

論文 / 著書情報
Article / Book Information

Title	Examining the cognitive load of instructors for perceiving the status of learners in videoconferencing lectures
Author	Yu Ara, AKINORI NISHIHARA
Journal/Book name	Global Learn Asia Pacific 2011, , ,
Issue date	2011, 3
Copyright URL	http://www.aace.org/conf/copyright.htm
Copyright	Copyright (c) 2011 Association for the Advancement of Computing in Education

Examining the cognitive load of instructors for perceiving the status of learners in videoconferencing lectures

Yu Ara

Graduate School of Decision Science and Technology
Tokyo Institute of Technology
Japan

ara@nh.cradle.titech.ac.jp

Akinori Nishihara

The Center for Research and Development of Educational Technology
Tokyo Institute of Technology
Japan

aki@cradle.titech.ac.jp

Abstract: In this study, the authors tried to unfold one of the causes which prevent smooth interactions between lecturers and learners in videoconferencing settings, by focusing on the instructor's cognitive load. Through an experiment, the authors found that constantly monitoring the state of learners requires heavy cognitive load while lecturing. This result suggests that displays showing lecture contents and learner image should be closely set to reduce the split-attention effect, and some forms of additional support are effective to ensure quality videoconferencing educational environment.

Introduction

In recent decades, rapid evolution of ICT has promoted the drastic advancement of learning environment. One of the remarkable advancements, which contributed to relax temporal and spatial restrictions on the access of education, is the dissemination of distance education (DE). Thanks to the rapid progress of personal computers and network infrastructure, current distance learning programs do not require any special hardware to participate in. This progress in the accessibility of education enabled learners to choose the most convenient and comfortable learning environment from a wide range of choices. As these new forms of education gradually gained widespread use, their quality became next focal point.

When examining the quality of DE, we should not mix up various settings of DE altogether, because every DE setting has specific advantages and disadvantages. DE settings can be classified into two general categories in terms of temporal synchronization; synchronous or asynchronous DE. Today, both synchronous and asynchronous DE have spread over the world, and they have been steadily embedded into general educational courses. In particular, videoconferencing learning environment has become one of such easy DE settings to participate in, as its minimum settings only require webcam and videoconferencing software which is sometimes offered freely, such as Skype. In this study, the authors focus on videoconferencing learning environments, and discuss their quality.

Though it seems some classic educational theories and technologies are still effective in some essential educational issues, educators are always challenged to investigate emerging educational environments. In other words, it was a question posed to the research field related to DE whether this newly emerged form of education can strike a balance between accessibility and quality. In fact, the answer to this question is still in the haze, as Moore (Moore & Kearsley, 1999) stated in his book that, much more fundamental researches are necessary to build a foundation for quality DE environment.

Previous comparative studies between VC and F2F

Understanding advantages and disadvantages of distance learning environment is a prerequisite to pursue

the quality videoconferencing learning environment. There are numerous studies, which compare DE with traditional face to face settings, to examine the quality of DE. Since most studies intended to claim the effectiveness or efficiency of distance learning, the results of such studies were biased toward positive results to distance learning. Furthermore, the file drawer effect prevents cases of failure from being published. For these reasons, the authors reviewed meta-analysis studies which fairly collected sample researches of both positive and negative results.

The study conducted by Cavanaugh (2001) showed small positive effect towards DE after analyzing 19 studies. As a conclusion, the study claims that DE can supplement traditional educational settings with possible achievement expected. In contrast, other meta-analysis researches showed that synchronous distance learning does not reach the level of face to face settings in terms of educational quality, and thus synchronous distance learning cannot become the substitute of face to face settings (Allen, Bourhis, Burrell, & Mabry, 2002; Bernard et al., 2004). Thus, the effect of distance learning invoked contradictory arguments and it is still not clear that what factors make distance learning better or worse.

One of the key factors affecting the quality of DE is interaction. As described by Moore (Moore & Kearsley, 1999), interaction is necessary to reduce the transactional distance between distant participants. However, even today, many teachers still bring traditional educational strategies into the videoconferencing learning environments, though almost two decades have passed since Moore's study came out. In videoconferencing learning environment, participants including instructors have less perception abilities than in face to face environment, causing the lack of awareness of distant places. As a result, educators are struggling to have enough interaction in their classes.

