

The negative impact of media diversity on self-regulated learning strategies and cognitive load

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Quality of instruction within media-rich environments is an important aspect of the online learning process. Instructors need to avoid the presentation of confusing content caused by diverse forms of media, which can induce higher levels of extraneous processing and negatively affect germane cognitive load. Maintaining high levels of germane load is imperative for student success in e-learning, as germane load directly contributes to learning through the processing of relevant information. One approach that students may take to manage diverse forms of media is to regulate their effort, as past research has shown that high levels of effort not only positively contribute to learning, but also aid students in effectively overcoming distractions within the online learning environment. However, because extraneous processing caused by distracting media has such a negative influence on learning, it is hypothesised in this study that media diversity negatively moderates the relationship between self-regulated effort and germane load. This study analysed survey responses from a group of university students ($N = 2363$) who participated in online learning classes in South Korea and looked at the moderating effects of media diversity on the relationship between self-regulated effort and germane load. The results showed that as media diversity increased, the strength of the relationship between self-regulated effort and germane load decreased. A review of the extant research is provided along with analytical explanations as to why the results of this study show that self-regulated effort is not enough to overcome confusing content from media diversity.

Introduction

Instruction should be delivered in a way that effectively meets the needs of students, particularly within online learning environments, which have been linked to a lack of interest and loss of motivation among learners (Lee & Rha, 2009; Russo & Benson, 2005). Ineffective delivery of course content contributes to engagement issues and ultimately leads to confusion in e-learning environments (Lange & Costley, 2017; Gerjets & Scheiter, 2003; Kester, Kirschner, & van Merriënboer, 2005; Kizilcec, Bailenson, & Gomez, 2015; Mayer, 2014). To address such issues, instructors need to deliver content in a clear way that allows students to maintain their focus and process information relevant to the learning process. Instruction and the way it is delivered to learners within e-learning can be understood through cognitive load theory. Unclear and confusing content delivery results in high levels of extraneous load, which is caused by unnecessary processing of information that does not contribute to learning (De Jong, 2010; Leppink, Paas, van der Vleuten, van Gog & van Merriënboer, 2013; Sweller, van Merriënboer & Paas, 1998). Germane load, on the other hand, is promoted when students apply effort to processing relevant information that directly contributes to learning (Cierniak, Scheiter & Gerjets, 2009; Kolfschoten, Lukosch, Verbraeck, Valentin, & Vreede, 2010; Leppink et al., 2013;

Schmeck, Opfermann, van Gog, Paas & Leutner, 2015; Sweller et al., 1998). Furthermore, germane load levels are increased through a general enhancement of understanding and knowledge of the content being delivered (Leppink et al., 2013; Kolfschoten et al., 2010; Sweller et al., 1998). Within an academic setting, Leppink et al. (2013) specifically related germane load to the enhancement of knowledge through the understanding of concepts and definitions associated with course content. Within e-learning environments, the goal of instructors should be to present the content in ways that help students avoid extraneous load and increase germane load, as doing so ultimately promotes a positive learning experience.

The presentation of content through diverse forms of media can play a significant role in the way students process information. Media diversity is represented through visual media including illustrations, images, graphs, maps, animations, and words in the form of slides and rolling text (Costley & Lange, 2017b; Mayer, 2014). Although media diversity has been shown to be beneficial to the online learning environment (Costley & Lange, 2017b; Costley & Lange, 2017c), instructors need to present the content in a way that does not confuse the learners. Content delivery that occurs through diverse forms of media can leave learners more susceptible to extraneous processing, as learners can become distracted when their focus is placed on two or more forms of media simultaneously (Fanguy, Costley & Baldwin, 2017; Leppink et al., 2013; Kalyuga, Ayres, Chandler & Sweller, 2003; Kirschner, 2002; Sweller, 2005). This is particularly relevant when presenting textual content associated with pictorial content. Although the dual coding theory supports the presentation of verbal (text and speech) and nonverbal (graphics and animation) content in order to integrate separate representations in a way to make sense of it (Paivio, 1991; Schmidt-Weigand & Scheiter, 2011), care needs to be taken to avoid overloading the learners with extraneous information when doing so. Such distraction involving simultaneous presentation of textual and pictorial content can occur by processing redundant information or splitting one's attention between sources which ultimately confuses learners and diverts cognitive processing to information that does not contribute to germane load (Mayer, Heiser & Lonn, 2001; Mayer & Moreno, 1998).

