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Effects of Presenting Text or Narration in Difficult E-learning Contents

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ABSTRACT

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The trends and the ways of education have been changing over the years thanks to developments on the Internet and communication technology (ICT). These advancements in computer technology, Internet technology, and an increase in the number of people who can use them have made e-learning one of the most popular mediums of learning and it has been gaining popularity day-by-day. E-learning can be thought of as using different types of ICTs such as mobile phones, tablets, laptops, and other technological tools for educational purposes and it

incorporates several learning technologies and strategies. E-learning enriches the learning experience in education, so it has the potential to affect education positively. E-learning is growing with the development of the information society and with these developments, the way how e-learning content is delivered has been changing too. Moreover, people are more likely to be engaged with learning if the content is presented as multimedia because it enables an effective learning experience by providing text, graphics, or audio simultaneously rather than in a sequential manner

Multimedia offers unique advantages in the field of education however, as in any learning program, designing multimedia learning is important for effectiveness. That is why it is important to consider principles for preparing multimedia. Among those design principles, the modality principle has been more widely tested than any other principle of multimedia design. The modality principle suggests that learning from pictures and verbal text is more effective than learning from pictures and on-screen text. Although the modality principle has high empirical support, its effect is limited to certain conditions. Among those conditions, this research focused on difficult information. It was suggested that if the context of information is complicated for the learners then the printed text is a better option than using narration. Besides, among the circumstances that the modality principle has

not been tested, it was suggested that there is a need to test the effect of using on-screen text and narration in one multimedia learning design. By taking these results into account, this study tested the use of printed-text and verbal text along with visuals when the content is difficult through conducting a recall test.

This study used a pilot-test, prior knowledge questionnaire, and recall test on control and treatment groups. 60 participants were randomly assigned to either the narration-only group (NO) which is the control group or the narration-text group (NT) which is the treatment group. An instructional video was prepared for each treatment group. Participants in NO group received a self-paced, computer-based instructional video that includes narration only to explain the Artificial Intelligence and related concepts. The NT group received the same computer-based instructional video; however, the same explanation was presented as the narration. The narration part was removed, and the on-screen text was added when the incoming information is complicated. After they watched the instructional video, the recall test was conducted. After collecting data, independent samples t-test was conducted to compare the mean score of the groups. According to data analysis of recall test, the statistical results showed that providing on-screen text instead of narration in multimedia material when the information is difficult is more effective on recalling the information than providing the

narration only.

This study has significance due to the following reasons. Firstly, by exploring the use of on-screen when the information is convoluted, the present study contributes to the growing research base on the design of multimedia materials. The results obtained from this study can be used by instructional designers as a reference. and it can contribute to positive learning outcomes. Secondly, since there is a need for testing different circumstances of modality principle, this study makes contributions to literature. Finally, since there is no investigation about using text instead of narration when information is complicated, the present study is important because it can be a base study for future studies in terms of testing other variables besides learning such as motivation, learning perception, and, so on.

Keywords: modality principle, e-learning, multimedia principles, electronic learning

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I. INTRODUCTION

1. Background of the Study

The trends and the ways of education have been changing over the years thanks to developments on the Internet and communication technology (ICT). Developments in ICT is one of the factors that is considered as a major reason for improvements in education (Afshari, Bakar, Wong, Samah & Fooi, 2008; Wong, Atan &Sabudin, 2010). With these advancements in computer technology, Internet technology and an increase in the number of people who can use them have made e-learning as one of the most popular medium of learning and it has been gaining popularity day-by-day (Goyal, 2012). E-learning stands for "electronic learning" and it can be thought of using different types of ICTs such as mobile phones, tablets, laptops, and other technological tools for educational purposes (Clark & Mayer, 2016) and it incorporates several learning technologies and strategies (Sife, Lwoga & Sanga, 2007).

Another definition of e-learning can be using new multimedia

technologies and the Internet to develop the quality of learning by promoting connection to services and resources (Holmes & Gardner, 2006). E-learning has been giving opportunities to learners to access different multimedia contents at any time and from anywhere and in any format online or offline. (Naidu, 2006).

E-learning enriches the learning experience in education, so it has the potential to affect education positively (Holmes and Gardner, 2006). As stated above, with improvements in network and computer technologies, e-learning has been used widely because it allows learners to learn without being disadvantaged for physical or geographic reasons. Moreover, thanks to e-learning, learning is not limited by facilitators or teachers and time, so it is convenient to learn (Raab. Ellis & Abdon, 2002).

According to Ali, Hossain, and Ahmed (2018), and Albors-Garrigos, Segarra-Ona, and Ramos-Carrasco (2011), e-learning is effective for learners because it is easy to use, fast, interactive, cost and user friendly, and appropriate to work independently.

According to Kahiigi, Ekenberg, Danielson, and Hansson (2007), e-learning is growing with the development of the information society and with these developments, the way how

e-learning content is delivered has been changing too. Clark and Mayer (2016) claim that people are more likely to be engaged with learning if the content is presented as multimedia because it allows them to make connections between the pictorial and verbal representations.

The emerging and evolution of multimedia are significant for e-learning and related to developments in technology. The concept of e-learning has been evolving from use of CD-ROM products, radio, television to deliver content and influence learners 'learning (Chou & Tsai, 2002; Moore & Kearsley, 2005), to today's distributed systems and web to provide larger quantities of information in different formats and on different platforms(Gros & Garcia-Penalvo, 2016). In education, multimedia can be defined as the digital integration of graphics, text, animation, static pictures, or dynamic pictures and motion video seamlessly and it lets individual users control their learning in high-level (Tarawneh, Tarawneh, & Alzboun, 2011).

Multimedia offers unique advantages in the field of education. For example, using only text to explain a content is not enough for effective learning. Multimedia enables effective learning experience by providing text, graphics, or audio simultaneously rather than in a sequential manner (Clark & Mayer, 2016;

Tarawneh et al., 2011; Mayer, 2014). In recent years, especially e-learning courses promote the learning with multimedia by providing different formats ranging from text, audio and, visuals and they include both the content (that is, information) and instructional methods (that is, techniques) (Clark & Mayer, 2016). These educational sources, i.e., e-learning courses, enable the new educational sources for learners and they generally combine visual and verbal information to support the learning (Mayer, 2009, 2014a). This type of learning is called multimedia learning and the wide use of multimedia learning design tools in the light of the development of the Internet and technology has increased the facilitation of multimedia in e-learning (Mast, 2015). With the developments of the platforms that can be helpful for e-learning such as YouTube (Video Sharing Platform), edX, Coursera or Udemy(e-courses), learners can study independently to the contents that they want to learn (Bernard et al, 2004; Letterie, 2003).

Although development in ICT gives many opportunities to learners by making e-learning courses to be reached easily and fast and interactive, using just technology is not enough for meaningful learning to occur (Clark & Mayer, 2016). It is essential to have a better understanding of how people learn

for designing instruction. However, many e-learning courses don't take the human cognitive process into account, so they do not optimize learning (Clark & Mayer, 2016).

In other words, as in any learning program, designing multimedia in e-learning courses that are compatible with human learning processes is important for a design to be effective in terms of promoting learning. That is why the human learning process should be considered for multimedia design (Clark &Mayer, 2016).

Through research about the design of multimedia learning, Mayer (2014a) found that if the multimedia in e-courses includes words and pictures together rather than words alone, which can be called as multimedia learning hypothesis, then people tend to learn more deeply. To provide guidelines for designing multimedia materials, the cognitive theory of multimedia learning (CTML) was suggested as a base theory of the guidelines (Mayer, 2001, 2009). This theory was introduced to clarify why the design of multimedia learning is important and how to use it effectively for meaningful learning. Moreover, with the guidance of research-based theory (CTML) and the set of principles that are created for multimedia design, it is possible to design multimedia learning which does not cause confusion and an increase of cognitive load in learners'

minds. That is why while designing multimedia learning, it is important to consider these multimedia principles. The cognitive theory of multimedia learning and the design principles for multimedia learning has been tested through many studies (Mayer, 2001,2009,2014). Among those design principles, the modality principle has been more widely tested than any other principle (Mayer, 2014b).

Mayer (2009) defined the modality principle as learning from pictures and spoken words are more effective than learning from pictures and printed words. And for the modality effect, Low and Sweller (2014) defined it as following.

> *"a cognitive learning effect that occurs when a mixed-mode (partly visual and partly auditory) presentation of information is more effective than a single-mode (either visual or auditory alone) presentation of the same information (p.227)."*

In both definitions, it is indicated that dual modality which is using auditory and visuals together instead of using on-screen (printed) text and visuals can help to improve learning performance (Mayer, 2005b; Mayer,2014; McNeill, Doolittle, & Hicks, 2009). Thus, it is important to avoid using only words and pictures in multimedia learning since it can cause overload in learners' minds.

As it was mentioned above, there are a number of studies concerned about multimedia principles and among those principles, the effectiveness of using pictures and spoken text (narration) instead of pictures and on-screen text which is called as modality principle has been a subject of intense research and tested by different researchers for many years. The different conditions were applied while testing the modality principle. Even though the empirical support for modality principle and modality effect is high (e.g., Carney & Levin, 2002; Mayer, 2014; Neto, Huang, & Melli, 2015; van den Broek, Segers, & Verhoeven, 2014), and generally beneficial influence of modality principle has been thoroughly proven (e.g., Mayer,2017), the effect of modality principle may be limited to certain conditions.

Some studies have indicated that under certain conditions, learners have better learning outcomes when the multimedia presented as printed text and visuals instead of spoken text and visuals. This situation has been called a reverse modality effect. (Crooks, Cheon, Inan, Flores & Ari, 2012; Singh, Marcus & Ayres, 2012; Tabbers, Martens & van Merrienboer, 2004). The conditions where modality principle fails or reverse modality effect occurs, are referenced as boundary conditions (Clark & Mayer, 2016; Mayer,2014).

Therefore, although several studies have shown the appearance of the modality principle and modality effect, there are conditions when reverse modality effect occurs, or modality principle fails. Some of these conditions found by researchers are the type of pace in learning (that is, self or system), the language of the content (that is, native or foreign language), learners' prior knowledge, lengthy verbal segments, familiarity of the content, and so on (Brünken, Plass & Leutner,2004; Clark & Mayer, 2016; de Westelinck, Valcke, de Craene, & Kirschner, 2005; Ginns 2005; Inan, Crooks, Cheon, Ari, Flores, Kurucay & Paniukov, 2015; Mayer,2014; Schuler, Scheiter, & Gerjets, 2013).