In this study, the authors tried to unfold one of the causes of this mal-interaction, by focusing on instructor's cognitive load in videoconferencing settings. In face to face settings, learners and lecture contents can be in the same eyesight of lecturers, and therefore lecturers can move their eye line from learners and lecture seamlessly. On the contrary, in ordinary videoconferencing lecture settings, lecture material and the image of learners are separately shown in two or more displays, which would cause split attention effect (Kalyuga, Chandler, & John Sweller, 1999) on lecturers. It requires a lecturer to intentionally turn his/her eye direction when they want to see other displays. This is "extraneous", if comparing videoconferencing to face to face, cognitive load. This extraneous cognitive load (J Sweller, 1988) would cause malfunction of lecturer's routine work, especially in monitoring learners, which further leads to insufficient perception of learners and less interaction between the lecturer and the learners. In this study, the authors tried to settle this issue, by examining instructor's cognitive load during videoconferencing lectures.

Methods

The purpose of this study is to find out how difficult for novice instructors of videoconferencing educational environment to perceive the state of learners behind the screen. To be precise, the goal of this study is to measure and visualize the cognitive load of instructor for perceiving learners' state in videoconferencing. Simply comparing F2F and videoconferencing will not provide insights directly related to this issue, as consequences from such experiments will be affected by various factors, other than cognitive load of instructors, attributed to the differences of environment. To examine the effect of cognitive load of instructors less affected by external factors, the authors designed two different conditions (hereafter, condition A and B) of mock videoconferencing lectures.

Condition A is relatively close settings to a normal videoconferencing lecture than condition B. In condition A, the subjects explain an educational content as a lecturer, to the learners in a display as the same as ordinary videoconferencing lecture. Under this condition, the subjects are required to monitor the learners by themselves while lecturing. In contrast, in condition B, the subjects are supported to perceive the learners' state by the software called Learner Status Notification System (hereinafter referred to as LSNS). The difference between two conditions is only this point; whether the subject is supported by LSNS or not. This difference will unfold the cognitive load on lecturers to perceive the state of learners in videoconferencing lectures. The details of the experiment settings are delineated below.

Subjects

Sixteen subjects were recruited from graduate students. Four out of sixteen were women. The mean age was 25.0 (SD = 2.82). All subjects had teaching experiences, to a greater or lesser extent, as a preparatory school teacher or a private tutor, and they also had experiences of ordinary videoconferencing. No one, however, had a teaching experience through videoconferencing. Thus, all subjects are novice instructors of videoconferencing lessons.

As the experiment is conducted under within-subjects design, all of them experienced two lecture conditions A and B, as a lecturer of videoconferencing lessons. To cancel the order effect on lectures, half of them started with conditions A, and vice versa.

Lecture contents

The authors selected two lecture contents from the field of environmental education, which none of the subjects is specialized in. The difficulty of the lecture contents is adjusted so as to impose appropriate teaching load on subjects. The lecture materials contain PPT slides and explanatory text sentences with which subjects can conduct distant lectures without preparation. It took approximately 15 minutes to finish one content material by the subjects.

Learners in the videoconferencing lecture

According to the purpose of the study, this experiment requires opportunities to judge whether the subjects appropriately conduct diagnosis actions, when it is necessary, to perceive the change of learners' state, e.g. when learners change their learning attitude from deeply concentrating state to distracted state. If learners consistently keep a behavior of "good learner", the subjects would gradually think that they can reduce the frequency of diagnosis actions, and not much attention should be paid to monitor these "good" learners. In this case, it will be expected that the amount of explicit diagnosis actions of subjects will decrease, and it thus makes difficult for experimenters to distinguish whether the subjects intentionally decrease the monitoring actions, or they are not able to perform monitoring actions due to external factors, such as cognitive overload etc., although the focus of this study is to investigate if the latter case actually happens or not. To set the boundaries between aforementioned two states and to induce explicit and observable actions of the subjects, the authors decided to include some learners in typically bad states, e.g. chatting with friends, lying on a desk, and sleeping. Such "bad learners" require careful attention by lecturers, and therefore the experimenters can evaluate whether the subjects appropriately conduct monitoring actions or not. However, it is difficult to have such rude learners on a constant basis in real videoconferencing lecture settings, the authors prepared videos of mock learners of videoconferencing lectures prior to the experiment.