The autonomous nature of online learning along with the cognitive demands associated with media diversity highlights the need for students to apply additional effort when dealing with unclear content in e-learning environments (Chandler & Sweller, 1991; Cunningham & Billingsley, 2003; Jung, 2001; Kalyuga et al., 2003; Mayer & Moreno, 2003; McManus, 2000). One way in which learners may be able to overcome confusing textual and pictorial content and enhance germane load levels is through specific self-regulated learning strategies implemented to deal with confusing content. Self-regulated learning occurs when students take charge of their learning through motivational techniques that help them accomplish their goals (Zimmerman, 2008). Such motivation allows them to be persistent when faced with challenging situations within the learning environment (Dabbagh & Kitsantas, 2012). Furthermore, self-regulated learners are generally able to avoid behaviours that may divert their attention from the learning process (Dabbagh & Kitsantas, 2012). The effort and determination that accompanies such strategies is generally seen as a key determinant of success within distance learning (Puzziferro, 2008; Shea & Bidjerano, 2012). Effort regulation strategies are reflective of such determination,

as students who self-regulate their effort maintain focus and persistence in order to finish what they planned to do, particularly when instruction may be difficult to understand (Pintrich, Smith, Garcia & McKeachie, 1991). Because self-regulated effort involves determination and persistence when faced with difficult situations within the learning environment, it is a point of interest to examine whether it is effective in dealing with distracting textual and pictorial content delivered simultaneously to online learners.

Theoretical background

Ways in which media diversity affects learning

Using various forms of media throughout a lecture affects the perception of content by learners, and can ultimately have positive effects on cognitive processing as well as the overall learning experience (Kalyuga et al., 2003; Mayer & Moreno, 2003; Mayer, 2014; Sweller, 1999; Sweller et al., 1998). The benefits of using multimedia can be explained through both the dual coding theory and the generative theory of multimedia. Pavio's (1991) dual coding theory states that the use of both cognitive channels (verbal and nonverbal) allows for more effective cognitive processing to take place. Similarly, the generative theory of multimedia (Mayer, 2014) states that learning takes place at a greater rate when both auditory and visual media are combined as students are able to make cognitive connections between the two formats. Empirical evidence supports such theory, as extant research shows the benefits of using diverse forms of media to enhance the learning experience. Within multimedia contexts, Clark and Paivio (1991) found that the integration of verbal and nonverbal forms of media lead to higher levels of learning, while Mayer and Anderson (1992) found that the addition of narration to visual media allows learners to retain more information. Specific to online learning contexts, Costley and Lange (2017a) found that diverse forms of media used over the course of an online lecture increase levels of germane load, while Kim et al. (2011) found that the multiple forms of media used throughout a semester increased students' levels of perceived learning. While such studies emphasise the benefits of diverse media, other studies point out that the inappropriate use of diverse media has a negative effect on learning.

When instruction involving media diversity fails to address the needs of the learners, a negative effect on learning can occur. Providing students with multimedia content that is irrelevant to learning, for example, has been shown to decrease levels of comprehension (Mayer, 2014). This is due to the fact that essential information processing that is required for learning may be overshadowed by unnecessary processing of irrelevant content. Such processing of irrelevant content can occur if graphical content used to complement textual content is ineffectively delivered. For example, Mautone and Mayer (2001) stated that when extraneous textual facts coincide with confusing graphical content, learning is negatively affected due to the processing of nonessential information. Additionally, providing redundant information through diverse forms of media such as text, images, or graphs further distracts learners who attempt to process the extraneous information (Mayer, Heiser & Lonn, 2001). This complicates the presentation of essential material by presenting it multiple times through various formats concurrently, creating cognitive overload for the learners (Mayer & Moreno, 2003). The split-attention effect further

contributes to distractions when diverse media is used (Mayor, 2014). This effect occurs when instructors present on-screen information from multiple sources that are physically separated from each other, i.e. textual information physically separated from the image or graph it is describing, which contributes to extraneous processing and negatively affects learning through lower levels of problem-solving transfer (Chandler & Sweller, 1991; Sweller, 1999; Mayer & Moreno, 1998; Mayer & Moreno, 2003; Moreno, et al., 2001).

