-to-face classes. The instructor presents himself on one side of the computer. And gestures on the other side, ask questions and interact with each other through the chat function. However, the live lecture is limited by technology, Internet speed, and live broadcast equipment (Chitanana et al., 2008). As the latest emerging technology of online learning and instruction, AI chatbot can assist the instructor converts the instructional design into a dialogue in advance, and the learning occurs in a question-and-answer interactive format. AI chatbot can not only embed images, videos, tests, and other content but also collect learning data. Meanwhile, AI chatbots can enhance interactive learning. In a survey on the application of AI chatbots in India, most students stated that AI chatbots can help them solve their problems most quickly (Sandu & Gide, 2019). Although the AI chatbot allows for timely interaction, it lacks emotional transfer. There is a lack of research that compares AI chatbots, pre-recorded videos, and live lectures. Further research is needed to explore whether there are differences in online learning.

### *2.2 Cognitive Load Theory and its Use in Online Learning*

Cognitive load refers to the total mental activity imposed on working memory at any given moment when performing a specific task (F. Paas, 1992). Sweller (1988) first proposed the Cognitive Load Theory (CLT) in the process of problem-solving.Meanwhile, Sweller (2019) divided cognitive load into three categories: Intrinsic Cognitive Load (ICL), Extraneous Cognitive Load (ECL) and Germane Cognitive Load (GCL). Effective instructional design should minimize ECL as much as possible while using the same ICL to set more cognitive resources for GCL (Sweller et al., 2019).

The three types of cognitive load has also been widely discussed. The definition of the three types of cognitive load shows that the complexity of content determines intrinsic cognitive Load (ICL). At the same time, online learning technology is a vehicle of knowledge for its concerns with the presentation of learning materials and the processing of knowledge by learners. Online learning technology could not influence ICL. Based on the previous cognitive load model (Sweller, 1988), Skulmowski and Xu (Skulmowski & Xu, 2022) proposed the Cost-benefit model in digital learning, which can be seen in Figure 1. In the Cost-benefit model, ECL is seen as a cost, while GCL is seen as a benefit. ECL is considered the effort required for learners to understand the presentation of learning materials, while GCL is the extent to which learners utilize their working memory resources. The Cost-benefit model supports ECL and GCL as essential considerations in online learning.

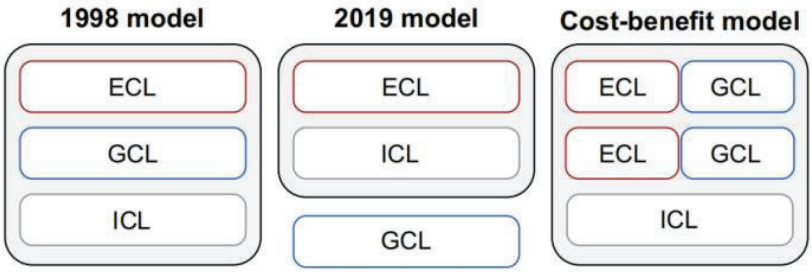


*Fig 1.* The evolution of the models of cognitive Load (Skulmowski & Xu, 2022)

### *2.3 The Measurement of Cognitive Load*

Objective and subjective measurements are currently the main ways of measuring cognitive Load (F. Paas et al., 2003). Subjective measurement is participants who report their cognitive Load by Self-reported. Objective measurement can be psychological, physiological, procedures of tasks, time used in tasks, or reaction time. Objective measurements may cause different results in a survey for its sensitivity and physiological quality. Additionally, objective measurement relies on expensive equipment, and task performance is highly related to the task type. Therefore, subjective measurement may be better than objective measurement in this research study.

There are many self-reported scales for the cognitive load. In the early 1990s, Fred Paas (1992) developed the first cognitive load scale. This Uni-dimensional 9-Point Symmetrical Category Rating Scale has excellent consistency and is widely used in research (F. Paas et al., 2003). Nevertheless, these existing scales do not notice categories of cognitive load. Leppink et al.( 2013) developed a scale to measure different types of cognitive load, which contains the extraneous and intrinsic cognitive load. In this study, we adapt the Cognitive Load Scale (Leppink et al., 2013) for data collection.

