The effects of captions on deaf students' contents comprehension, cognitive load and motivation in online learning

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ABSTRACT

This study aims to examine the effects of captions for the deaf in online learning materials in terms of contents comprehension, cognitive load, and motivation.
The subjects of this study are 62 deaf adult students who have similar literacy skills and use sign language as a first language. In this research, the independent variable is the existence/non-existence of captions, and the dependent variables are level of contents comprehension, cognitive load, and motivation. This study applied posttest-only control group design.
The results of the experiment showed a significance difference ($t=-2.16$, $p<0.5$) in contents comprehension, but no significant difference was found in cognitive load and motivation. Based on the results, recommendations were made along with discussion in the aspect of instructional technology.

Key words: Deaf people, Captions, online contents, contents comprehension, Cognitive load, motivation

□. INTRODUCTION

Human beings react to external sound through auditory organ and promote language development.
However, if the organ is damaged by innate/acquired reason, people lapse into condition of hard-of-hearing or deafness, the entire loss of hearing ability. Hearing loss is much more complex than we realize which can lead to a number of other functional difficulties. It creates limitation in linguistic-information collection and spoken language ability, which leads to hamperedness in linguistic development and verbal learning, along with negative impacts in cognitive development.
Although KEDI-WISC test showed no difference in intelligence between deaf students and hearing students, deaf students displayed notable downturn in stage-by-stage manipulation test that was based on Piaget's cognitive development theory. This seems to be a result of procrastination in language-development influenced by external environmental factors (Choi & Yun, 2001).
Deaf children use relatively fewer vocabularies than hearing children, and deaf kids complain about the difficulties in learning words with multi-meanings (Paul & Quigley, 1994).

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And, deaf children aged from 12 to 14 displayed approximately 5 years of procrastination in reading comprehension compared to their peer, hearing students (Kwon, 1987). Further, literacy development of the deaf falls behind by 2 years until they reach 3rd grade in elementary school. And, since then, they show very slow language-development and it does not go beyond the level of a 4th grader when they graduate high school (Choi, 2005).

In spite of the use of sign language, it was not unusual to consider deaf persons as being linguistically deficient even when a higher level of communicative competence was present in manual language.(Malcolm J. Norwood,1976) This linguistic deficiency of deaf persons has been restricted access to information and knowledge in learning environments.

Therefore, there has been an effort to support them in learning and many multimedia learning materials have been developing to support Deaf students' learning.

To serve the unique needs of the deaf learner, application of visual learning aids is suggested to be effective (Luckner, 1992). Multimedia learning-contents and videos are being made with captions to supplement their needs, and though rarely, support both captions and sign-language video clips.

This is, most learning materials for the deaf tend to add captions rather than having captions and sign language video clips at the same time. It is simply assumed that adding captions would be enough to support deaf students in learning.

In this regard, several studies have been conducted in regard to comparison of the various modes of transmitting verbal information to deaf subjects. Studies revealed that the use of captions was superior to those treatments that made no use of captions. And, the amount of verbal information received by deaf students was significantly greater, when captions were incorporated into the presentation.

Although literacy skills level may vary among deaf people and this does not apply to people who are hard-of-hearing who tend to have less difficulty in understanding the content of a material solely from the captions, most deaf people who have limited literacy skills and use sign language as a first language may have difficulties in learning the materials only from captions.

However, little research was done on the effectiveness of captions when it is provided along with sign language video in multimedia learning materials.

Further, it is pointed that having more visual tools in multimedia learning aids affects learners' cognitive load negatively. To examine its impact on learning, cognitive theory needs to be looked into. A cognitive load indicates the levels of working memory load and cognitive effort.

When the information is provided in a single kind of a form, cognitive load rises and it is called modality effect. And, when an identical content is provided in the same form, the cognitive load also rises (Kirschner, 2002). It is called redundancy effect.