Ways in which student effort affects learning

Students who self-regulate their learning believe that confronting challenging tasks and showing more effort in developing a deeper understanding of the material enhances learning in a way that creates success when dealing with difficult coursework (Perry, Phillips & Hutchinson, 2006). Additionally, those who show higher levels of effort through self-regulation typically hold themselves accountable for their learning outcomes, rather than blaming them on external situations (Zimmerman, 1990). Within e-learning specifically, self-regulated learners who take accountability for their learning rather than blaming any external factors have shown higher levels of achievement (Kosnina, 2007). Such effort and determination that accompanies self-regulated learning is generally seen as a key determinant of success in e-learning environments (Puzziferro, 2008; Saw, 2011; Shea & Bidjerano, 2012). Research supports this notion, as increased levels of effort used for planning in multimedia e-learning environments have been shown to lead to higher levels of learning (Moos, 2013; Moos & Azevedo, 2008a). Furthermore, online learners show higher achievement levels when they provide more motivational effort, monitor their performance, and make adjustments when needed (Moos & Azevedo, 2008b; Perry & Winne, 2006; Shih, Ingebritsen, Pleasants, Flickinger & Brown, 1998; van Gog, Kester & Paas, 2011; Winne, 2001). Further emphasising the importance of effort within e-learning, self-regulated effort strategies have had a positive impact on achievement among university students taking online courses (Lange & Costley, 2018; Puzziferro, 2008).

In addition to simply being linked to learning, student effort has specifically been linked to overcome challenging aspects of instruction in order to promote higher levels of learning. Gerjets, Scheiter and Tack (2000) showed that when challenging instruction was presented to students through the reduction of learning time, those that showed effort through learner control processing strategies were able to overcome such instruction to a point where learning was not negatively affected. Effort used to supplement the lack of specific instructional elements within online environments has also been shown to be beneficial to learning. For example, students who use effort to construct mental images of content to compensate for lack of representational images accompanying expository text have shown increased levels of reading comprehension and ultimately learning within an online learning environment (Leutner, Leopold & Sumfleth, 2009). Additionally, students who apply more effort can overcome the lack of instructional feedback, as Moos (2011) showed that students who received no feedback were able to outperform a group of students who did, due to the fact that they showed higher levels of effort through self-monitoring strategies.

The role of media diversity in the relationship between effort and learning

Because self-regulated effort refers to how committed and dedicated students are when it comes to dealing with particular instructional tasks that may be perceived as difficult (Duncan & McKeachie, 2005; Pintrich, et al., 1991), it would make sense that such commitment and dedication may be useful when dealing with unclear instruction delivered with diverse media. Through previous research, it is known that self-regulated learners adopt strategies that enable higher levels of achievement when faced with cognitive demands brought on by inadequate study conditions and distractions within the environment (Gerjets, et al., 2000; Joo, Bong & Choi, 2000; Komarraju & Nadler, 2013; Leutner & Sumfleth, 2009; Moos, 2011; Lane & Lane, 2001; Linnenbrink & Pintrich, 2002; Lynch & Dembo, 2004; Saw, 2011; Wang & Newlin 2002; Zimmerman, 1990). However, it is a point of interest to find out if effort can overcome inadequate conditions and confusion brought on specifically by media diversity.

One contributing factor that may affect the ability of self-regulated learners to overcome cognitive load brought on by media diversity is their use of self-regulation strategies. According to cognitive load theory, distractions from media diversity can create cognitive demands on the learners, as effort is directed towards processing information that is unnecessary for learning (Leppink, et al., 2013; Kalyuga, et al., 2003; Kirschner, 2002; Sweller, 2005). Additionally, the effort involved in self-regulation used to overcome distractions in the learning environment is accompanied by further cognitive demands (Saw, 2011; Zimmerman, 2008). Because distractions created by some forms of media diversity may, according to cognitive load theory, create effort directed toward information that is irrelevant to learning, effort regulation may compound the adverse effects of such distractions. It is therefore a point of interest to look at the relationship between self-regulated effort and germane load when high levels of media diversity are present. Investigating connections between effort involved in self-regulation, and learning when presented with diverse forms of media, Scheiter, Schubert and Schüler (2017) showed that within multimedia learning environments, self-regulated learners contribute to deeper processing of images and text.