### *2.4 The Present Study*

In sum, different online learning technologies may bring different ECLs to learners and allow different GCLs, which effectively indicates learning involvement. This study aims to investigate ECL and GCL perceived by in-service teachers while learning online with three online learning technologies (AI chatbot, pre-recorded videos, and live lecture). The research questions are as follows:

- What are the in-service teachers' perceived ECL and GCL while learning online with three online learning technologies?
- How do the in-service teachers' perceived ECL and GCL differ among these three learning technologies?

## 3. METHODOLOGY

### *3.1 Participants*

This online training lasted 21 days, starting on July 10, 2022, and ending on July 31, 2022. A total of 399 teachers participated in this course. After the training, the teachers who attended the online training completed questionnaires on the widely used online questionnaire platform (https://www.wjx.cn/). We collected 220 valid questionnaires with a valid return rate of 55.10%. All participants voluntarily completed the anonymous questionnaire, and their privacy was ensured not to be disclosed. 15.45% (n=34) of them are males and 85.55% (n=186) are females. Teachers are involved in all subjects. 64.09% (n=141) of the teachers came from primary schools, 24.55% (n=54) from junior high schools, and 11.36% (n=25) from senior high schools.

### *3.2 Materials*

The main aim of this study was to explore online learning technologies which were more effective between AI chatbot, pre-recorded videos, and live lectures. To compare the difference in GCL perceived by teachers when using different online learning technologies, we arranged a 21-day online training and applied an online instructional platform to provide the participators with these three technologies.

To investigate the impact of different online learning technologies on ECL and GCL during learning, we adapted a questionnaire based on the Cognitive Load Scale (Leppink et al., 2013). The adapted Cognitive Load Scale effectively evaluates the ECL and GCL perceived

by teachers, including 13 items about basic information, ECL, and GCL. Moreover, no personal information that could reveal the identity of the participants was gathered.

### *3.3 Procedure*

All 220 teachers who completed a validated questionnaire participated in a 21-day online training course encompassing understanding, manipulating, applying, and evaluating visual thinking tools. The learning was divided into ten modules using an AI chatbot, pre-recorded videos, and live lectures. The learning process was explained as follows: Initially, teachers learned the concepts and cases through AI chatbot and pre-recorded videos and then participated in live lectures to review and consolidated what they have learned in the modules. The live lecture facilitated face-to-face and online communication between the learner and the lecturer, with the lecturer preparing the content beforehand and allowing the learner to ask questions at any time. After the course, a questionnaire was distributed to collect the data needed for the experiment.

### *3.4 Data Analysis*

We used SPSS 24.0 to analyze the quantitative data collected by the questionnaire. Firstly, we examined the reliability and validity of the measurement questionnaire through exploratory factor analysis. Subsequently, one-way repeated-measures ANOVA was used to compare the size of ECL and GCL generated by teachers while learning knowledge using different online learning technologies. Compared to traditional ANOVA, repeated measures ANOVA is more suitable for analyzing the effects of implementing an intervention on multiple variables within the same group of subjects.

## 4. RESULTS

### *4.1 Analysis of Reliability and Validity*

The reliability and validity of the questionnaire were examined from the valid data. As shown in Table 1, the ECL and GCL scales demonstrated high internal consistency with Cronbach's *α* coefficients of .89 and .96, respectively. This questionnaire was adapted from a well-established scale in previous studies, and the scale's validity was further confirmed by exploratory factor analysis, with KMO=0.89 > 0.7.