1. Statement of the Problem

Among the boundary conditions that cause failing or reversing the modality effect, one of the conditions is difficulty of the information. When studying relatively complicated topics, the reverse modality effect may appear (Clark & Mayer, 2016). Kalyuga, Chandler & Sweller (1999) also claim that speech (that is, auditory or narration) may not be an effective way if the speaking content is complicated. Similarly, Mayer (2014) mentioned that the studies which have found reverse modality effect or failed modality principle usually used complicated audio materials so it is likely that under conditions where

auditory text materials are difficult, working memory may be overloaded and this eliminates all the effects of modality principle. According to Leahy and Sweller (2011), the reason why reverse modality effect occurs is that under most conditions, while a written statement is permanent on the screen so it can be returned indefinitely while the spoken information is lost when it is spoken so it is relatively transient. As a consequence of transient nature, there may be no favor presenting sophisticated information in a dual– modality form so modality principle fails, or the reverse modality effect appears. That is why it was suggested that using written text instead of spoken text is more beneficial when the incoming information is complicated for learners (Clark & Mayer, 2011; Leahy & Sweller, 2011). What is more, Inan, Crooks, Cheon, Ari, Flores, Kurucay and Paniukov (2015) conducted study about boundary conditions of modality principle and similarly, they suggested that if the context or information is complicated for the learners then the printed text is better option than using narration. According to Mayer (2014), having to remember earlier difficult information that has been heard, the processing of current information may overload working memory.

To sum up, since the goal of modality principle is reducing the cognitive load in the visual channel (that is through the eyes)

by off-loading some of the cognitive processing onto auditory channel (that is, the ears), if the condition, in this case, complicated information, then the words should stay as printed text to prevent cognitive load in working memory (Inan et al., 2013).

Moreover, among the circumstances that modality principle has not been tested, Clark and Mayer (2016) suggested that there is a need to conduct a study about using on-screen text and narration in one multimedia learning design (p.127). This means that one e-course should include both verbal text (narration) and printed text (on-screen text) along with visuals.

While several studies attempted to analyze and compare the effects of modality principle, those studies usually used the on-screen text and narration in different groups and then compared their results. For example, participants watched the lightning process (Experiment 1) or components of car's brake system (Experiment 2) as multimedia explanations in Mayer and Moreno's study (1998). In both experiments, one group watched the presentation with animation and written text, while the comparison group received narration instead of on-screen text. The study compared the on-screen text and narration groups' performance on transfer test. Similarly, the

narration and on screen-text groups were compared in secondary school biology class by Herrllinger, Höffler, Opfermann and Leutner (2016) and their performances on tests were compared in the results. Number of other studies conducted the similar experiments by comparing the on-screen text groups with narration groups (e.g., de Oliveira Neto, Huang & Azevedo, 2015; Fiorella, Vogel-Walcutt & Schatz,2011; Mayer and Anderson,1992; Moreno et al.,2001; Mousavi et. al., 1997, Tindall-Ford et al., 1997). Although there have been several studies that compared on-screen text and narration in different groups and comparing their results, it was found that effects of using text or narration in one difficult e-learning multimedia material has not been investigated.

By considering aforementioned results of the studies about using text instead of narration when the complicated information presented, the present study aims to test the condition where using printed-text and verbal text along with visuals when the content is difficult and expects to investigate how it affects learning performance on recall test. In other words, the content will be presented as visuals and narrations but on-screen instead of narration will be used on the screens when the incoming information is difficult for learners.

By using effectiveness of modality principle on multimedia learning, this study will explore the effects of one of the untested circumstances of modality principle. Moreover, by using the printed text, the cognitive load on working memory occurred when the information is sophisticated (Clark & Mayer, 2016; Mayer,2014) is expected to be reduced.

2. Needs of the Research

The needs of the study and the expected contributions the present study will make will be discussed in this section.

As noted earlier, the modality principle is still a work in progress (Cheon, Crooks & Chung, 2014). In general, this study will contribute to the testing the modality principle under different circumstance but there are other contributions that this study is expected to make.

- Needs of guidelines

Especially in e-learning environment, the design of the e-course is so important. Even though the developments in information and communication technology (ICT) make many learning opportunities possible, it is not possible to create meaningful learning by utilizing technology only (Clark & Mayer, 2016). It is important to understand how people learn and design the multimedia (in this case, e-course) accordingly.

As mentioned earlier, the multimedia principles for designing multimedia materials (Mayer, 2001,2009) were introduced as a guideline and among those principles, modality principle has been more widely tested than any other (Mayer, 2014b). Modality principle has indicated its positive impact on learning by reducing cognitive load on working memory, which in turn may improve the learner's recall of knowledge (Mayer, 2014). This means that narration of the text (information) is needed when it can improve the learner's cognition. However, it was also mentioned that narration should not be employed if the information is too difficult to take in, since it creates cognitive load. As other studies aimed to find multimedia effect under different conditions (see Chapter II. Literature Review) and inform designers about the effect of modality principle, this study also will contribute to inform designers about effects of the multimedia design under certain circumstances (inconsistent use of printed and verbal text). This knowledge will guide the multimedia design and enable meaningful learning by avoiding cognitive overload.

As a result, by pointing out use of on-screen when the information is convoluted, the present study can contribute to the growing research base on the design of multimedia materials. The results obtained from this study can be used by

instructional designer or teachers or integrated to other multimedia learning design circumstances and it can contribute to positive learning outcomes.

- Needs of testing modality principle

Although the modality principle was investigated by several studies and the superiority of auditory text was demonstrated in multiple studies (Kalyuga et al.,1999; Mayer & Moreno, 1998; Moreno & Mayer, 1999; also see Ginns, 2005), there are still questions that have not been addressed by many studies such as what is better in modality principle (what kind of animations or static pictures(Höffler & Leutner, 2007) or under which circumstances the learning outcomes are better (e.g., Höffler & Leutner, 2011; Huk, 2006; Kalyuga, 2008; Koć-Januchta, Höffler, Thoma, Prechtl, & Leutner, 2017), or how the learning is affected by inconsistent use of written text and verbal text (Clark & Mayer, 2016) and, so on. According to Sandoval (2016), since now the researchers know that using modality principle can be effective in multimedia learning, more studies on the situations that the modality principle holds are needed. Present study aims to test a specific condition that using on-screen text and verbal text depending on content difficulty. The results will be important for the literature about modality principle because there have been multiple studies

that concluded the fact that additional research about modality principle and modality effect should be conducted because it is not easy to predict the circumstances. (Oberfoell,2015; Pastore, Asino, & Briskin, 2019; Sandoval,2016; Stiller,2007). Moreover, as Mayer and Pilegard (2014) stated that instead of asking whether the modality effect exist, a much more promising direction is to investigate under which conditions the modality principle does and does not apply.

Therefore, by the needs of research about the circumstances where modality principle is tested, this study is expected to make contributions to literature.

- Needs of testing the circumstance in the present study

While testing modality principle and its effect, there have been studies that compares if the written text or verbal text is better for the learning (Harskamp et al., 2007; Rias, Zaman, & Norhana, 2011). And after certain number of researches, the studies about modality principle started testing how other variables are affected when the modality principle is applied such as effects on motivation(Dousay,2016), learners' attitude(Aldalalah & Fong, 2010), reading comprehension(Sandoval, 2016), and the learners' viewing behavior(Schmidt-Weigand, Kohnert, & Glowalla, 2010) and,

so on.

Since there is no investigation about using text instead of narration when information is complicated, present study is important because it can be base study for future studies in terms of testing other variables besides learning. This study aims testing how the learning is affected so future studies can refer to the obtained results and add other variables (motivation, learning perception, behavior and so on) to test the different conditions.

2. Research Questions

This study is designed to examine the effect of using printed and verbal text according to content difficulty on learning performance. Specifically, this study aims to reduce cognitive load on working memory by adding printed text when the information is not easy to process by just auditory channel. The study will compare two different strategies to present information: (a) by using narration only and (b) using narration mainly and adding on screen text when the information is difficult for learners.

The following research question was examined in this study:

> When learners are presented with visuals accompanied by printed – text or audio instruction depending on

content difficulty, does it affect their performance on recall test compare to those learners who are instructed with visuals and audio instruction only?

3. Definition of Terms

The followings are the used terms and their definitions in the present study. The definitions may vary from author to author, so definitions were chosen from the studies that were used or referred for this study.

Boundary conditions are defined by (Mayer,2009,2014) as situations under which a design principle is most likely to apply or least likely to apply. For Modality principle concept, it generally means the conditions that the modality effect does not appear. Boundary conditions that modality principle may not hold are pacing of presentation, difficulty of information or prior knowledge of learners and so on (Mayer,2014).

Complicated information; complicated as a word means that having many parts that are organized in a way that may be difficult to understand ("Complicated, n.d.). Similarly, in education context, complicated information means that consisting of many interconnecting parts or elements; intricate; involving many different and confusing aspects (Jonassen, 2008).

E-learning (electronic learning) has been defined differently in much research. While some authors explicitly define e-learning, others define according to a specific definition or their point of view. (Moore, Dickson-Deane, & Galyen, 2010). Clark & Mayer (2016) defined e-learning as "as instruction delivered on a digital device that is intended to support learning" (p.8)And stated that the hardware for delivery can vary from desktop or laptop computers to tablets or smart phones in e-learning, but the instructional goal is providing and supporting individual learning.

Multimedia learning in this study will be taken as a part of e-learning environment which means multimedia learning in digital environment and intended to support individual learning will be the base where multimedia content will be tested. (Clark & Mayer, 2016) Although modality principle is applicable to classroom learning, online and as well as distance learning (Clark & Mayer,2016; Mayer, 2014), this study's scope will be in e-learning environment.

E- learning courses are the electronic courses that delivered by digital devices using the form of printed (on-screen) or spoken (verbal, narration) text and graphics such as pictures, illustration, animation, photos, or video (Clark & Mayer, 2011, 2016). In present study term of e-courses is used

interchangeably with multimedia courses and multimedia materials and instructional video since the format of the e-course will be video and they commonly include presenting information by using audio, visuals and as well as text in e-learning environment. (Clark & Mayer,2016)

Element interactivity has been defined by Paas and Sweller (2014) as the extent to which information's element must be processed interact. If there is element interactivity, then elements cannot be processed individually which means that the material will be perceived as difficult to understand or learn. (p.40)

Recall Test measures the ability to remember information presented in the learning material. (Mayer,2009; Scheiter, Schuler, Gerjets, Huk, & Hesse ,2014)

Learner-centered approach refers to the type of approach to multimedia learning design based on adapting technology to the way people learn. *Technology-centered approach* on the other hand, refers to make cutting-edge technology available for learners. (Mayer, 2014)

Meaningful learning was defined as indicating good performance on tests by learning through understanding the material (Mayer,2014). Mayer and Moreno (2003), and Mayer

(2014) defined understanding the material as observing the important aspects of the presented material, organizing it into coherent cognitive structure mentally and integrating it with relevant and existing knowledge.

Overload refers to the time when the requested memory capacity is higher than available memory capacity. (de Jong, 2010)

II. LITERATURE REVIEW

1. Theoretical Framework

Since this study aims to examine the modality principle (Clark & Mayer,2016), the theoretical framework that informs this study includes Mayer's (2014) cognitive theory of multimedia learning which is the base of modality principle (Mayer, 2014).

In order to understand the requirement for the theory of multimedia learning (Mayer,2014), it is essential to understand how the mind works. Understanding this process can be traced to an explanation of learning processes called cognitive load and cognitive load theory (Sweller,2014).