The video includes nine learners sitting in a three by three matrix. The learners actually studied from recorded lectures presented at a screen in front of them, as if they were in general videoconferencing settings. The authors first provided directions to all learners to play typical "good learners" to record several good learning scenes. Next, the authors ordered to some learners to play bad attitude, e.g. start chatting with neighbors, lying down on a desk to start sleeping. Finally, the authors prepared three patterns of "good" learning scenes and four patterns of "bad" learning scenes.

During the experiment, these videos were presented to the subjects in a display located in front of the subjects, as shown in Figure 1. The video started with good learning scenes, and when the subjects reached certain checkpoints of the contents, the experimenters switched the video to bad learning scenes for a half minute or until the subject took necessary intervention e.g. speak to learners to attract their attention. The authors set five checkpoints in advance, so that every subject encounters the bad learning scenes at the same checkpoints, where the content impose approximately the same teaching load. The checkpoints had irregular intervals to the next one to prevent the subjects from anticipating the coming checkpoint.

System

The authors developed software, called LSNS, which automatically analyzes and notifies the status of

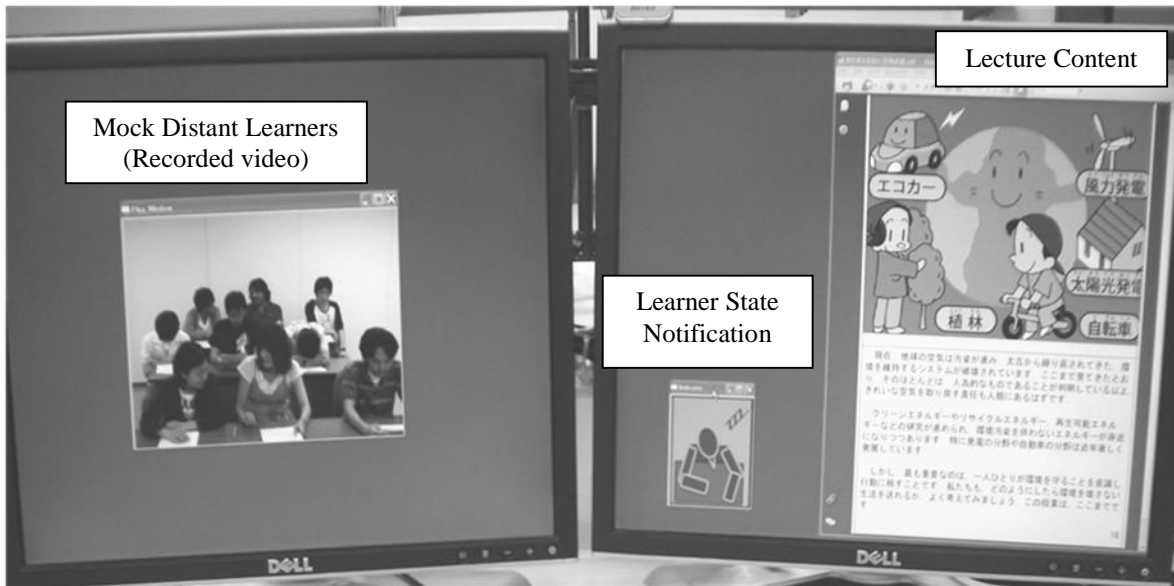


Figure 1 Subject's view

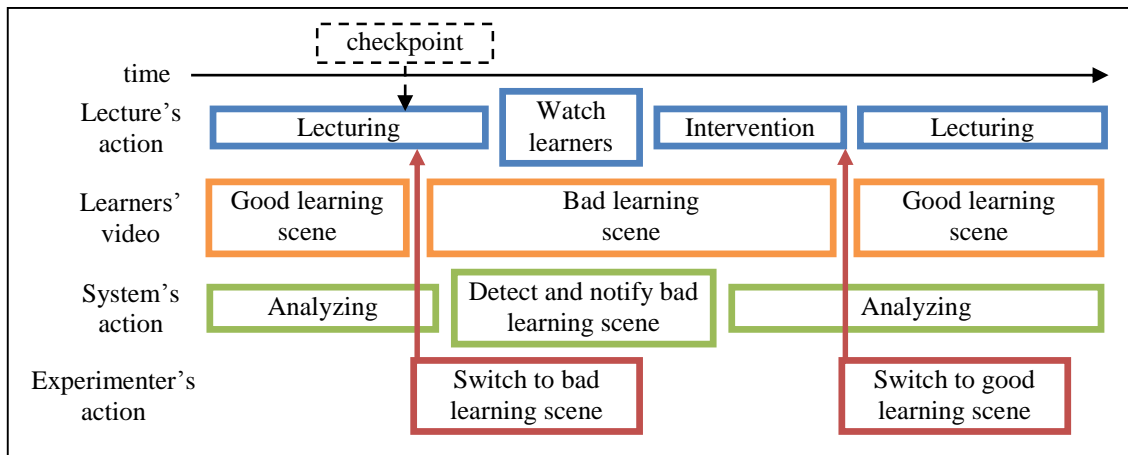


Figure 2 Timeline of the experiment around a checkpoint in condition B

the learners in the videos, based on Learner Status Acquisition and Notification System (LSANS) (Ara & Akahori, 2008). LSANS analyses the status of the learners by detecting the number of faces and calculating the change of optical flow. Based on the result of the analysis, LSANS evaluates the state of learners, and then provides notifications when bad learning scene is detected. Figure 2 shows the detailed timeline around a checkpoint when LSANS was on. LSANS was optimized to analyze the videos used in this experiment, so that the all five checkpoints set in the contents could be detected as bad learning scenes. Only when the subjects conduct a lecture in condition B, LSANS was set to work to support the subjects.