Hence, if the learning contents are composed only of visual materials, the cognitive load increases. And, no study has analyzed the effects of these two modes of presentation in terms of content comprehension, cognitive load, and motivation when they are presented at the same time in multimedia learning materials.

Therefore, this research aims to find out if online material with both captions and sign-language video clips is effective for deaf students whose first language is sign language and literacy skills are limited.

In this study, the term 'the deaf' is used to indicate people who are profoundly deaf and use sign language as their first language. And, it was hypothesized that there would be a rise in content comprehension, cognitive load, and motivation when both captions and sign language video clips are provided at the same time in multimedia materials. We have three following research questions in this study.

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And, experimental results are summarized and specific recommendations are made for future course of caption support and its instructional technological approach in producing online learning materials for the Deaf.

(1) Do online learning contents with sign-language video clips and captions result in increase of contents comprehension compared to learning contents that only provides sign-language clips?
(2) Do online learning contents with sign-language video clips and captions result in rise of cognitive load compared to learning contents that only provides sign-language clips?
(3) Do online learning contents with sign-language video clips and captions result rise of motivation compared to learning contents that only provides sign-language video clips?

□. METHODS

1. Subjects

The subjects of this experiment are deaf people with hearing disability degree ranging from 1 to 3. 35 students from Ilsan Vocational Training Institute of Korean Employment Agency for the Disabled(KEAD), and 27 deaf students from Korean Nazarene University(KNU), totaling 62 students, have gathered for this experiment. Through random assignment, final 31 test subjects for experimental group (20 males, 11 females) and 31 test subjects for control group (20 males, 11 females) were selected. As in age range, there were 60 participants who were in their 20's (96.8%), 2 participants in their 30's (0.2%). Regarding their academic achievement, there were 58 high school graduates (93.5%) and 4 college graduates (6.5%).
The experiment took place in a computer lab with estimated time of experiment of roughly 40 minutes. The subjects were allowed free choice of seating, and were not informed of condition they will be put into. And, during the experiment, there were students who did not understand the questionnaire and such participants were supported by sign-language interpreters.
However, most of the participants responded to the questionnaire with their own literacy skills. And, as there exists a possibility that participants will answer by chance when they have difficulty in understanding the questionnaire, some questions in questionnaire were explained using sign-language interpreters to reduce these errors. To improve the credibility of experiment, the vocabulary in a questionnaire was revised in the easiest form of word as possible and sign language interpreters were provided.

2. The Experimental design

The independent determinant of this experiment is the existence/non-existence of captions, and dependent determinants are the learning effects (contents comprehension, cognitive load, and motivation). Thus, the control group was exposed only to sign language video clips.
As for the experiment plan, posttest-only control group design had been used.
To homogenize the difference among test subjects, Test of Proficiency in Korean (TOPIK), which is made by Korea Institute for Curriculum and Evaluation, had been used. The TOPIK is a standardized test targeting foreigners or Koreans who dwell in foreign countries and do not use Korean as their mother language. It is consisted of four sections (vocabulary, writing, reading, listening comprehension), but taking into consideration the nature of hearing impairment, listening section was omitted.
As for the whole procedure of this experiment, as displayed in <Figure 2>, students were to take a preliminary inspection with TOPIK first, and then selected students who scored in the range

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from 60 to 80 and homogenized them before dividing them into two groups. Thus, all subjects in the study were homogenized in terms of reading levels through the pre-test.
Usual place of study was chosen as the location of the experiment to provide comfort and familiarity. Also, to avoid preliminary knowledge, a section with the highest difficulty and interesting contents was chosen among 20 sections of the contents. Each group was to watch the contents playing on a large-sized screen without help from others. And, post-tests were administered to all groups.
When taking a test for contents comprehension and filling in questionnaires, most students did them by themselves, but for students who needed translation, professional sign-language interpreters were provided.