1.1. Cognitive Load Theory

It has been more than half a century that researchers have made assumptions and discussed human cognitive architecture, especially in terms of working memory and long-term memory. According to Miller (1956 cited in Mayer,2014), since working memory is limited, people have difficulty while keeping information which has more than nine chunks. In other words, this introductory research indicated that the mind is able to store nine chunks of information at most without exceeding cognitive capacity and it can hold roughly five to nine chunks

at most (Cowan,2005). Limitations in working memory affect learning and when information processing exceeds the capacity of working memory, which is referred to as cognitive load, a significant increase in cognitive load occurs (Chandler & Sweller, 1991; Sweller,1993). Moreover, cognitive load is one of the important factors that need to be considered in education (Yeung, Lee, Pena, & Ryde, 2000).

Australian educational psychologist John Sweller (1988,1994) developed the cognitive load theory, which claims that both long term and working memory in human memory is limited in terms of the information it can process. Even though the term cognitive-load theory was first coined by John Sweller in the late 1980s, its roots may be traced back to 1960s. Atkinson and Shiffrin (1968) proposed a model representing short-term and long-term memory. This model shows that the details of new information are passed into short-term memory for processing, adoption, and it is stored into long-term memory for being retrieved back later. This study conducted on cognitive processing was extended by Paivio (1986) to present two separate systems of memory, visual and oral, which is now known as Dual Coding Theory. Paivio's findings about cognitive processing made the Information-Processing Theory has become important to

acknowledge as information can be obtained through both audible and visual presentation.

Another study about working memory was conducted by Baddeley (1986) cited as working–memory model. It is a base model for recent research on working memory. According to working–memory model (Baddeley,1986), working memory consists of multiple subsystems and each of these systems has its own limited capacity. The working memory that allows systems to work independently, however the space available for each system is limited. While some tasks require independent systems to work, other more complicated tasks may use more than one system at a time. Especially, presenting textual information as visually along with pictorial information causes overload in working memory due to the need to process both pictorial and textual information within the same memory subsystem.

Further studies on core components of the Information–Processing Theory and working memory were conducted by Sweller, van Merrienboer & Paas (1998) to investigate the role of working memory in the process. Sweller et al. proposed the Cognitive Load Theory by claiming that overloading working memory diminishes learning meanwhile underloading it does not cause interest.

Furthermore, according to Sweller et al. (1998), there are three subcomponents in cognitive load as intrinsic cognitive load (ICL), extraneous cognitive load (ECL), and germane cognitive load (GCL).

First subcomponent is intrinsic cognitive load which refers to the natural difficulty of the information that must be processed by the learners' working memory. The intrinsic cognitive load is determined by mental demand of the tasks and levels of element interactivity (Sweller, 2010). In other words, intrinsic cognitive load caused by interacting elements that are intrinsic to the task and must be proceed concurrently. The intrinsic cognitive load is fixed in each task with a certain knowledge level. It can be altered but only changing the nature of the task or the participants' knowledge level (Paas & Sweller,2014).

Second subcomponent is extraneous cognitive load, and it is also caused by high levels of element interactivity. However, in this case, the element interactivity happens because of inappropriate instructional design that increase the number of elements that is required for learner to process and it results in ineffective learning (Sweller,2010).

The last subcomponent is germane cognitive load, and it refers to working memory resources dealing with intrinsic cognitive load rather than extraneous cognitive load

(Mayer,2014). Cognitive processes relevant to learning directly impose the germane cognitive load (van Merrienboer, Schuurman, de Croock, & Paas, 2002, p.12). That is why if extraneous cognitive design is kept at minimum and the intrinsic cognitive load is higher in an instructional design, then the germane cognitive load may be high as well. This means that the instruction is more effective. In other words, if instructional design is appropriate, learners can use germane cognitive load to help in the construction of pattern in specific domain of interest (Paas & Sweller,2014).

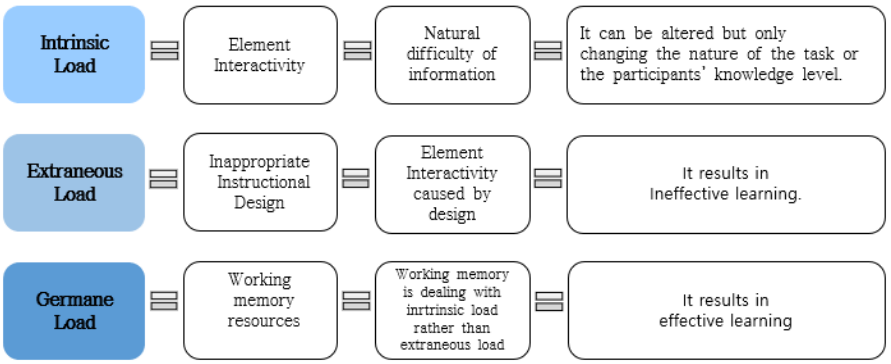

Figure 1 Subcomponents of Cognitive Load (Sweller, van Merrienboer & Pass,1998)

Since the information needs to be processed bore being transferred to long-term memory, short-term memory, or working memory is essential in learning, especially in multimedia learning (Schuler, Scheiter & van Genuchten, 2011). For the information to be processed in working memory first the learner perceives and chooses the relevant

information and then this information is organized into a mental model which is coherent. During this process, connections are constructed between prior knowledge and processed information (Mayer, 1997). In other words, when complex tasks are presented, this sophisticated process may become even more complex. Cognitive load theory is concerned with the learning of complex cognitive tasks that make learners overwhelmed because of the number of interactions in information which need to be concurrently processed.

1.2. Cognitive Theory of Multimedia Learning

Even though cognitive load theory provides the basic structure for designing multimedia instructions, there is need to explain how visual, verbal, and auditory representation variations affect multimedia learning. By including those aspects, Mayer (1997,2001,2005a,2009; Mayer & Moreno, 2003) suggested Cognitive Theory of Multimedia Learning, which is the base framework of this study, to explain multimedia learning and provide information for multimedia design. According to Mayer (2014), three fundamental theoretical assumptions underlie the theory of multimedia learning: (a) dual-channel assumption, (b) limited capacity assumption, and (c) active-processing assumption and the reason why these are related to cognitive theory of multimedia

learning is that these three basic assumptions are about how the human mind works. (Mayer, 2014)

(a) Dual channel Assumption

The dual-channel assumption means that there are separate channels for processing visual/pictory and auditory/verbal information which is why dual-channel assumption relative to the cognitive theory of multimedia learning. Humans begin to process information in visual channel when information is presented to the eyes by using animations, video, illustrations, or on-screen text; when information is presented to ears by using narration or nonverbal sounds, humans start processing that information in the auditory channel (Mayer,2009,2014). There is a long history behind the concept of separate information processing channels and currently it is most related to Paivio's dual-coding theory (Paivio,1986,2006; Clark & Paivio,1992 cited in Winn & William,2020) and Baddeley's model of working memory (Baddeley,1999; Baddeley, Eysenck, & Anderson, 2009).

(b) Limited-capacity Assumption

Limited-capacity assumption means that humans are limited in the amount of information that can be processed in each channel at one time. When an animation or illustration showed,

only a few images can be hold in the visual channel of working memory at any one time. Moreover, when a narration presented, only few words can be stored in the verbal channel at any one time (Mayer,2009,2014). The conception of limited capacity within consciousness has had a long history in psychology, and some of the modern examples are Baddeley's theory of working memory (Baddeley,1999; Baddeley et al.,2009) and Sweller's cognitive load theory (Sweller,1999; Sweller, Ayres, & Kalyuga, 2011).

(c) Active-processing Assumption

Active-processing assumption means that in order for humans to establish a consistent mental presentation of their experiences, they actively engage in cognitive processing. There are three cognitive process required for active processing; first process is *selecting* which means that paying attention to relevant incoming information for transfer to working memory, second process is *organizing* which is organizing(mentally) selected information into coherent cognitive structure in working memory, and last one is *integrating* which refers to connect incoming information with other knowledge such as relevant prior knowledge retrieved from long-term memory (Mayer,2014).

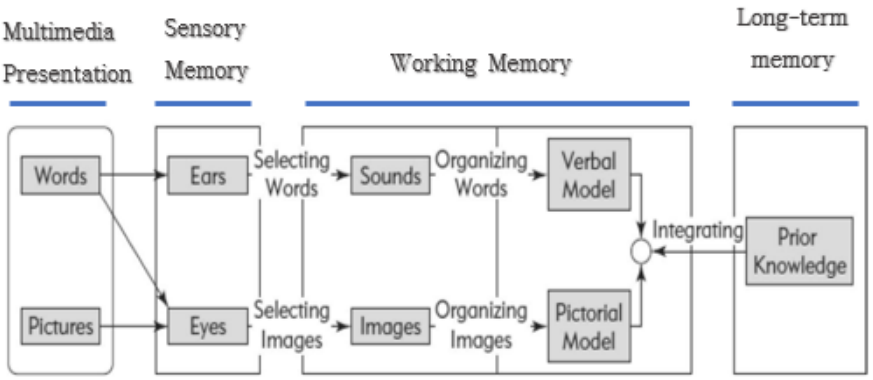

Figure 2 Cognitive Theory of Multimedia Learning (Adapted from Mayer, 2014c)

Figure 2 presents a cognitive model of multimedia learning intended to represent the human information processing systems. The boxes represent memory stores. According to Mayer (2014), there are three memory stores in the cognitive theory of multimedia learning. The first memory store is *the sensory memory* which holds pictures and textual inputs briefly. The second one is *working memory* which is responsible for selecting information from sensory memory to process and integrate. Finally, long-term memory stores organized knowledge permanently.

There are five different process in cognitive theory of multimedia learning (Figure 2). The first process is called as *selecting words* which means that attention on relevant words to create sounds in working memory. The second process is

selecting images and it refers to the attention on relevant pictures to create images in working memory. The next process is *organizing words* which means building connections among selected words to create verbal model. The fourth process is called as *organizing images* and it means that building connections among selected images to create pictorial model. The last process is *integrating* which means that building connections between verbal and pictorial models and with prior knowledge. (Mayer, 2014; Mayer & Moreno, 1998)

Mayer (2014) claims that it is a big challenge to guide the learner's appropriate cognitive processing during learning without overloading the learner's working memory capacity. Mayer (2009,2014) formed the cognitive theory of multimedia learning by incorporating the aforementioned types of cognitive load into redefined types of cognitive processing. This is referred as the triarchic model of cognitive load in Cognitive Theory of Multimedia Learning (CTML) and consists of following three processing (demands) on cognitive capacity during multimedia learning.

(a) *Extraneous processing* is the cognitive processing that is not linked with the instructional goal and it requires extraneous cognitive load. Extraneous processing should be minimized during the design of multimedia instruction. It is

caused by poorly designed instruction.

(b) *Essential processing* is the cognitive processing that represents the essential presented material in working memory and needs the intrinsic cognitive load. It is related to the goal of learning and it involves selecting information. it is caused by complexity of the material.

(c) *Generative Processing* is the cognitive processing that aims at making sense of the material. In other words, it is required for deeper understanding and needs the germane cognitive load. It is caused by motivation to learn and involves both organizing and integrating the new information which leads to meaningful learning.

Mayer (2014) suggests that the sum of extraneous processing plus essential processing plus generative processing cannot exceed the learner's cognitive capacity. Since the learner's capacity is limited, extraneous cognitive processing should be reduced, essential cognitive processing should be managed, and generative cognitive processing should be developed in multimedia source so that most of cognitive resources can be reserved for effective learning.