Procedure

The experiment was conducted as shown in Figure 3. First, the procedure was explained and informed consent was obtained from the subjects. The subjects were told that lectures were recorded to later examine difficulties of videoconferencing by third-party observation, so that the subjects seriously give lectures to mock

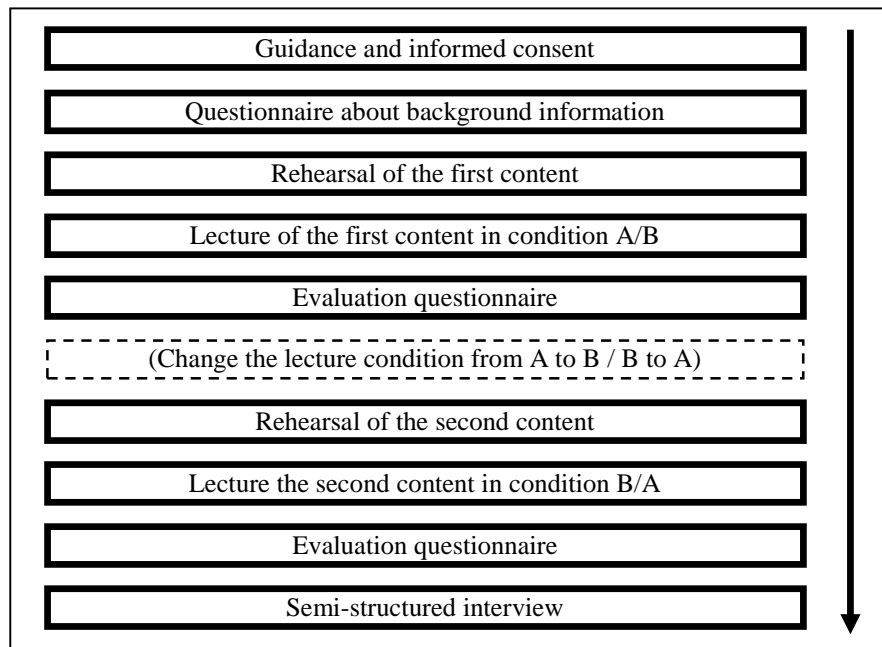


Figure 3 Procedure of the experiment

learners. In addition, the subjects were told that, although the learners were videotaped in advance, their attitudes would be automatically changed based on the evaluation of the lecture by software as the same as real learners. In fact, the attitude of the learners was controlled by the experimenters behind the subjects' back. Furthermore, the subjects were directed to maintain the speed of explanation to keep the learners in good learning state, to prevent the subjects from gazing the learners without lecturing honestly.

After filling in the questionnaire about the background information, the subjects quickly read through the first content for prior checkup. Then, the subjects started lecturing to the mock learners under either condition, A or B. The subjects were then asked to fill in the evaluation questionnaire, which consists of thirteen multiple choice questions with six point Likert scale. The questionnaire is designed to obtain information about the ease of lecturing and cognitive load felt during the lecture. Next, the experimenters asked the subjects to give another lecture with different contents under different condition. After filling in the evaluation questionnaire, the subjects participated in a semi-structured interview, through which overall impression and feedback of the environment were acquired.