It has also been shown that motivation may not always be enough to overcome the negative effects of extraneous processing created by extraneous media diversity. For example, Lange, Costley and Han (2017) found that high levels of self-regulated effort were not enough to overcome instruction that imposed high levels of extraneous load. Although media diversity was not directly linked to the high levels of extraneous load in their study, Fanguy, Costley & Baldwin (2017) posited that confusing instruction brought about through multiple representations of content through diverse forms of media may have played a role in the results. Research that directly links extraneous load to diverse media shows that effort cannot overcome diverse media that distracts the learner from separated sources involving images and text. Specifically, it has been shown that effort exerted through self-explanation strategies is less effective for learning when such effort is directed towards visual and textual information physically separated from each other within online learning lectures (Renkl, 2014; Tarmizi & Sweller, 1988).

The current study

Because online learners are faced with challenging situations where unclear content is presented through media-rich environments, it is worth investigating whether self-regulation is an effective technique in dealing with such challenges. Within e-learning, presentation of diverse media that is extraneous, irrelevant, or redundant has been shown to negatively affect learning (Mautone & Mayer, 2001; Mayer, 2014; Mayer & Moreno, 2003; Mayer, et al., 2001). On the other hand, the use of self-regulated learning strategies has been shown to contribute to the learning experience, as students who provide effort through such strategies have been more successful, and have overcome distractions within e-learning environments to show higher levels of performance (Kosnina, 2007; Lane & Lane, 2001; Lynch & Dembo, 2004; Joo, Bong & Choi, 2000; Puzziferro, 2008; Saw, 2011; van Gog, et al., 2011; Wang & Newlin 2002). Additionally, some studies have shown that effort is effective in learning when media diversity creates distractions within the learning environment (Scheiter, et al., 2017), while other studies have shown that effort regulation strategies are not enough to overcome such distractions (Renkl, 2014; Tarmizi & Sweller, 1988). Using self-regulated effort as a representation of motivational effort, and germane load as a representation of learning, this study looked at various relationships within an e-learning environment in South Korea. These include the relationship between media diversity and germane load, and the relationship between self-regulated effort and germane load. The main aspect of this study is to look at the moderating effect of media diversity on the relationship between self-regulated effort and germane load.

Research hypotheses

Due to extant research claiming that media diversity and self-regulation are beneficial for the learning process, the first two hypotheses state the following:

1. Media diversity is positively correlated with germane load.
2. Self-regulated effort is positively correlated with germane load.

The main hypothesis focuses on a moderating effect of media diversity on the relationship between self-regulated effort and germane load. Due to the negative influence that distractions associated with media diversity have been shown to have on the learning process, it is hypothesised that self-regulation cannot overcome these challenges. The main hypothesis is stated as follows:

3. Media diversity moderates the relationship between self-regulated effort and germane load.

Methods

Study context

Students who were taking classes at the Open Cyber University (OCU) in South Korea were asked to participate in this study. The OCU was founded in 1997, with classes

beginning there in 1998 (Jung & Rha, 2001). There is a network of 23 traditional brick-and-mortar universities that are called the “consortium”, who are tasked with the funding and management of the OCU. The main reason that the OCU was set up was to create an online learning environment that would provide credit classes for students who were taking traditional offline classes at the OCU’s member universities. This aside, the OCU also provides non-credit courses for students who are not enrolled at any of the member universities (Jung, 2000).

Students who wish to take classes at the OCU are only required to pay if they are not enrolled at one of the member universities. The OCU is the largest online consortium in South Korea, providing more classes to more students than any other online learning provider. The OCU runs approximately 400 classes each year for approximately 120,000 students (About OCU, n.d.). Most OCU classes are fully online, though a few offline meetings are held to give an opportunity to those not enrolled at an offline university to have face-to-face interaction with other students. Also, it has been noted that most OCU classes do not have a great deal of student-to-student interaction online (Jung & Rha, 2001).

Direction for the OCU is provided by the member universities who also provide the design, content, and professors for the classes. A group of delegates selected from the member universities form a council tasked with the mission to guide policy and pedagogy in the OCU (Jung & Rha, 2001). Also, to help improve instruction and administer the OCU, a team of instructional designers and programmers help the instructors run the classes. Furthermore, all aspects of the OCU are overseen and course quality is evaluated by an evaluation team (About OCU, n.d.).

Research procedures and data collection

The research reported here began in January 2016 with a set of qualitative interviews to obtain a broad overview of the OCU and how it operates. These interviews were followed by a small scale survey ($N = 86$) to gain an overview of how students perceived their learning environment. This survey is outlined in more detail in Costley (2017e). Both these steps, the interviews and small-scale survey, gave a good overall picture about student to student interactions, but also showed that learning was mostly centred upon video lectures. For this reason, following the interviews and a small survey, two large ($N = 1500+$) surveys focused on video lessons were conducted in 2016. The data used in the current study was from a third larger survey that conducted from May to June 2017.