2. The Modality Principle

As it was mentioned above, since cognitive load should be reduced for effective learning and among other design principles derived from the cognitive theory of multimedia learning, the modality principle has gained scholarly attention because of its effectiveness on lowering cognitive load and increasing learning (Mayer,2014; Mayer & Moreno,2003).

Since text, graphics and audio are used to deliver instructions in multimedia materials which is a part that making e-learning more effective, the modality principle suggests that learning will be enhanced if the information presentation to learners is conducted through spoken words (auditory channel processing) rather than merely on-screen text(visual channel processing) (Ginns,2005; Mayer,2001,200,2014; Mayer & Moreno, 2003).

Given that when there is concurrent processing of graphics and on-screen text, the learners' visual channel can be overloaded and cognitive load on working memory occurs which is the explanation of forming modality principle (Clark & Mayer, 2008). In other words, when learner's attention is directed at on-screen text, then they might not be able to direct the same amount of attention toward the graphics or animation especially when the on-screen text and graphics are

presented simultaneously displayed.

The modality principle suggests that if the visual figure (e.g., graphics or illustrations) is linked with auditory (e.g., spoken words or narration) rather than visual statements (e.g., written on-screen text), then the modality effect occurs. The modality effect is closely related to Paivio's dual-coding theory (Clark & Paivio,1991; Paivio,1986) and Baddeley's model of working memory (Baddeley,1986,1999). It can also be explained by cognitive load theory which is based on human cognitive architecture and it suggests that limitations of working memory should be overcome for effective learning (Low, Jin & Sweller, 2011).

2.1. Evidence Studies for Modality Principle

As it was mentioned above, the modality principle received much scholar attention due to its promising effects. That is why there are many research that have tested if the modality principle holds under different conditions.

There have been studies testing the modality principle and its effect on learning which is evaluated by the result of tests. For example, Mayer and Moreno (1998) conducted experiments which compares one group with visuals and narration, and the other group with visual and on-screen text.

The results showed that there was modality effect which meant that the narration and visual group performed better than the visual and on-screen text group. There were some other studies which demonstrated this principle similarly (e.g., Atkinson, 2002; Gambari, Ezenwa & Anya, 2014; Kalyuga et al.,1999; Mayer & Anderson, 1992; Moreno & Mayer, 1999; Moreno, Mayer, Spires & Lester, 2001; Mousavi et al., 1995; Tindall-Ford, Chandler & Sweller. 1997)

Some of studies in the literature showed the effect of modality principle under different conditions. For example, the modality effect has been found in studies that were conducted either in classroom or laboratory settings, that were learner or system-paced and the content of the multimedia was varying such as scientific or non-scientific subjects (e.g., Brünken, Steinbacher, Plass, & Leutner, 2002; Brünken et al. 2004; Mayer, Dow & Mayer, 2003; Moreno & Mayer 2002; Moreno et al 2001;).

Furthermore, there have been studies included different instructional methods and tools. They found modality effect in these studies which means that the modality principle holds for different instructional methods and tools. For example, Moreno et al. (2001) and Moreno and Mayer (2002) tested modality principle by using agent-based multimedia game on botany. O'

Neil et al. (2000) used virtual raining environment and Fiorella, Vogel-Walcutt and Schatz (2011) conducted a study to test modality principle by using simulation. Moreover, AbuSaada, Pei and Fong (2013) used video streaming to test modality principle.

Finally, researchers have tested the effect of modality principle when a certain variable is included to study. These studies found the modality principle holds for different variables as well. For example, learner's prior knowledge (Stiller,2007), learner's visual cognitive style (Kóc-Januchta, Höffler, Eckhardt & Leutner, 2019).

III. RESEARCH METHODOLOGY

1. Overall Research Design

This chapter describes the study that investigated the use of text or narration depending on content difficulty on college students. The investigation was about how the participant's performance on recall test is affected if the written text is added to the parts in which incoming information is complicated. In order to assess the effect on learning performance, a recall test (RT) was prepared based on the first level of Bloom's taxonomy (Anderson & Krathwohl, 2001). The independent variable in this study was the method of instruction and the dependent variable was the recall test.

This study used a pilot-test, prior knowledge questionnaire and recall test on control and treatment groups. Before the data collection, the participants were informed about the study briefly. Ethical conditions such as privacy and confidentiality were explained, and they were informed that they are free not to participate in study if they change their minds.

Participants were randomly assigned to either the narration-only group (NO) which is the control group or the narration-text group (NT) which is the treatment group. Participants in NO group received a self-paced, computer-based

instructional video that includes narration only to explain the Artificial Intelligence and related concepts. The NT group received the same computer-based instructional video; however, the same explanation was presented as the narration. The narration part was removed, and on-screen text was added when the incoming information is complicated. After they watched the instructional video, recall test was conducted.

The study applied independent samples t-test, which is also known as independent t-test, two-samples t-test, or student t-test. Independent samples t-test is an inferential statistical test that shows whether there is a significant difference between the means of two unrelated groups. That is why to determine whether there is a statistically significant difference between the control and treatment (NT and NO) group's recall test results which means to investigate if the treatment is effective, independent two samples t-test was used. According to the comparison in the NO group and NT group's recall test, the hypothesis was tested.The present study tested the following hypothesis.

- The effect of the delivery type of modality on the recall test results.
    - H_0 There is no statistically significant mean difference between recall test results of NO and NT

groups.

- H_1 There is a statistically significant mean difference between recall test results of NO and NT groups.

2.Materials and Instruments

2.1. Instructional Video

In this study, an instructional video was designed to test modality principle and it was tested in computer-based environment.

While creating the instructional video, Mayer's following basic multimedia learning principles were considered to ensure that the instructional video is helpful to learning (Clark & Mayer, 2016). The considerations that were applied as follows: Based on the spatial contiguity principle, the graphics, and corresponding on-screen keywords were placed close to each other; based on the coherence principle, the graphics were relevant to the content in the video; based on the temporal contiguity principle, narrations during the video were played simultaneously with the corresponding graphics; based on signaling principle, the keywords in the video were highlighted; based on the pre-training principle, the key content were explained briefly before begin to experiment (Mayer, 2009).

The features of the instructional video were as follows. The length of the videos were around 16 minutes because as Hong, Lim, and Park (2013) stated that if the instructional video is between 15 minutes to 20 minutes then it is useful and helpful for learners. Moreover, the video was self-paced which means participants could stop and play the video as they want; however, there was a total time limit which is 30 minutes to prevent spending too much time on one screen or getting distracted (Sandoval,2016). The video was self-paced so participants could stop-and play the video whenever they want; however, the backward or forward was not allowed to prevent revisiting or skipping the screens continuously since it can affect the content validity of the study outcomes. (Neto, Huang, & Melli, 2015) The tool that was used for designing instructional video was Doodly. The content and their graphics were chosen the same for both control treatment group. The only difference was that there was on-screen text instead of narration in treatment group when the incoming information is difficult. One of the screens that was used in both groups as follows.

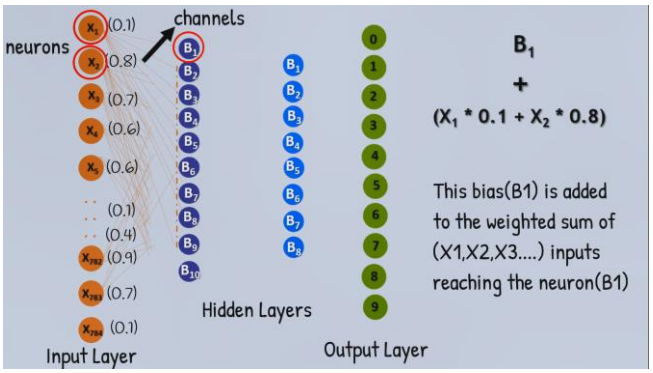

Figure 3 : How do convolutional neural networks work? (Treatment Group: No narration on this screen)

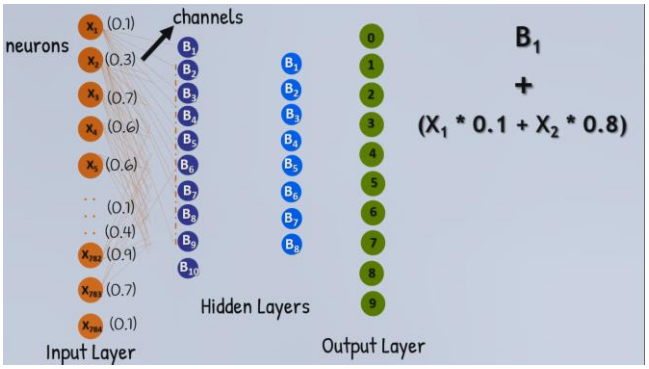

Figure 4 How do convolutional neural networks work? (Control Group: Narration on this screen)

-Deciding the Content Difficulty

The concept of artificial intelligence was selected as the content of the video. Contents in the previous studies have been generally about as geometry, mathematics, physics, biology, and electrical sciences so the modality principle has been tested in the limited concerning subject matter (Tabbers,2002). The literature review of the multimedia

principle indicated that artificial intelligence and its content have not been tested. Moreover, since this study aimed to investigate adding on-screen text to parts in which the complicated information or relationship is presented, the content such as artificial intelligence was suitable to choose. Given these considerations, the present study was about the concept of artificial intelligence. The specific content and its range were decided after analyzing related content, videos, and research studies about artificial intelligence. Moreover, feedbacks related to content were gotten from professionals from artificial intelligence in education field. As a result, the instructional video included Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks and Applications of Artificial Intelligence (Natural Language Processing and Computer Vision) concepts. The content was completed, and related feedbacks were received from professionals. After all modifications, the videos were prepared.

As it was mentioned above, the videos prepared identical in terms of the content and the graphics. The difference between treatment and control groups video was the parts where presented information was complicated. It was proven by many researchers that when the presented information is complicated for learners, using written text instead of spoken

text is more beneficial (Kalyuga, Chandler & Sweller,1999; Clark & Mayer, 2011; Leahy & Sweller, 2011; Inan et al.,2015). That is why the screens where difficult information was presented included narration with graphics in control group while on-screen text along with graphics in treatment group.

As Jonassen (2008) defined the complicated information, it consists of multiple components or elements that are interconnected; sophisticated; containing many distinct and confounding aspects. For artificial intelligence and related concepts, the difficult parts of the content were decided with two professionals in artificial intelligence field. The output then was discussed with two professionals in education field and it was finalized. The next diagram shows the finalized output that shows relations between concepts and aspects that are confusing. These concepts are related, interconnected and they have various common and different points that need to be differentiated.

