Correlation Between the Change of Cognitive Load and Learning Performance in Video-based Learning

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Abstract: This study explore whether cognitive load arising from learners' self-directed activities are significantly related to learners' cognitive activities in video-based environment where self-directed learning elements are implemented. Eye tracking and learning performance data of the experimental group (n = 60) of self-directed learning environment and comparison group (n=49) without the self-directed elements were collected in the first semester of 2018. Statistical difference verification and correlation analysis was performed subsequently. Study shows significant difference of cognitive load between two groups. In comparison group, the variables related to fixation and saccade have a significant correlation with learning achievement. There was no correlation between the indicators of cognitive load and learning performance in the experimental group. However, there have been differences in the kinds of indicators that correlate with performance between two groups, indicating that the variables related to cognitive load may differ depending on the supporting factors available to learners.

Introduction and material and methods

The purpose of this study is to explore whether the cognitive load generated by learner's self-directed activities in the video-based learning environment with self-directed learning elements is significantly related to the learners' cognitive activities. Therefore, the self-directed learning elements that can be used by the learner was implemented as a video player function, and the cognitive change that appeared through the learning elements in the learning process was explored. Specifically, the cognitive load of learners was measured and compared through eye movements and pupil dilation of the groups. The cognitive load indicators were compared and correlations with learning performance are found. Secondly, the differences of the analysis results were compared according to the content complexity levels. Experiment was conducted for undergraduate students located in Seoul. For stable performance of pupillary response, students with physical impairment (e.g., eye disease) and contact lens wearers were excluded. 82 people for the comparison group and 77 people for the experimental group were recruited. After preprocessing, there were 49 comparative subjects and 60 experimental subjects.

Figure 1. Features of the video player for experimental group.

The video player used by experimental group was developed for the experiment and includes supportive functions for self-directed learning. Descriptions of the functions are in [picture 1]. Users of this player can leave comments and bookmarks to video contents based on the timeline, which provide monitoring and visualizing students learning process. In addition, the annotations can be shared by other learners watching the same video.

In this experiment, video learned through the player was given equally to both groups. Content is divided into lesson 1 and lesson 2 according to the content composition degree. lesson 1 corresponds to the sub-system of lesson 2 and can be said to be a section with lower element interactivity.

Results and future research agendas

As a result, MPD(mean pupil dilation) in low complexity level(p = .032) and MFD(mean fixation duration) in high complexity level(p = .047) showed differences between two groups, and the levels were higher in the experiment group, meaning that higher total cognitive load was generated in each level.

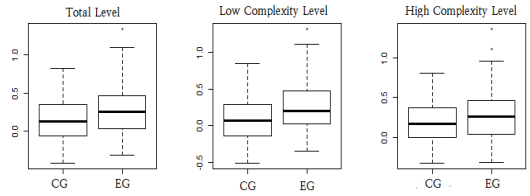

Figure 2. Comparison of pupil dilation.

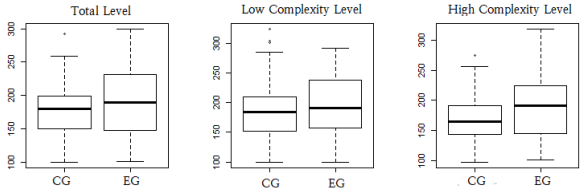

Figure 3. Comparison of fixation duration.

Table 1: Correlation between two groups' variables and learning performance

CG(without experimental video player)				EG
Total level				
	TFD	TFC	MSD	TSC
Achievement (increased score)	-.204	-.321*	.361*	.291
Low complexity level				
	TFD	TFC	MSD	TSC
achievement	-.254	-.370**	.382**	.292
High complexity level				
	TFD	TFC	MSD	TSC
achievement	-.016	-.093	.082	.250

Comparative group which carried out the video-based learning without the self-directed learning element showed a significant correlation between TFC(total fixation count), MSD(mean saccadic duration) indicators and the learning outcomes indicators at the overall content complexity level. TFC showed a negative correlation with the degree of improvement of score(r = -.321, p < .05), meaning that the cognitive load indicated by the increase in gaze fixation had a negative correlation with learning performance.

Considering Minsun Kim(2017)'s similar result and conditions to comparison group's learning environment that learners couldn't adjust the learning speed, TFCs are likely indicators of cognitive load beyond learners' capacity in situations. On the other hand, MSD showed a positive correlation(r = .361, p < .05) with learning outcomes, and the overall results are consistent with the findings of Holmqvist and colleagues(2012) reported long fixation and short saccade indicate high cognitive load, which can negatively related to learning. The lack of correlation between TFC, MSD and learning outcomes only at high complexity and the fact that MPD showed a difference only in low complexity may be the result of losing motivation. Relationship between variables and cognitive load does not hold up if students give up due to high content complexity(Plass, Moreno, & Brünken, 2010).

Only in the experimental group, TSC(Total saccade count) showed weak positive correlations at all levels. Unlike other indicators, the correlations do not show difference according to the levels of complexity. This may represents that the indicators interacted with the self-directed learning element of the video-based learning environment, which may have led to learning outcomes by promoting beneficial cognitive load. However, not all subjects actively used self-directed learning factors in the experimental group's learning environment, and the evidence is not sufficient considering that other variables do not show a significant relationship. In the follow-up studies, there is a need to use more elaborate analytical methods. Also, Since the comparison group and the experimental group took different levels of learning time, the difference between the cognitive loads was analyzed only by average indicators. However, as shown by Junghyun Kim and Il-Hyun Jo(2019), cumulative indicators can be more sensitive to dynamic cognitive load change.

References

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293-332.

Junghyun Kim, Il-Hyun Jo. (2019). Objective Measurements of Cognitive Load in Complex Problem Solving. *Korean Association for Learner-centered Curriculum and Instruction, 19*(5), 25-44.

Kalyuga, S. (2009). Knowledge elaboration: A cognitive load perspective. *Learning and Instruction, 19*(5), 402-410.

Minsun Kim. (2017). *A study on relation of visual behavior, learning flow, and learning achievement in video-based learning environment.* Unpublished master's dissertation, Ewha Womans Univerity, Seoul.

Plass, J. L., Moreno, R., & Brünken, R. (Eds.). (2010). *Cognitive load theory.* New York, NY, US: Cambridge University Press.

Zimmerman, B. J., & Risemberg, R. (1997). Self-regulatory dimensions of academic learning and motivation. In G. D. Phye (Ed.), *Handbook of academic learning: Construction of knowledge* (pp.105-125). San Diego, CA: Academic Press.