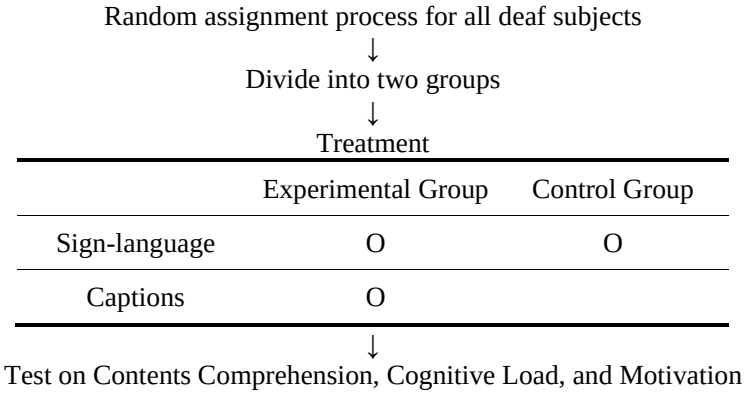

Figure 2. Experiment Procedure

2. Test Materials (Online Contents)

The online learning material developed by Korea Employment Agency for the Disabled was selected for the experiment and the contents is about a successful work life for people with disabilities. The contents are visually composed of flash animation along with both sign-language video clips and captions. For the research, the contents of successful financial life part were taken. That part is consisted of 20 sections and each section takes 40 to 50 minutes to finish. Specifically, as displayed in <Figure 1>, 'investment techniques' part was chosen, which is a subject that not only had induced great curiosity among deaf students but which is also considered as a difficult subject to approach, eliminating the possibility of preliminary knowledge of the test contents.
In the contents, sign-language video clip was primarily displayed on the lower right and captions were displayed on the lower center of the screen. Although the captions had on/off control, it was deleted for the control group to prevent from accidentally turning it on.
And, other text information (preparation, study, review, orderly arrangement) showing on the screen was fully perceived by preliminary instruction and its review.

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Figure 1. Screen display of the on-line contents

3. Measurements

1) Contents Comprehension

Contents comprehension test was conducted by using a worksheet consisting of 10 questions handed out after experiment took place. The test worksheet was developed by the researcher and it as made up of multiple-choice items.

Scaling each question in maximum of 10 points, the total was scored out of 100 points. Most students read and responded to the questions by their own, and for the parts needed additional explanation in understanding, professional sign-language interpreters were in presence to provide help.

2) Cognitive Load

The measure the main factors of cognitive load, the questionnaire developed by Ryu(2009) was taken. The questionnaire is consisted of 5 main sections (Physical effort, mental effort, difficulty of perceived assignment, self-evaluation, and availability of data structure), and each question is answered out of maximum point of 7: 1 point=’absolutely disagree’, 2 points=’disagree’, 3 points=’slightly disagree’, 5 points= ‘neutral’, 6 points =’agree’, 7points=’completely agree’.

3) Motivation

Based on Keller’s theory on motivation, the experiment used the ARCS-based IMMS (Instruction Materials Motivation Survey). It sets full score of 5, and the maximum score of 4 for lower criterions (Attention, Relevance, Confidence, Satisfaction), which were computed by the average score of each question.

4) For further information

After the experiment, individual in-depth interviews were held to obtain feedbacks on captions and contents of the learning material.

5. Data Analysis

For data analysis, computation on average and standard deviation of contents comprehension, cognitive load, and motivation had been conducted. The difference between the two groups was analyzed using t-test at the .05 significance level.

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□. RESULTS

1. Effects on Contents Comprehension

<Table 1> Result of contents comprehension

	N	M	SD	df	t	P
Control group(Sign-language)	31	66.13	12.56	60	-2.16*	.035
Experiment group (Sign-language + Captions)	31	73.23	13.26			

*p<.05

As display in <Table 1>, the control group, which was only exposed to sign-language video clips, scored an average of 66.13 points, and the experimental group in which its instruction supported both sign-language and captions, scored an average of 73.23 points, recording 7.1 points higher points than the control group. Notable statistical difference (t=-2.16, p<.05) between two groups had been drawn, showing the positive effect on contents comprehension by the presence of both sign-language clips and captions. Also, estimates gained by researcher's experiment that do not rely solely on statistical data, which are average of samples, difference between groups, the coefficient of correlation, recorded .565(>.5) in effect size, a method that checks practical significance of above estimates. Such figure tells that the result is significant.