Results and Discussion

Result of eye gaze analysis

Figure 4 shows the average intervals of the monitoring actions of the subjects under both conditions A and B. The intervals are calculated by dividing the total elapsed time for a lecture by the number of times the subjects put their visual line on the display showing learners.

Statistical significance of the difference of intervals between two conditions was examined by Wilcoxon's signed rank sum test. The result of the test revealed the difference was statistically significant ($Z = 2.897, P < .05$), indicating that the subjects confirmed the learners more frequently in condition B, compared to condition A.

Result of evaluation questionnaire

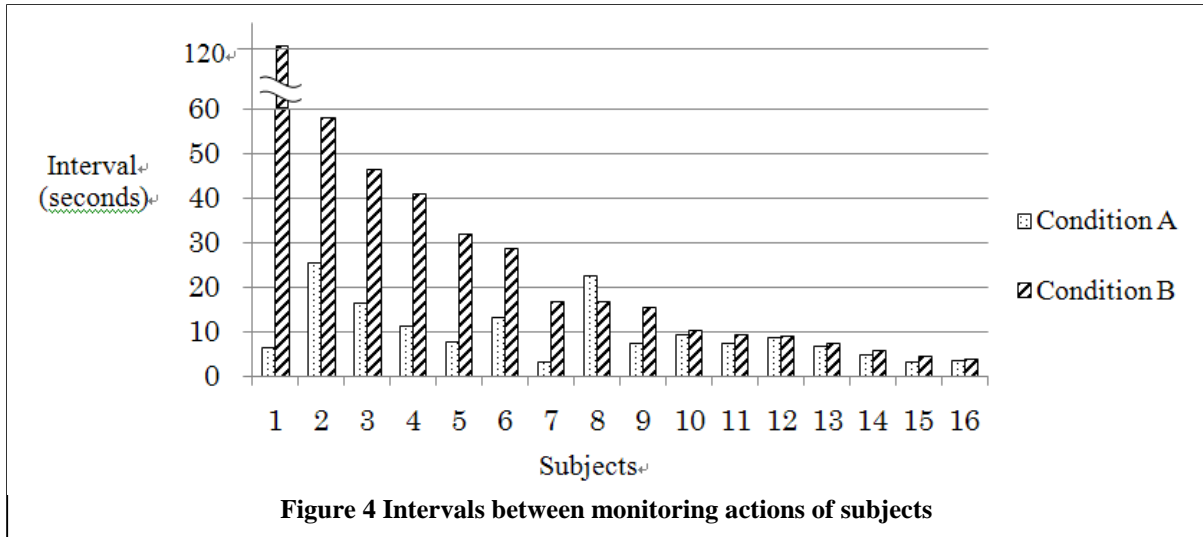


Table 1 shows the result of the evaluation questionnaire. The subjects answered the same questionnaire twice, right after they finished a lecture. Each item was tested by Wilcoxon's signed rank sum test and a statistically significant difference was found in two items: Q9 and Q10.