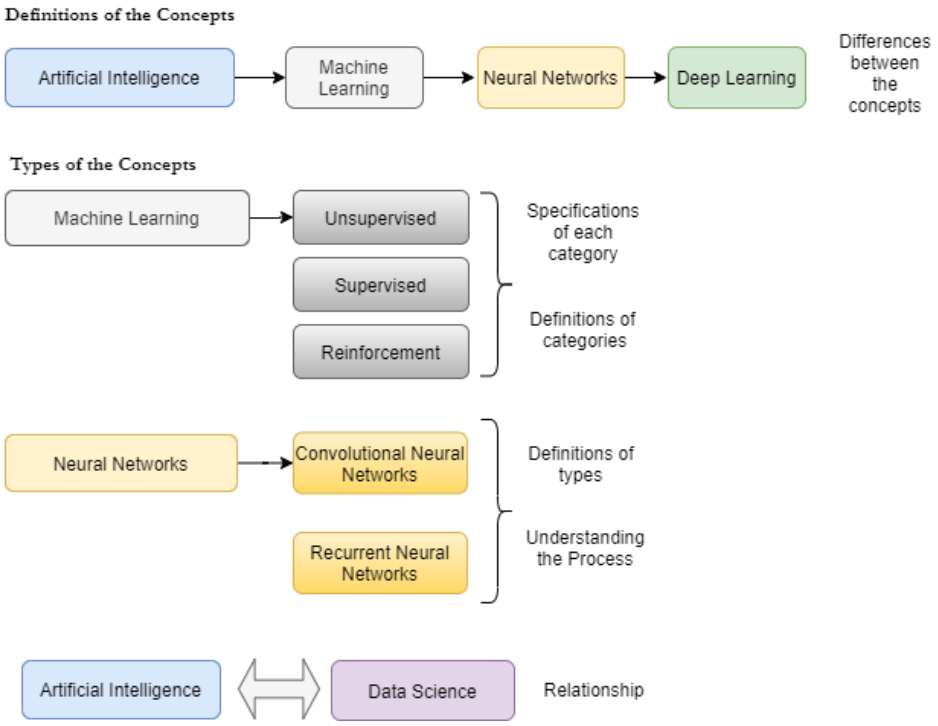

Figure 5 Basis of Content Difficulty in the Instructional Video

Figure 5 was used as a basis for the instruments. Related parts were presented as on-screen text in treatment group and recall test questions were prepared accordingly as well.

2.2. Instruments

This study consisted of a pilot phase, prior knowledge questionnaire and recall test. All materials were prepared by online programs that allowed storing the data. Each test's aim and their design processed are defined as follows.

2.2.1. Pilot Phase Process

Since every data collection instrument must satisfy two key requirements which are reliability and content validity (Sampieri, Collado & Lucio, 2006), a pilot test was applied to identify the factors that might impede the efficiency of the treatment. 10 participants were selected and assigned to the control and treatment groups. They were asked for the feedbacks related to the design of the video, prior-knowledge questionnaire, and recall test. The feedbacks and how they reflected can be found in Appendix 1. The issues identified through the pilot test were modified before conducting the treatment.

2.2.2. Prior Knowledge Questionnaire

A prior knowledge questionnaire was employed to ensure that participants did not have prior knowledge related to the content of the instructional video. The questionnaire was used to eliminate the learners who have prior knowledge regarding to the context of the instructional video. There were 10 questions including demographic information and the content of the video. One excerpt from the prior knowledge questionnaire as follows (See Appendix 2 for the full Questionnaire).

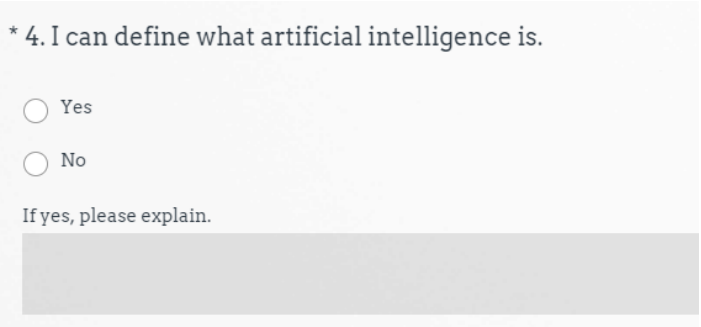

Figure 6 One Question from Prior Knowledge Questionnaire

To measure if the learner indeed knows the answer or s/he is not wrong about it, "If yes, please explain" option. If the learner answered yes and explained the answer correctly, then it was evaluated as right answer. In case the learner chose yes, but explained the answer wrong, then it was evaluated as wrong.

Prior knowledge questionnaire was employed as an elimination step, so it was conducted before the study. According to the answers of the questionnaire, the applicants who had no prior knowledge related to artificial intelligence concepts were selected as participants of this study. Applicants who had a prior knowledge, on the other hand, were eliminated and were not included to data collection step. the participants who were included to the research process were assigned to either Narration Only (Control Group) or Narration-Text (Treatment Group) randomly.

2.2.3. Recall Test

After the participants complete the experiment, the recall test (RT) was applied. The recall test was employed to measure the first level in Bloom's Taxonomy (Revised) that is "remember" (Anderson & Krathwohl, 2001). This test included questions with one answer choices. Since this study aims to investigate the effect of presenting text when there is complicated information, the recall test included questions related to those parts where complicated information was presented.

- Design of the Recall Test

Design process of the recall test and its implementation will be discussed in this part.

This test aimed to assess how much content the participant will remember from the multimedia content specifically the parts that the information was complicated. The recall test was prepared according to the principles of preparing tests (Gronlund, 1977). The principles that were applied as follows.

1. Determining the purpose of the test

According to Gronlund (1977), if the purpose of testing is assigning grades to the learners at the end of the instruction, then the test should be summative test. Moreover, summative

tests often used to normalize performance so that they can be measured and compared. Since the aim of recall test is comparing NO and NT groups' performances at the end of the video instruction, summative test was chosen as the purpose of the test.

2. Identifying the learning outcomes

The learning outcomes to be measured by the test were identified by considering the Taxonomy of Educational Objectives (Anderson & Krathwohl, 2001). Since the purpose of the recall test was measuring how much the participants remember from the content, cognitive domain of the taxonomy and its Knowledge (Remembering) field was taken as a reference for identifying the learning outcomes. In the preparation of the recall test, the cognitive domain of taxonomy is extremely helpful. It relies on a detailed and seemingly complete set of mental processes to be included in the identification of learning outcomes, includes a standard vocabulary for the description and classification of learning outcomes, and acts as a reference for the determination of learning outcomes in terms of individual student activities (Gronlund, 1977).

3. Defining the learning outcomes in terms of specific and observable behavior.

Gronlund (1977) stated that in test preparation, the learning results to be evaluated by a test are most helpful when they are indicated as measurable terminal behavior. That is, they should specifically reflect the performance of the individual to be seen at the end of the learning experience. First, the learning outcomes should be defined as general learning outcomes, and then, before being used for test planning, they should be defined further in terms of specific student behaviors. The general learning outcomes for the instructional content were identified as follows:

(1) At the end of the video instruction, learners will know the name and definitions of artificial intelligence, its concepts and application areas.

(2) At the end of the video instruction, the learner will know the specifications and differences about artificial intelligence, its concepts and application areas.

After defining the general outcomes, the specific learning outcomes were defined. According to Gronlund (1977), after a sufficient list of general learning outcomes has been identified and explicitly stated, the next step is to list the specific student activities to be recognized as proof that the findings have been

reached. The specific learning outcomes were defined under each general learning outcomes (They will be present under Table of Specifications title).

4. Outlining the subject matter to be measured by the test.

The subject matter used in the instructional video was Artificial Intelligence and Related Concepts. The content was outlined in this step to make sure that the learning outcomes (both general and specific) match with the subject matter.

5. Preparing a table of specifications

The table of specifications can be thought as a blueprint that can be basis for preparing tests and it also specifies the number of the items in the test. The table of specifications that was prepared for the recall test as follows.

Table 1

Table of Specifications as Basis of Recall Test

General Learning Outcome	Specific Learning Outcome At the end of the video instruction, learner will be able to	Lower Levels −Knowledge −Recall −Identification Number of Questions/Question Type
1. At the end of the video instruction, learners will know the name and definitions of artificial− intelligence, its concepts and application areas.	recall the appropriate definition of the machine learning category without an error.	2 Multiple−choice Questions

	recognize the definition of the deep learning without an error.	1 Multiple-choice Questions
	Identify the definition of artificial neural networks types without an error	2 Multiple-choice Questions
2. At the end of the video instruction, the learner will know the specifications and differences about artificial intelligence, its concepts and application areas.	select the correct specifications of data science without an error.	1 Multiple-choice Question
	identify the specifications of the categories of machine learning.	1 Multiple-choice Question
	select the correct specification of machine learning without an error.	1 Multiple-choice Question
	name the steps in the process of how convolutional neural networks work without an error.	1 Multiple-choice Question

In the table of specifications (Table 1), instead of listing all the learning outcomes related to instructional video, the learning outcomes that are related to parts where the information was complicated to process through narration were listed only. Since the aim of the recall test is measuring the effect of using on-screen text without narration when the information is complicated, the test includes the questions related to the parts where the incoming information is difficult.

6. Matching questions to the specific learning outcomes.

As a last step in the process of preparing the test, the specific learning outcomes were matched to the multiple-choice questions (See Appendix 3). Based on the specific learning outcomes, the questions were prepared by referring to the various artificial intelligence online resources. After researcher prepared questions by matching them to learning outcomes, an expert evaluated the output and gave feedbacks according to the checklist recommended by Gronlund (1977). (See Appendix 4)

- Implementation of the Recall Test

After reflecting feedbacks, the researcher finalized the recall test. The recall test included 9 multiple choice questions with 4 options. According to the feedback in pilot study, the "I do not know" option was added as a fifth option to prevent the chance of choosing the correct answer randomly. One excerpt from the specific learning outcome-question matching is presented below.

General Outcome: At the end of the video instruction, learners will know the name and definitions of artificial intelligence, its concepts and application areas.

Specific Learning Outcome: recalls the appropriate definition of the machine learning category without an error.

Question 1:

It finds qualifications according to the patterns and relationships in the provided data and creates clusters according to these qualifications.

Which one of the following is the machine learning category that is defined above?

A. Supervised Machine Learning

B. Semi-supervised Machine Learning

C. Unsupervised Machine Learning *

D. Reinforcement Machine Learning

Question 2: Which one of the following is NOT TRUE for the definition of Supervised Machine Learning?

A. It builds algorithm with a set of rules and constraints.*

B. It is used for classifying the provided data.

C. The more data provided, the more accurate it becomes.

D. It is trained on human-labeled data.

Figure 7 An excerpt from question-learning outcome matching process

The test was implemented after the instructional video was watched. There was no time limit for the test, and it was implemented as an online test. The test was given after the participant finished the instructional video. Re-watching the video or using any other resources were not allowed during the test.

3. Participants

The participants were recruited from university students. There were thirty students in control group and thirty students in experiment group (n=60, Male=26, Female=34). Before starting to the experiment, the participants were informed about the process of the study and they were reminded the rules. Each participant received the video content that is about the Artificial Intelligence and related concepts individually. They were assigned to the control group (NO) and treatment group (NT) randomly.