2. Effects on Cognitive Load

In 5 categories that are: physical effort (t=-.30, p=.765), mental effort (t=.71, p=.479), difficulty of perceived assignment (t=-.20, p=.840), self-evaluation (t=.66, p=.515), availability of data structure (t=.65, p=.520), no significant distinction was drawn. However, regarding the aspect of contents, physical effort (M=4.25, M4.32) which represents level of physical fatigue, and mental effort (M=4.96, M=4.77), which represents general magnitude of cognitive load, showed response that were above-the-average (4points). Moreover, difficulty of perceived assignments (M=4.04, M=4.08), which represents the level of understanding the subject had accomplished, showed 'neutral' (4 points) score. Self-evaluation (M=4.91, M=4.76), which signifies effectiveness of cognitive activity, and availability of data structure (M=5.05, M=4.87) that represents effectiveness in application came out as more than average (4 points).

Thus, no significant difference was noted on cognitive load between two groups.

3. Effects on Motivation

Effects on motivation is measured in four different categories including attention (t=.71, p=.478), confidence (t=.18, p=.861), relevance (t=-1.14, p=.261), and satisfaction (t=.27, p=.788). The listed subcategories showed no statistically significant difference between two groups, and 3 to 4 students who already had experienced online educational contents before expressed boredom and dullness during the experiment.

4. In-depth Interview

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The overall responses on both captions and sign-language video clips were positive. However, there were some feedbacks such as “The pace of the program was too fast,” “There were some words hard to understand in captions but it helped, ”I looked at the closed captions only when I had to.” As above, some students complained about the fast pace and difficult vocabulary level of the contents.

Ⅳ. DISCUSSION

As a result, providing captions and sign-language video clips at the same time in online contents turned out to have a positive effect on learning. This can be interpreted to indicate that exposure to both captions and sign language video clips resulted in the transmission of a greater amount of verbal information than does exposure only to sign language video clips.
This result is also in agreement with the findings of other researchers that captions facilitate verbal learning among deaf viewers.
It was clear that the group that was offered both kinds of aid showed a positive effect on contents comprehension. And, it is presumed that although the subjects have poor reading skills, they used the captions to complement their understanding of the contents along with sign-language video clips.

However, the relative effectiveness of interpreted and captioned formats may vary depending on the literacy skills and sign language skills of deaf learners.
Thus, the level of sign language skills of the subjects in this study might vary and they might not have competency in sign language to the same degree as do interpreters in the video clip. Hence, along with reading skills of the subjects, their sign language skills might have affected the result in contents comprehension. That is, according to deaf student’s reading level and sign language skills, their dependency and preference for each kind may differ. However, this part was not explored in this study and the limitations in this regard exist.

Next, as to cognitive load, there was no statistically significant difference between two groups and this is contrasted to modality effect and redundancy effect.
Such outcome seems to result from deaf people’s different learning style which habitually relies on visual information only. Further, the fact that self-evaluation (M=4.91, M=4.76) and availability of data (M=5.05, M=4.87) structure scored high points indicates that the participants efficiently used their cognitive ability, along with positive feedback of the contents. It seems that their different learning style, which solely rely on visual information when studying due to their haring loss(Luckner, 1992).
And, the lower readability level of the learning material itself that raised their intrinsic cognitive load might have affected their later cognitive load. That is, the subjects might have difficulty with the syntax or the vocabulary and this might have raised their intrinsic cognitive load.