Table 1 Evaluation questionnaire

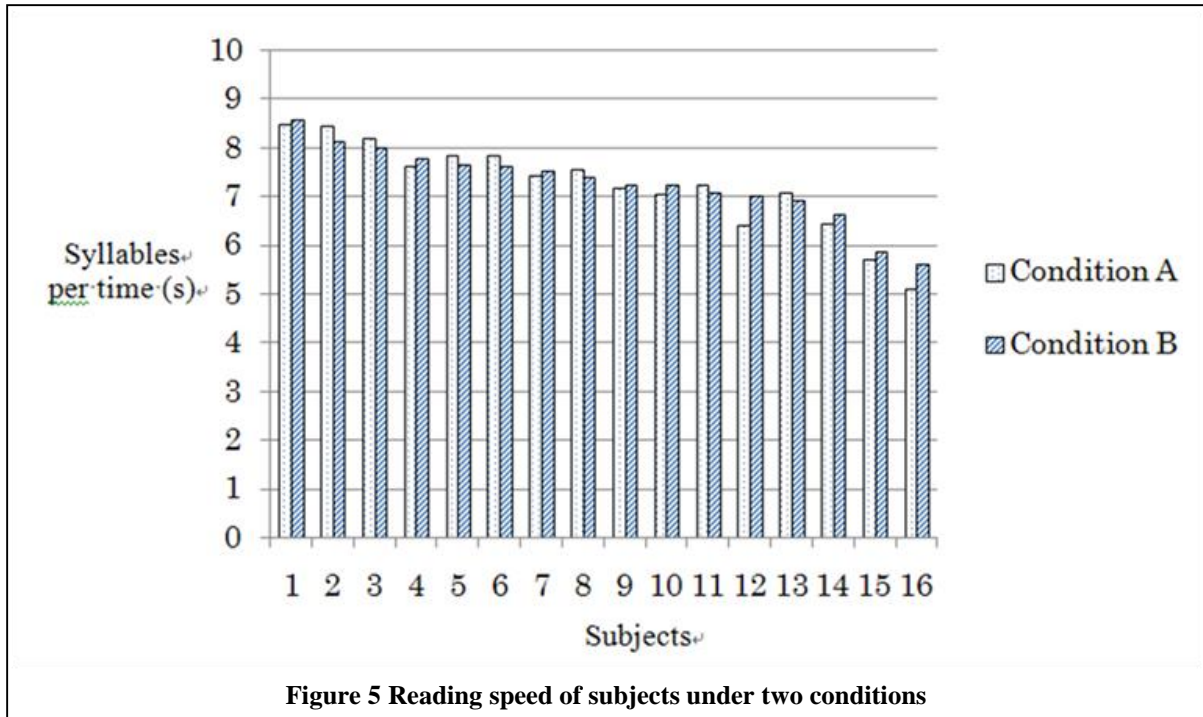
No.	Question	Mean (SD)		
		Condition A	Condition B	
1	Characters in the learning material maintained enough visibility.	5.06 (0.85)	5.31 (0.60)	
2	(-) I don't think there are too many characters in the learning material.	3.44 (1.21)	3.81 (1.28)	+
3	(-) I didn't feel strange to lecture videotaped learners.	3.81 (1.22)	3.69 (1.20)	
4	Learners in the display are clearly seen.	4.69 (1.25)	4.69 (1.25)	
5	(-) I had enough room to check the status of the learners though busy in lecturing.	3.19 (1.05)	3.19 (1.47)	
6	I could easily perceive the status of learners from the video of learners.	3.81 (1.42)	4.19 (1.11)	+
7	(-) I was distracted by jumpy video.	3.94 (1.65)	4.31 (1.62)	+
8	I think I could appropriately perceive the status of the learners.	3.31 (1.30)	3.56 (1.46)	
9	I could concentrate on lecturing.	3.06 (1.06)	3.88 (1.50)	*
10	I could perform appropriate interventions when learners were in bad learning status.	3.50 (1.21)	4.38 (1.15)	*
11	I conducted the lecture in easily understandable format.	2.75 (0.93)	3.31 (1.20)	+
12	I think I could perform better if I had real (not recorded) learners.	3.06 (1.61)	3.13 (1.54)	
13	I felt relaxed because the learners were not real.	3.88 (1.67)	4.31 (1.30)	

N = 16. Six-point Likert scale. Median = 3.5. Items in the reverse are starting with (-).

Wilcoxon's signed rank sum test: *: $p < .05$, +: $p < .1$

Result of the comparison of reading speed of the subjects between two conditions

Under both conditions, elapsed time for each lecture was measured, and reading speed was calculated by dividing the number of syllables contained in the learning material by the elapsed time (syllables per time), as shown in Figure 5. To examine the significant differences between two conditions, paired t-test was conducted. The result showed not statistically significant ($t(15) = 0.66, p > .05$), which indicates that the reading speed of the subjects was not different between two conditions.



Discussions

From the result of eye gaze analysis, it was found that when subjects gave a lecture in condition A, they were required to check and diagnose the learners much more frequently than in condition B. This means, in native settings of videoconferencing, lecturers need to physically move eye line frequently between two monitors, from learning material to learners' image or vice versa, to keep perceiving learners' state. On the contrary, in face to face settings, lecturers can acquire information of learners' state with less cognitive load, as learning contents and learners are in the same seamless space, and lecturers are free to arrange how they locate several sources of information. In short, lecturers have to manage more physical and cognitive load in videoconferencing than in face to face settings. Although the learners in this study seem to be ruder and more distracted than in real videoconferencing lectures, distant learners easily lose concentration even in real videoconferencing settings when they feel they are not appropriately taken care of. Thus, instructor's regular intervention is necessary to keep the learners attracted and motivated. However, as shown in this result, to keep perceiving the state of learners require much load on instructors, it is hard to achieve a perfect balance between two activities; lecturing and monitoring.