Table 1. *EFA and Cronbach's α Values for the ECL and GCL (n = 220)*

| | Factor and Items | Factor Loading | Mean | SD | Cronbach's α |
|---|---|---|---|---|---|
| ECL | | | 2.21 | .82 | .89 |
| | Live lecture | .89 | 2.24 | .92 | |
| | Pre-recorded videos | .94 | 2.15 | .86 | |
| | AI chatbot | .85 | 2.25 | .95 | |
| GCL | | | 4.13 | .53 | .96 |
| | Live lecture | .84 | 4.15 | .42 | |
| | Pre-recorded videos | .88 | 4.13 | .32 | |

### *4.2 Analysis of the Effect of Different Online Learning Technologies on In-service Teachers' ECL and GCL*

The results of the repeated measures ANOVA showed that there is a significant borderline effect among ECL of different online learning technologies ($F$ (1.67,364.73) = 2.708, $p$ = .078

< .10, partial $\eta 2$ = .012), which suggests that teachers produce different ECL when using various technological tools to learn knowledge. ECL perceived by teachers when learning with pre-recorded videos is significantly lower than the ECL of AI chatbot ($p$ = .016 < 0.05) and ECL of live lecture ($p$ = .035 < 0.05). ECL of the AI chatbot and live lecture have no significant difference ($p$ = .85 > 0.05). Regarding the analysis of GCL, we used Greenhouse-Geisser estimates of sphericity ($\varepsilon$ = .95) to correct degrees of freedom for sphericity violations (Mauchly's $W$ = .95, $\chi 2(2)$ = 11.93, $p$ = .003). Repeated-measures ANOVA showed no significant difference in the GCL when teachers used different online learning technologies, with $p$ = .59 > 0.05.

Table 2. *Repeated-measures ANOVA and post hoc tests*

| Variable | F | Sig. | partial η2 | Post hoc comparisons |
|---|---|---|---|---|
| ECL of different Online Learning | 2.708 | .078 | .012 | pre-recorded videos < AI chatbot, pre-recorded videos < live lecture |
| GCL of different Online Learning | .505 | .594 | .002 | |

## 5. DISCUSSION

This study tries to compare how teachers feel when they learn online with chatbots, videos, and live lectures. The result shows that pre-recorded videos are more effective than AI chatbot and live lectures in reducing ECL. In contrast, AI chatbot and live lectures have no difference.This may be because of some reasons. First, new technologies can make learners stressed and confused (Riedl, 2012). Learners have a better understanding of videos compared to live lectures and chatbots. Additionally, new technologies can encounter errors or teaching-related issues. For example, chatbots may not provide accurate or clear answers, while live lectures can be affected by network problems. As a result, these factors can cause learners to lose their focus or interest.
However, it is worth noting that chatbots did not create more confusion for learners compared to live lectures, which indicates that teachers found them beneficial.

None of the three online learning technologies greatly impacted GCL, indicating that extrinsic technology had a limited effect on fostering intrinsic cognitive structures and motivation. Learners need to talk and interact more in the class to understand better. Other studies also said that videos work better with different kinds of knowledge and teacher help (Hong et al., 2018).

This study has some limits. It only asked learners how they felt, which may not show how they really thought. It also did not look at other things that can affect thinking and learning, like what learners know before, how they feel, what they like, or what they want.

## 6. CONCLUSIONS AND IMPLICATIONS

These findings suggest that teachers who learned through pre-recorded videos had a lower perception of their ECL compared to those who used AI chatbots or attended live lectures. In regards to GCL, the three different online learning technologies do not show a significant difference in GCL. This study gives some ideas for future research studies. First, future research studies could utilize more advanced AI technologies to improve the design and implementation of AI chatbot, such as natural language processing models, speech recognition systems, and generative AI. Second, future research studies could expand from teachers to students. We can analyze how different online learning methods affect different groups of learners, such as age, gender, knowledge, and preferences. Third, subjective and objective measurements can be combined to enhance the results from multiple perspectives when measuring cognitive load or considering other relevant variables in online learning will

be a valuable topic. Fourth, future research could focus more on technology-assisted instruction than technology-replaced instruction.Technology can make teaching easier, but it cannot do what teachers do. Teachers do not only give knowledge but also show thinking, skills, and values to learners.

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