- Summary of the Treatment Procedure

The process for the study as follows. First, to identify if there is an issue with the tests or instructional video that threats the validity of the content, or reliability of test, a pilot test was applied before the main treatment. Feedbacks related to content, instructional video design, tests and so on were received in this step. After identifying the issues by the help of the feedbacks, the instruments and instructional video were modified accordingly. The experiment was conducted both online and offline. Firstly, the researcher informed the participants about the study. During the online experiment, participants were asked to share their screen so that researcher could see what they are doing. The link for the

recall test was shared afterwards. During the offline experiments on the other hand, headphones or laptop were provided to the participants who needed them. To make sure that participants were watching video without skipping and answering questions without taking any kind of help, the process was done with the supervision. The total learning time was limited to 30 minutes. After watching the video, the participants took the recall test on the computer. There was no time limit for test.

Before conducting statistics, the data collected were coded. The right answers for each question were coded as '1' point and the wrong answers were coded as '0' point. The overall scores of every participant in the control and experiment groups were calculated and then analyzed afterwards by using inferential statistics.

4. Data Analysis

The data were collected and analyzed to produce responses to the research question posed in chapter II.

Research Question

When learners are presented with visuals accompanied by printed – text or audio instruction depending on content difficulty, does it affect their performance on

recall test compare to those learners who are instructed with visuals and audio instruction only?

Although the empirical support for modality principle and modality effect have been shown high by research studies (e.g., Carney & Levin, 2002; Mayer, 2014; Neto, Huang, & Melli, 2015; van den Broek, Segers, & Verhoeven, 2014), and generally beneficial influence of modality principle has been thoroughly explored (e.g., Mayer,2017), the effect of modality principle may be limited to certain conditions. Some of these conditions found by researchers are the type of pace(that is, self or system) in learning, the language (that is, native or foreign) of the content, learners' prior knowledge, lengthy verbal segments, familiarity of the content, and so on (Brunken, Plass & Leutner,2004; Clark & Mayer, 2016; de Westelinck, Valcke, de Craene, & Kirschner, 2005; Ginns 2005; Inan, Crooks, Cheon, Ari, Flores, Kurucay & Paniukov, 2015; Mayer,2014; Schuler, Scheiter, & Gerjets, 2013). One of the mentioned conditions is difficulty of the information. When studying relatively complicated topics, modality effect may not appear and on-screen text may be more beneficial (Clark & Mayer, 2016; Kalyuga et al.,1999; Mayer,2014). That is why if complicated information is provided, then the words should stay as printed text to prevent cognitive load in working

memory (Inan et al., 2013).

By considering these results, current study aimed to find out the effect of using printed-text and narration along with visuals depending on difficulty of content and to investigate how it affects learning performance of learners on recall test. By conducting this study and collecting related data, this study can be one of the base studies related to modality principle. By using effectiveness of modality principle on multimedia learning, this study explored the effects of one of the untested circumstances of modality principle. This study's collected data and analysis could either show a significant increase in recall when text is provided if the information is difficult, or the results could show that there is no significant difference between the group which was provided narration and the group which was provided narration and text in the same instructional video material.

The data collected and the analysis conducted in this study can contribute to the expanding research field related to modality principle by providing common language. It contributes to the research field by comparing number of studies' results regarding to modality principle and employing them to explore the effect of a new circumstance that has almost no data in the literature. It is also significant

to mention that the current literature on the modality principle is inadequate. The further study for the implications of the modality principle has been gaining importance with the continual increase in technology in the field of education and specifically e-learning (Duffin,2020) in order to ensure that the best practices are being placed into the e-learning materials and contents.

4.1. Use of Prior Knowledge Questionnaire

In this study, prior knowledge questionnaire was used merely to eliminate the learners who are already familiar with the related content. The topic of the instructional video material was Artificial Intelligence and Related Concepts. Both of the prepared videos included identical content and visuals. The content consisted of the definition of the artificial intelligence, types of artificial intelligence, the relationship between data science and artificial intelligence, definition of machine learning, categories of machine learning, definition of deep learning and the types of neural networks. That is why participants were asked if they had prior knowledge related to these contents through prior knowledge questionnaire.

Since this study aimed to test a specific condition, the condition where the participant already has prior knowledge related to the content and can answer the recall test might

threat the validity of the results. According to Shapiro (2004), prior knowledge related to the experiment's content may affect the results drastically. Without considering the prior knowledge of the participants, it is not possible to know if the prior knowledge is masking the study or affecting the way that learners interact with the questions. Therefore, ignoring the participants' prior knowledge diminishes the potential of deeper understanding of the study and results. That is why it was ensured that the participants did not have prior knowledge related to content by before conducting the study, the participants were asked to complete the questionnaire. After reviewing the result of the questionnaire, it was decided whether the participant will be included to the experiment or not. This step was completed while inviting participants for the experiment.

4.2. Recall Test Analyses

A recall test was employed in this study. The recall test aimed to assess how much content the participant will remember from the multimedia content specifically the parts that the information was complicated. The test had nine questions and each question had four options and one correct answer. Each correctly solved question was awarded one point, and the maximum possible point was nine points.

There are several methods for analysis of multiple-choice test items. One of those methods is the item analysis which refers to the process where learner responses to the individual test items and those answers are examined in order to assess the quality of the items and the test as a whole. The difficulty (p) and the discrimination (r) indices of the items are calculated in this type of analysis (Ozcelik,1989). Although the questions were obtained from different sources such as Massive Open Online Courses (MOOCs), the item analysis was still conducted to ensure the test is working well before getting results from the data analysis. As it was mentioned by Kocdar, Karadag and Sahin (2016), item analysis contributes the validity and reliability of the tests by showing whether the items are measuring what they supposed to measure or not. While item difficulty refers to the percentage of learners who answered an item correctly, the discrimination index of an item means ability to distinguish high and low scoring learners (Kocdar et al.,2016). Recall test results of narration text and narration only groups were used to conduct the item analysis.

When completing a study, it is important to verify the reliability of the study. Reliability means the consistency of a measure. The consistency of scores was checked by using Kuder and Richardson Formula 20(KR20). KR20 can be used

to check the internal consistency(reliability) of measurements with dichotomous choices i.e., correct versus incorrect. A correct question is scored as 1 and incorrect question is scored as 0. It measures whether responses are consistent across test items or not and the value of reliability should be at least .70 to be referred as good reliability (Heyliger & Hudson, 2016).

After conducting item and reliability analyses, further analysis was conducted. Before conducting independent samples t-test, it was checked whether the data is normally distributed. The recall test results of narration only and narration text groups were used to find the skewness and kurtosis values. After that, independent samples t-test was conducted by using narration only and narration text group's multimedia material as independent variable and recall test score as dependent variable. IBM SPSS was used to conduct t-test. The results of the analyses will be presented under the IV. Results chapter.

IV. RESULTS

1. Prior Knowledge Questionnaire

The prior knowledge questionnaire was sent to seventy-two applicants who wanted to participate the study. After reviewing the result of the questionnaire, it was decided whether the participant will be included to the experiment or not. This step was completed while inviting participants for the experiment. Among seventy-two applicants who wanted to participate the study, twelve of them had prior knowledge related to at least one specific learning outcome of the study. These twelve participants were eliminated so they were not included in the experiment process.

2. Recall Test Analyses Results

First the item analysis was conducted. Item difficulty and discrimination index were calculated under this analysis. While item difficulty refers to the percentage of learners who answered an item correctly, the discrimination index of an item means ability to distinguish high and low scoring learners (Kocdar et al.,2016). If the test has difficulty between .30 and .70 then, it can be said that the test is moderately difficult (Bichi,2016).

In this study, the difficulty of the test results is .47 (p=.47)

which can be interpreted as moderate difficulty. According to Heyliger and Hudson (2016), while tests that are too easy may cause unrealistic scores, tests that are too hard can cause decrease in scores. That is why both extremes may lead to inaccurate measurements. Hence, it can be said that the recall test in this study has an acceptable difficulty.

The discrimination index on the other hand, is a basic consideration when evaluating a test item is the degree to which the item discriminates between high test scorers and low test-scorers. In short, it means how much the test can discriminate the participants who know and do not know the content. Although there are several methods to assign high and low test-scorers, one of the most used methods is based on Kelley's (1939) derivation. The upper and lower 27% rule is commonly used in item analysis and the discrimination index can be calculated by using the difference between correct responses as a percentage of the upper 27% and lower 27% of the total group. This study employed this rule to find discrimination index of the recall test. According to Bichi (2016), tests that have .40 discrimination index can be referred as functioning in excellent level while Heyliger and Hudson (2016) states that to be defined as excellent discriminator, the test should have more than .50

discrimination index. The discrimination index of the recall test was found .63(*D*=.63) in this study so it means that the test has a high-level discrimination.

After measuring the validity of the recall test results, reliability of the results was measured. It was measured by using Kuder and Richardson Formula 20(KR20). The reliability index of the recall test in this study was .71 and it indicates that the test has good reliability and enough consistency according to KR20.

3. Independent Samples T-test Results

Before conducting independent samples t-test, the normal distribution was analyzed. A skewness ranged from -.55(NO Group) to .75(NT Group) was well below suggested level of the absolute value of 2.0. In addition, a kurtosis ranged from -.76(NT Group) to -.41(NO Group) showed that the variables are not peaked overly and below the absolute value of 9.0 as suggested by Schmider, Ziegler, Danay, Beyer and Buhner (2010). Therefore, the values revealed that the normal distribution can be assumed for the further analysis.

Independent samples t-test was conducted to compare recall test results for narration only (NO) and narration-text groups' participants. It was hypothesized that there will be a

significant difference between the control group that was provided narration only instructional video and the experiment group that was provided narration and on-screen text regarding to the content difficulty.

Table 2

Mean Differences between the Groups for RT

Measure	Narration Only Group (NO) (n = 30)		Narration Text Group (NT) (n = 30)		t	p	d
	M	SD	M	SD			
Recall Test Score	2.37	1.48	6.03	1.83	8.55	<.05*	.80

*$p < 0.05$

According to independent samples t-test results, there was significant difference in the recall test scores Narration Text Group (M= 6.03, SD = 1.83) and Narration Only Group (M = 2.37 , SD = 1.47) , t = 8.55, p < .05. Further, Cohen's effect size (d = 0.80) suggested a high practical significance.

These results suggest that there is significant difference between Narration Only and Narration Text groups in favor of Narration Text group.

4. Summary

The overall results of this study investigated the effect of using on-screen text instead of narration when the incoming

information is difficult in multimedia material. It was found that participants' recall test scores were significantly higher when the on-screen was used instead of narration depending on content difficulty than when the narration was used only.

The prior knowledge questionnaire was used to eliminate the participants who have prior knowledge related to instructional video content. This step was included to study to make sure the participants answer the questions by recalling the information that they learned from the video material. Moreover, eliminating the participants who have prior knowledge was important for the validation and reliability of the results. The next step was including the participants who had no prior knowledge to the treatment step. The participants were assigned either narration only or narration text groups randomly. They were presented a video material related to Artificial Intelligence and Related Concepts. Each participant was given the video material individually. The watching video and completion of the test were done with supervision to make sure that participants were answering the questions without taking any kind of help.

To make sure the test results are valid and reliable, several analyses were conducted. After being sure that the recall test results have an enough validity and reliability to be used as

assessment method for the study, the independent samples t-test was conducted, and the results were analyzed accordingly.