The result of the questionnaire also indicates that the subjects in condition A felt more cognitive load than condition B. The result of Q9 and Q11 revealed that lecturers had more room to conduct a lecture as load for monitoring learners was taken over by LSNS. From the result of Q10, we can assume that the subjects in condition A felt that they could not achieve sufficient intervention, even though they did more, more than twice for some subjects, than in condition B.

These results suggest that, consistent monitoring requires much cognitive and psychological load on lecturers of videoconferencing, and therefore extra support should be provided for quality educational environments. In particular, when teachers, who are novice of videoconferencing, are required to have classes through videoconferencing, they should have sufficient practice and preparation or supportive systems such as LSNS.

There was no significant difference found from the result of the comparison of reading speed or the subjects between two conditions. This result implies that the instruction, that is to maintain the reading speed, was successfully observed by the subjects. The experimenters also found from observation that the subjects

engaged in the experiment seriously and sincerely.

Conclusion

In this study, the authors found that constantly monitoring learners' state requires heavy cognitive load while lecturing in videoconferencing settings. This result suggests that monitors showing lecture contents and learner image should be closely set to reduce the split-attention effect.

Although this study is conducted focusing on the cognitive load of instructors in traditional lecture settings, the authors did not advocate traditional lecture styles. Or rather, the authors found that the result of this study emphasizes the difficulty of lecture when learners are not highly motivated. In general formal education, such non-autonomous learners commonly exist, and they will be less motivated when they physically separated from instructors. Such learners will be easily distracted and lose concentration. However, to be always aware of distant learners' status requires much load on lecturers of distance classes, as the result of this study suggested. As a consequence, the lecturers may leave the learners behind and move forward alone. To avoid such miserable cycle, providers of educational courses should consider not only physically locating two monitors closely, but introducing active and interactive lesson design, other than traditional lecture styles. This improvement will increase the interactivity of lessons, which leads to embed diagnosis actions of instructors into general teaching behavior without causing extra cognitive load on instructors. Although there are several barriers to accomplish quality distance learning environment (Galusha, 1997), designer of educational courses must confront this issue.

As this study adopted "in vitro" type experiment to obtain clear results on cognitive load of videoconferencing lecturers, there shall be other factors, which are ignored in this study, affecting the cognitive load of lecturers on site. To unloose this limitation, practical validation of the result of this study is necessary in future.

References

- Allen, M., Bourhis, J., Burrell, N., & Mabry, E. (2002). Comparing Student Satisfaction With Distance Education to Traditional Classrooms in Higher Education: A Meta-Analysis. *American Journal of Distance Education*, 16(2), 83-97. doi: 10.1207/S15389286AJDE1602_3.
- Ara, Y., & Akahori, K. (2008). Enhancing Instructor 's Awareness of Learners in Videoconferencing Learning Environment. *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008* (pp. 3586-3593).
- Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, a, Wozney, L., et al. (2004). How Does Distance Education Compare With Classroom Instruction? A Meta-Analysis of the Empirical Literature. *Review of Educational Research*, 74(3), 379-439. doi: 10.3102/00346543074003379.
- Cavanaugh, C. S. (2001). The Effectiveness of Interactive Distance Education Technologies in K-12 Learning : A Meta-Analysis. *International Journal of Educational Telecommunications*, 7(1), 73-88.
- Galusha, J. M. (1997). Barriers to Learning in Distance Education. *Interpersonal Computing and Technology*, 5(3-4), 6-14.
- Kalyuga, S., Chandler, P., & Sweller, John. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology*, 13(4), 351-371. doi: 10.1002/(SICI)1099-0720(199908)13:4<351::AID-ACP589>3.0.CO;2-6.
- Moore, M. G., & Kearsley, G. (1999). *Distance Education: A Systems View*. Thomson/Wadsworth.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257-285. doi: 10.1016/0364-0213(88)90023-7.