Items were first written in English then translated into Korean, which is the language of the OCU. An expert in both the OCU and online learning examined the items to verify both their accuracy as representations of the English items and their appropriateness for the OCU. The items were then put into a *Google Sheets* (Google, n.d.) form and a link was given to the OCU’s administration. The OCU administration then assessed that the survey was acceptable to be given to their students and the link was put on the main student noticeboard of the OCU with an invitation for students to participate in the research.

Participants

OCU students who wished to take part in this research answered questions on a *Google Sheets* (Google, n.d.) survey from a link that could be found on the student noticeboard. There were 2422 students who were invited to participate by submitting surveys. The link was active from 25 May 2017 to 25 June 2017 after which the link was dead and the data file was downloaded for analysis. A total of 2422 surveys were submitted; however, some surveys (38) were substantially incomplete, with some having none of the cells filled out. The removal of these left 2384 valid and complete surveys. The next step was checking for outliers using Cook and Mahalanobis' leverage values as described in Yuan and Zhong (2008). This was done in reference to the three main constructs used in this research. This study considered that the failure of any two of these tests would result in the case being removed as an outlier. According to this standard, 21 cases were removed as outliers, leaving 2363 cases to be used for the analysis that attempts to answer the research questions that are a part of this study. There were no shared traits among the outliers, and all following tables and figures in this paper are generated from the 2363 cases that were complete and not outliers. The following results and tables subsequent to this are generated from these 2363 remaining subjects. Of the remaining 2363 subjects, 1228 (52%) were female and 1135 (48%) were male. The oldest participant was 54 and the youngest was 18; the average age was 23.7, with a standard deviation of 3.7. The gender and age distribution of subjects in this research is similar to other research into e-learning environments in South Korea (Suh & Kim, 2013) and the OCU specifically (Costley & Lange, 2018). Students who took part in this research took a variety of classes. There are several sub disciplines that the OCU recognises and students who participated in this study took a range of which may be categorised as follows: social sciences (30%), lifestyle and health (27%), humanities (10%), business and management (10%), foreign language (6%), mathematics (6%), natural science (6%), and computers and information technology (5%). The distribution of subject areas is similar to the general distribution found in the OCU (Lange, 2018).

Instrument development

To develop the germane load measurement, items from Leppink et al.'s (2013) *The development of an instrument for measuring cognitive load* was used. Leppink et al.'s (2013) paper gives descriptions of the three main types of cognitive load (intrinsic, extraneous, and germane) and a method to measure them in a survey. A total of four items were used in the present study for germane load. The items used for the germane load construct were: *The lecture really enhanced my understanding of the topic; the lecture really enhanced my knowledge and understanding of the class subject; the lecture really enhanced my understanding of the concepts associated with the class subject; the lecture really enhanced my understanding of concepts and definitions.* There was a small change between the present research and Leppink et al.'s (2013) study, which was the word "activity" being replaced with the word "lecture". The Cronbach's alpha for the germane load construct was .955, which was high enough to be used in this type of research.

To generate the self-regulated effort construct, items from the *Motivated Strategies for Learning Questionnaire* (MSLQ) were adapted for use. The MSLQ (Pintrich et al. 1991) is designed to test varied aspects of a student's use of learning strategies and motivational orientations. The aspect of the MSLQ used in this study, self-regulated effort, is made up of four items: *I often lose focus when I study so I quit before I finish what I planned to do (reversed); I work to do well at school even if I get confused; when coursework is unclear, I give up or only study the easy parts (reversed); even when study materials are complex, I manage to keep working until I finish.* The Cronbach's alpha for self-regulated effort was .770, which though lower than the germane load construct, is still appropriate for this type of research, and higher than what Pintrich et al. (1991) found in their original study.

To measure diversity, three items were used. These items were designed so as to reflect how information that was presented visually to students might impair their ability to comprehend the contents. These items were based around comments made by students in Fanguy, Costley & Baldwin (2017), in which changing the professor in mid-lecture caused a lack of focus, and lowered student memory retention. The students' comments and results showed that elements of visual diversity would lead to lower levels of learning which contradicts the results of Costley and Lange (2017b). They were as follows: (1) *It was difficult for me to relate textual and pictorial information to each other;* (2) *The illustration distracted me from textual information;* and (3) *The textual information distracted me from the illustration.* The Cronbach's alpha for this construct was .877, which is high enough for research of this type. All items in the survey used a Likert scale ranging from 1 to 5. All items used in the survey can be seen in Appendix 1.