Significant difference in the recall test scores was found in favor of NT (narration text) group. Moreover, Cohen's effect size suggested a high practical significance as well. All in all, these statistical results showed that providing on-screen text instead of narration in multimedia material when the information is difficult is more effective on recalling the information than providing the narration only.

V. DISCUSSIONS AND CONCLUSION

The aim of this study was to examine the modality effect in a specific circumstance. This study investigated which condition offers more beneficial outcomes through recall test whether the multimedia material prepared using narration or on-screen text depending on the content difficulty or the one prepared using narration only. The multimedia prepared for this study was a video material about Artificial Intelligence and Related Concepts and the participants were university students.

The findings of this study showed that the group watching the video that has on-screen text when the information is difficult (NT group) performed better on the recall test than the group watching the video that has narration regardless of the difficulty of the content. By identifying the significant mean difference between the groups (NT and NO), the study was able to confirm that it is more effective on recall of information if the multimedia material is prepared by using narration and text depending on content difficulty. This finding is consistent with the number of other studies in the literature.

There are many studies that proved the modality principle is effective for learning and it should be considered while preparing the multimedia materials. It was also confirmed that the modality effect may be limited to certain conditions, i.e., boundary

conditions, and these conditions can decrease the effect of the modality principle. One of the conditions that were mentioned by several researchers and included in the scope of this study is the content difficulty. A decrease in the effect of modality can be observed if the relatively complex topics are being studied (Clark & Mayer, 2016; Mayer,2014). Moreover, there were other studies that suggested using on-screen text instead of narration if the information is difficult to process through the auditory channel (Clark & Mayer, 2011; Inan et al.,2015; Leahy & Sweller, 2011).

Based on these results and suggestions, this study took the circumstance where the incoming information is difficult and combined the use of on-screen text and narration depending on the content difficulty. This means this study used narration and on-screen text in one multimedia material(video) by considering the difficulty of the information and compared the results with the group that watched the multimedia material with narration only.

The videos in both groups were self-paced and about the same length. The participants had no prior knowledge related to the video content in both groups and they were given 30 minutes to finish watching video. These conditions were provided the same to both groups since merely the effect of using narration text and

narration only were aimed to be explored. The results in the literature can be used to explain why NT group scored better than NO group on recall test. When the participants in NO group had to watch all content by only listening, they had to listen not only definition of the concepts but also, the ways to distinguish those concepts (e.g., differentiating deep learning from other concepts) and the processes in those concepts (e.g., the process in neural networks) and, so on. Mayer (2014) suggested that narrations that have difficult content may overload the working memory and trying to remember them can eliminate the modality effect. That is why narration only group was not likely to get benefits of dual-modality form.

On the other hand, whenever the difficult information is presented, it was presented as on-screen text in NT group's video. Although the content and visuals were the identical with narration only (NO) group, they had a chance to see the content when it is difficult to process by only listening to it, as on-screen text. Because of transient nature of narration (Sweller, 2011), providing on-screen text was more effective so the results of narration text groups were better than narration only group.

Lastly, this study addressed an untested circumstance in literature. Addressing this circumstance. which is using on-screen text and narration in the same multimedia material

inconsistently, showed that it is important to conduct research related to modality principle under different conditions. By addressing each unique circumstance, it is possible to improve the literature and provide base results for the future studies. That is why by conducting this study, the studies that mentioned that the research related modality principle is limited, and it should be tested more under various conditions were addressed. (Oberfoell,2015; Mayer & Pilegard,2014; Pastore, Asino, & Briskin, 2019; Sandoval,2016; Stiller,2007)

1. Contributions of the Study

One contribution of this study is making additions to the literature. This study explored the effects of using narration and on-screen text depending on the content difficulty in e-learning. Unlike the previous studies that compared on-screen text and narration in literature, this study combined narration and on-screen text and use them in one multimedia material, and explored the effect on recall test. While the multimedia material was prepared by considering the modality principle, the parts where the incoming information is difficult were presented as on-screen text.

Although the literature has several studies stating that presenting difficult information by using narration is a boundary condition of modality principle, there was no attempt to use narration and on-screen text together to overcome this boundary condition. This study collected data and conducted an analysis for this specific circumstance and it also explored the effect of using on-screen text when the information is difficult.

The results are important for filling the gap related to the specific circumstance and creating a different point of view about modality principle. The results can be used to see how the result is when on-screen text and narration are used in

one material while putting on-screen text when the information is difficult. (Mayer & Pligard,2014; Oberfoell,2015; Pastore, Asino, & Briskin, 2019; Sandoval,2016; Stiller,2007). Current research in this area is limited so this study contributes to the growing research field of modality principle by addressing the circumstance that has not been tested before. The results require continued research to understand the best applications around the use of the modality principle.

Furthermore, the modality principle has provided effective strategies for instructional designers for over thirty years. These studies, which began in 1998, have shown that the utilization of the dual channels, auditory and visual, allows the instructional designer to provide free working memory space. This study contributed to the possible ways that can be used to prepare e-learning materials so the result of this study can be used by instructional designers or teachers as a reference or guidance.

2. Implications of the Study

The implications of the current study include recognizing that using narration and text in one multimedia material does not always affect the recall of knowledge in a negative way. As Mayer and Pilegard (2014) stated, instead of asking whether the modality principle is valid or not, a much more promising

direction is to explore under which conditions the modality effect occurs or does not occur. By using the results in the literature related to the use of on-screen text when the information is complicated and testing the circumstance where the narration and on-screen text are in the same multimedia material, this research found that the learners recall more information if they are provided the on-screen text when the information is difficult. By considering the right parts to put the on-screen text, this study showed that it is possible to assist learners with recall of the knowledge even though the on-screen text and narration are in the same material.

That is why instructional designers are required to stay on top of future research so that they may be able to provide the most beneficial practices for e-learning design. This also requires the instructional content that was prepared to utilize narration only and is still being implemented to be revised. The difficulty of the content should be assessed first and it should be supported by using on-screen text instead of narration in the material so that the intended impact of the e-learning content and how much the learners will remember can be enhanced. This also can impact the institutions, businesses, or companies that provide multimedia materials for e-learning. The content they used and how they present the information is

impacted as well. The modality principle needs further research to enhance the recall of information and provide more studies to be applied for a better e-learning experience.

3. Limitations and Future Directions

The first limitation is the participants. This study recruited participants from universities. That is why the participants included in this study were only university students. It may therefore be difficult to generalize the findings of this study to the other populations in different education levels. Moreover, the overall number of participants(N=60) further limits the ability to generalize results to the larger populations. That is why additional research should be conducted with both various educational level participants and including a larger number of participants.

The second limitation of this study is the method that difficult information in the content was decided. This study used an expert's opinion to decide the difficult information in the content. Although the expert has professional background related to Artificial Intelligence subject, it is still maybe a blind spot for expert the evaluate if the information is difficult or not. Future studies may get both professional and learners' opinions related to difficult parts in the content and prepare the multimedia material accordingly.

Another possible limitation is the fact that learners' prior knowledge was not used as a variable in this study. This study eliminated learners who have prior knowledge related to content of multimedia material by conducting a questionnaire. It was employed to make sure that learners remember the information from the video, not from their prior knowledge related to content. This can be a limitation to generalize the results of this study for the learners who have prior knowledge related to content. Future studies may focus on prior knowledge and examine if the result holds for learners who have prior knowledge as well.

Moreover, this study did not conduct a pre-test and post-test and analyze how learners' performances on tests change after the video instruction. That is why future studies may conduct pre-test and post-test and statistical analysis of the results.

Additionally, this study conducted a recall test to analyze how much learners remember after the video instruction since the scope of this study was to see how much they remember. However, this can be a limitation when generalizing the results of this study. The future studies should focus on conducting other types of tests that requires high order thinking such as analyzing, comparing, and contrasting, classifying, illustrating

and, so on (Anderson & Krathwohl, 2001).

Finally, this study was conducted as a one-time experiment by using 15 minutes video related to artificial intelligence and related concepts. Therefore, it has a limitation when it comes to generalizing the results since it was not tested in the long term such as a part of one class. Long-term studies should be conducted in future analysis to make better prediction effects of using on-screen text or narration in difficult e-learning contents.

Future studies should focus on the variables that can affect the results as well. By adding the variables such as learner characteristics, prior knowledge, learning time, the pace of the instruction and so on to the research, additional studies related to this research should be conducted.

4. Conclusions

E-learning, which had been considered computer - assisted learning, has been around since the 1960s but after the developments of the Internet and technology, it started gaining popularity. From that time to today's world, e-learning evolved rapidly in parallel with the development of Information and Communication Technologies, and its tools and methods have been advanced as well. It found its application in business,

military, education, and wherever it is needed.

Although it had a continuous development, the outbreak of COVID-19 increased the use of e-learning because of the sudden suspension of schools, colleges, universities, and other institutions (Soni,2020). In the beginning, the main focus of e-learning was the reliability and options of the technology that supports e-learning (Bezhovski & Poorani,2016) while nowadays, the usability of the platforms and the preparation of the materials are the main concerns. Because of the pandemic crisis that has caused a significant change in the shift of education, teachers and educators convert the materials that they used in traditional education to be used in e-learning platforms. That is why they are required to allocate extra time and find guidance while they are designing the materials to be used in e-learning platforms (Soni,2020).

It can be said that research regarding the modality principle and its implications is needed. Now that teachers and instructors have to design their course contents on online platforms, testing modality principle and recording their implications can help them while they are designing their course materials. Although e-learning can fulfill the demands of today's learners by providing the learning at their comfort and by providing various types of materials that compatible

with all devices (Colchester et al., 2017), the design of the materials is one of the important factors for the effectiveness of e-learning. By testing the modality principle in different circumstances and exploring its implications for the learners, it is possible to understand the modality principle more deeply and prepare effective e-learning instructions that include effective materials.

This study explored the effect of modality principle under one of the untested conditions, using narration and on-screen text depending on content difficulty, teachers or instructional designers can choose to refer to this study and design their contents accordingly. As this study did, more studies on the modality principle are needed. Additional studies can contribute to the existing research on modality principle and boundary conditions

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APPENDIX

Appendix 1: List of Feedbacks from Pilot Study

Appendix 2: Prior Knowledge Questionnaire Questions

Appendix 3: Specific Learning Outcomes and Multiple-Choice Questions Matching

Appendix 4: Checklist for Evaluating the Items

Appendix 5: Informed Consent Form

Appendix 1: List of Feedbacks from Pilot Study

Prior Knowledge Questionnaire

Explanation part does not have enough space to explain the content. → **Reflected.** Added more space

Instructional Video

- The transitions between screens are too fast. → **Reflected.** Added extra screens between transitions to make it slower
- The hand animation (in the video) is distracting → **Reflected.** The hand animation was removed.
- The transition effects between screen are too much. → **Reflected.** Removed the transition effect in several screens.

Recall Test

- The instructions in the questions are not clear. (If it is explanation or definition) → **Reflected.** Definition, process, and so on were added to each question stem as keywords.
- "I do not know" should be one of the options. → **Reflected.** I do not know added as option five to each question to prevent answering the questions if they do not know.