And, for the captions itself, the quality of captions would affect the amount of information and it is related to caption placement, spacing, presentation rate, language mechanics, and sound effects. Poorly captioned media will not really provide equal access to the information.
Hence, for effective captions, it should be synchronized (appear at approximately the same time as the audio is available), equivalent(content in captions should be equal to that of the spoken word), and accessible(readily available to those who need them). These components provide true access for those who cannot hear the audio. All external sound effects should be included, either in words or symbols(Camp, C.,& Stark, W.,2006).
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As to the effects on motivation, there was no significant difference between two groups and 3 to 4 students even displayed signs of boredom and lack of attention during the experiment.
This can be interpreted to indicate that constant barrage of contents led the deaf to quickly lose interest. Therefore, presence of captions did not affect motivation of deaf learners. The data showing that both groups recorded 2 to 3 points in motivation area, which is below the average (3 points), it seems that such debasement is not due to captions or sign-language video clips but other reasons.
Furthermore, besides captions and sign language video clips, the instructional design of the contents might have failed to meet the unique needs of deaf learners in terms of motivation and learning interests.
This part was not explored in this study and further studies should be undertaken in this regard.

Lastly, in-depth interviews showed that deaf students favor both sign-language video clips and captions, but they also expressed difficulty in vocabulary and pace of the contents. Such feedbacks are judged to be due to their low literacy skills, and is also owing to the design of the contents which was initially made for hearing people and sign-language clips or captions were simply added later.
In this regard, considering deaf learners low literacy skills, the contents itself should be designed for their reading level. And then, both sign-language video clips and captions should be structured to complement and maximize their learning. This measure will benefit deaf learners in terms of cognitive load and motivation.

Moreover, as mental and physical effort in cognitive load are invested more than average and low scores were shown in motivation as displayed in the result of the experiment, it calls for a need for a close look-up in regard to cognitive load and motivation aspects in order to produce effective contents for deaf learners. Further, extraneous cognitive load such as the placement of sign-language video clips and captions, the speed, color, font size are in close relation to understanding the contents.
Hence, it is important to remember that captioning should occur during the production stage. Otherwise, captions may not fit in naturally if they are added in later.
Thus, the whole design of multimedia materials should be based on instructional technology to meet the unique needs of deaf learners.

V. CONCLUSIONS AND RECOMMENDATIONS

Under the limitation of experimental design, subject sample, and analysis procedure employed, the flowing conclusions are presented.
This study deducted a conclusion that providing captions and sign-language video clips at the same time is rendering positive effect in understanding the contents. And, there was no significant effect on cognitive load and motivation. Especially, among the substructures of cognitive load, physical and mental effort displayed higher-than-average figure regardless of group, and also, both groups recorded values that were below the average for motivation.

Based on these results, following recommendations are proposed.

First, captions should be provided along with sign-language video clips, and the type and the quality of captions should be taken into consideration in terms of literacy levels of the learners.

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If the reading level of learning materials does not fit the level of deaf learner who have lower literacy skills, texts containing difficult vocabularies are to be disregarded. This is similar to the fact that a hearing person with poor English skills tends to avoid books that contain difficult English words.

Second, it is more effective to suggest video typography when presenting animation or video clips in multimedia learning materials. Video typography switches reading information into visual information. And, it describes emotions, movement, facial expression, and other emotional and linguistic sense with written letters. Using video typography, the hearing-impaired will have drastically increased emotional understanding of an image. (Kwon & Huh, 2008) Hence, it would support deaf learners' learning.

Third, when in the production of contents for deaf people, it is common to design it for hearing people first and then simply add captions or insert sign-language video clips to take self-credit for providing equal access to information in learning materials. However, it is important to remember that captioning should occur during the production stage and the quality of captions should be taken care of.

In this regard, a systematic approach based on instructional technology should be considered to be responsive to deaf learners needs in the process of developing learning materials. Developing tailor-made instructional design, evaluation of the application, and further research should be emphasized to optimize their learning. Further studies need to be undertaken to explore the correlation between content comprehension, cognitive load, and motivation.

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