Appendix 2: Prior Knowledge Questionnaire Questions

Prior Knowledge Questionnaire

- This questionnaire is prepared by a Master's Degree student from Education Department in Seoul National University. The results of the survey will be merely used for research and the data collected will be used by the researcher only.
- This questionnaire is intended to determine what level of experience you had in artificial intelligence and related concepts. In case you don't know the answer, feel free to mark 'No'. Please don't use Internet or any other sources to answer these questions since the answers are important for research.
- If you feel any kind of pressure, you are free to not participate in this survey and the research as a participant.

Thank you for your time

Tuba UYANIK
Master’s Degree Student
Seoul National University

Personal Information

I. Please write your e-mail address.

II. What is your gender? Please choose one. (F/M/Prefer not saying)

III. What is your age?

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1. I can define what artifical intelligence is.

Yes() No()

If yes, please explain.

2. I can explain the types of artifical intelligence

Yes() No()

If yes, please explain.

3. I can define what machine learning is.

Yes() No()

If yes, please explain.

4. I can explain the categories of machine learning.

Yes() No()

If yes, please explain.

5. I can define what deep learning is.

Yes() No()

If yes, please explain.

6. I can explain the relationship between data science and artificial intelligence.

   Yes() No()

   If yes, please explain.

7. I can explain the types of neural networks

   Yes() No()

   If yes, please explain.

Appendix 3: Specific Learning Outcomes and Multiple-Choice Questions Matching (Recall Test)

TEST QUESTIONS

General Outcome: At the end of the video instruction, learners will know the name and definitions of artificial intelligence, its concepts and application areas.

Specific Learning Outcome: recalls the appropriate definition of the machine learning category without an error.

Question 1:

It finds qualifications according to the patterns and relationships in the provided data and creates clusters according to these qualifications.

Which one of the following is the machine learning category that is defined above?

A. Supervised Machine Learning

B. Semi-supervised Machine Learning

C. Unsupervised Machine Learning *

D. Reinforcement Machine Learning

Question 2: Which one of the following is NOT TRUE for the definition of Supervised Machine Learning?

A. It builds algorithm with a set of rules and constraints.*

B. It is used for classifying the provided data.

C. The more data provided, the more accurate it becomes.

D. It is trained on human-labeled data.

Specific Learner Outcome: recognize the definition of the deep learning without an error.

Definition: It is a subset of Artificial Intelligence and it enables AI systems to continuously learn on the job and improve the quality and accuracy of results. It enables systems to learn from unstructured data and it doesn't need human intervention to differentiate the given data.

Which one of the following is the AI technology that defined above?

A. Deep Learning *

B. Unsupervised Machine Learning

C. CNNs

D. Reinforcement Machine Learning

Specific Learner Outcome: identify the definition of artificial neural networks types without an error

Question 1

Which one of the following is NOT TRUE for Convolutional Neural Networks(CNNs)?

A. CNNs are commonly used in computer vision to recognize objects.

B. It can make use of information in long sequences.*

C. It creates more complex features from simple structures of data.

D. It transfers the data by using the filters and the several layers..

Question 2

Definition : It is a network that is spefically designed to interpret information and make better predictions by analyzing the context of the data.

Which one of the following is the AI technology that defined above?

A. CNN

B. ANN

C. RNN*

D. ML

General Learning Outcome: At the end of the video instruction, the learner will know the specifications and differences about artificial intelligence, its concepts and application areas.

Specific Learning Outcome: *select the correct specification of data science without an error*

Question: Which one of the following is NOT TRUE for Data Science?

A. It is an interdisciplinary field involving mathematics, data visualization and more.
B. It is the process and method for extracting knowledge from big amount of data.
C. Data Science can use various deep learning models or machine learning algorithms.
D. Artificial Intelligence is one of the subsets of the Data Science. *

Specific Learning Outcome: Identify the specifications of the categories of machine learning.

I. It cannot add labels to data, but it can differentiate the data.

II. It figures out how to achieve the goal by trying different combinations

III. It builds classification models according to the labelled data it gets.

Question: Which one is the following is correct representation of machine learning' s categories according to I, II, III?

A. Supervised Machine Learning– Reinforcement Machine Learning– Unsupervised Machine Learning

B. Supervised Machine Learning– Unsupervised Machine Learning– Reinforcement Machine Learning

C. Unsupervised Machine Learning– Reinforcement Machine Learning – Supervised Machine Learning*

D. Reinforcement Machine Learning– Unsupervised Machine Learning – Supervised Machine Learning

Specific Learning Outcome: select the correct specification of machine learning without an error.

Question: Which one of the following is NOT TRUE for the machine learning?

A. Machine learning is a subset of Artificial Intelligence.

B. Machine learning follows rule–based algorithms. *

C. Machine learning can be continuously trained.

D. Machine learning can be used to predict the data.

Specific Learning Outcome: Name the steps in the process of how

convolutional neural networks work without an error.

I. *The information is fed to a neuron in the _____ layer*

II. *The information is transferred from one layer with a value to another layer over _____ channels*

III. *All neurons have unique number associated with it; it is called as _____.*

IV. *The unique number of neurons then applied to a function which is called as_____ function and it determines if the neuron gets triggered or not.*

V. *The triggered neuron in the _____ layer corresponds to the entered information.*

From I. to V. is the process of how convolutional networks work. When you fill in the blanks, which one of the following is correct?

A. *Input – weighted– bias–activation–output**

B. *Neuron–bias–connected channels–activation–output*

C. *Input –activation– weighted–bias–output*

D. *Input– hidden–weighted–bias–output*

Appendix 4: Checklist for Evaluating the Items

	YES	NO (FEEDBACK)
Does each test item measure an important learning outcome included in the table of specifications?		
Is each item type appropriate for the particular learning outcome to be measured?		
Does each item present a clearly formulated task?		
Is the item stated in simple, clear language?		
Is the item free from extraneous clues?		
Is the difficulty of the item appropriate?		
Is each test item independent, and are the items, as a group, free from overlapping?		
Do the items to be included in the test provide adequate coverage of the table of specifications?		

Appendix 5. Informed Consent Form

I agree to participate to the study conducted by Tuba UYANIK at Seoul National University, Department of Education.

I hereby understand that the aim of this study to watch a provided video and have a test afterwards. I understand that I will be monitored during the study. I was explained the rules of the study and I understand them.

I understand that the participation to this study is voluntary and I can withdraw from the study if I feel any kind of discomfort during the session.

All information collected in the study is confidential, and my identification will not be exposed or shared at any time with anyone.

Please sign below to show that you have read and understand the information on this form.

Date: _____

Name: _____

Signature: _____

Thank you for your valuable time!

Tuba UYANIK

Department of Education

Seoul National University

국문초록

고난이도 이러닝 콘텐츠에서 텍스트 또는 내레이션 제시 효과

인터넷 및 통신 기술 (ICT)의 발달로 인해 교육의 추세와 방식이 수년에 걸쳐 변화해 왔다. 이러한 컴퓨터 기술, 인터넷 기술의 발전과 이를 사용할 수 있는 사람들의 수가 증가함에 따라 e- 러닝은 가장 인기있는 학습 매체 중 하나가 되었다. 전자학습-교육 목적으로 휴대폰, 태블릿, 노트북 및 기타 기술 도구와 같은 다양한 유형의 ICT를 사용하는 것으로 생각할 수 있으며 여러 학습 기술과 전략을 통합한다. e- 러닝은 교육에서 학습 경험을 풍부하게 하므로 교육에 긍정적인 영향을 미칠 수 있는 잠재력이 있다. 이러닝은 정보 사회의 발전과 함께 성장하고 있으며 이러한 발전에 따라 이러닝 콘텐츠가 전달되는 방식도 변화하고 있다. 또한 콘텐츠가 멀티미디어로 제공되는 경우 사람들은 순차적 방식이 아닌 텍스트, 그래픽 또는 오디오를 동

시에 제공함으로써 효과적인 학습 경험을 가능하게 하므로 학습에 더 많이 참여할 가능성이 높다.

멀티미디어는 교육 분야에서 고유 한 이점을 제공하지만 다른 학습 프로그램과 마찬가지로 멀티미디어 학습 설계는 효과를 위해 중요하다. 그렇기 때문에 멀티미디어 준비 원칙을 고려하는 것이 중요하다. 이러한 디자인 원칙 중 모달리티 원칙은 다른 멀티미디어 디자인 원칙보다 더 광범위하게 연구되었다. 모달리티 원칙은 그림과 구두 텍스트에서 학습하는 것이 그림과 화면 텍스트에서 학습하는 것보다 더 효과적임을 시사한다. 이 원칙의 경험적 지원이 높지만 그 효과는 특정 조건으로 제한된다. 그 중에서도 이 연구는 어려운 정보에 초점을 맞추었다. 즉, 학습자에서 정보가 복잡하다면 내레이션을 사용하는 것보다 화면 텍스트가 더 나은 선택이다는 제안을 고려하여 모달리티 원칙이 검증되지 않았던 상황인 한 멀티미디어 콘텐츠에서 화면상의 텍스트와 내레이션을 사용하는 효과를 검증하였다.

본 연구는 통제 및 실험 집단에서 파일럿 테스트, 사전 지식 설문지 및 회상 검사를 사용하였다. 60 명의 참가자는 사진들과 내레이션만 제시된 멀티메디아 콘텐츠를 학습할 집단(통제집단)과 또는 내레이션과 화면텍스트 제시된 멀티메디아 콘텐츠를 학습할 집단(실험집단)에 무작위로 배정되었다. 실험집단은 사진들과 함께 내레이션을 봤으나 정보가 어려운 부분에서 사진들과 함께 내레이션 대신 화면 텍스트로 학습하였다. 멀티미디어 콘텐츠인 교육 영상을 본 후 회상검사를 실시했습니다. 데이

터 수집 후 그룹의 평균 점수를 비교하기 위해 독립 샘플 t검증을 수행했습니다. 회상검사를 데이터 분석에 따르면, 통계 결과는 정보가 어려울 때 멀티미디어 자료에 내레이션 대신 화면 텍스트를 제공하는 것이 내레이션 만 제공하는 것보다 정보를 기억할 때에 더 효과적임을 보여주었다.

본 연구는 다음과 같은 점에서 의의가 있다. 첫째, 정보가 복잡할 때 화면상 활용을 모색함으로써 본 연구는 멀티미디어 자료 설계에 대한 연구 기반의 성장에 기여한다. 이 연구에서 얻은 결과는 교육 설계자가 참고 자료로 사용할 수 있으며 긍정적인 학습 결과에 기여할 수 있기 때문이다. 둘째, 모달리티 원리의 다양한 상황을 검증할 필요가 있기 때문에 본 연구는 문헌에 기여한다. 마지막으로, 정보가 복잡 할 때 나레이션 대신 텍스트를 사용하는 것에 대한 조사가 많지 않기 때문에 동기, 학습 인식 등 학습 외에 다른 변수를 검증하는 측면에서 향후 연구의 기초 연구가 될 수 있기 때문에 현재 연구가 중요합니다.

주요어 : 모달리티 원칙, 이러닝,e-러닝,멀티미디어 원칙, 전자학습

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