Results

Table 1 shows the means, standard deviations, and Pearson correlation coefficients of the main variables used in this study. This table shows that diversity is negatively and significantly related to self-regulated effort ($\rho = -.436, p < .01$). Diversity was also negatively and significantly correlated with germane load ($\rho = -.460, p = < .01$). Finally, self-regulated effort was positively and significantly related with germane load ($\rho = .522, p = <.01$). The mean for self-regulated effort was 4.91, with a standard deviation of 1.25.

Table 1: Descriptive statistics and Pearson correlation coefficients of the main variables (N = 2363)

	Mean	Std dev.	Self-regulated effort	Diversity	Germane load
Self-regulated effort	4.91	1.25	1		
Diversity	3.12	1.37	-.436**	1	
Germane load	4.86	1.31	.522**	-.460**	1

** Correlation is significant at the 0.01 level

The mean for germane load was 4.86, with a standard deviation of 1.31. Diversity was significantly lower than both self-regulated effort and germane load with a mean of 3.12, and a standard deviation of 1.37.

Linear regression was used to measure both diversity and self-regulated effort's relationship with germane load. The overall model had strong predictive power in relation to germane load ($r^2 = .586$). Furthermore, each 1 unit increase in the diversity scale lead to a .26 ($p = <.001$) decrease in germane load. Also, for every 1 unit increase in self-regulated effort there was a .41 ($p = <.001$) increase in germane load.

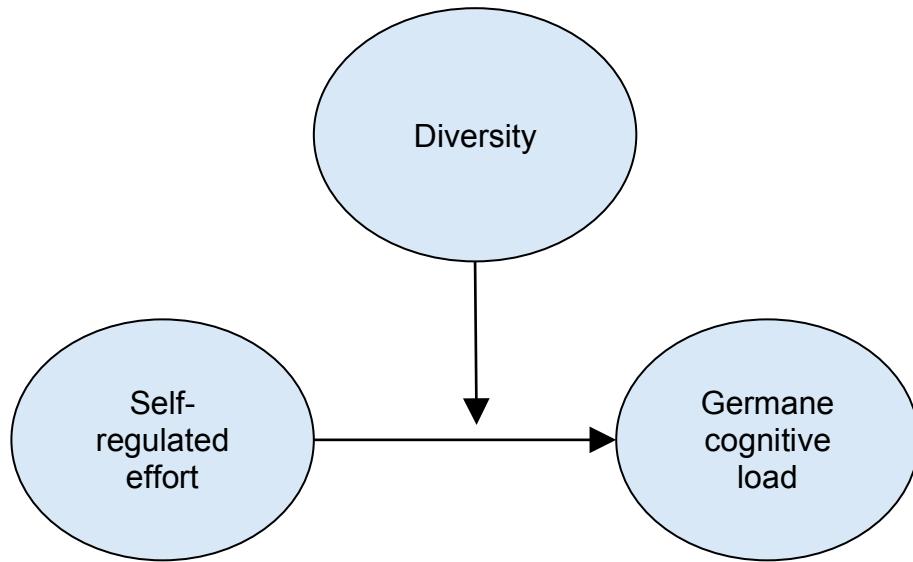


Figure 1: The moderating effects of diversity on the relationship between self-regulated effort and germane load

To test the interaction effect of self-regulated effort and diversity on germane load, PROCESS macro (model 1, Hayes, 2013) was used, as is shown in Figure 1. Variables were mean centered to $+/- 1$ standard deviation, which showed strong evidence of an interaction effect based on a standardised coefficient. Diversity negatively moderated the relationship between self-regulated effort and germane load, or in other words, as diversity increases, the strength of relationship between self-regulated effort and germane load decreases.

To measure the effect of moderation, PROCESS macro was used to center the variables and measure the relative effect of self-regulated effort on germane load at the average level of diversity, and at one standard deviation above and below the mean. This created a low, average, and high grouping of the relationships. In all conditions, there was a statistically significant relationship between self-regulated effort and germane load. However, as can be seen in Table 2, in the low diversity condition the effect size (.49) is stronger than in the average diversity condition (.41) and much stronger than in the high diversity condition (.33). As can be seen in Figure 2, this creates a fanning effect, whereby the low diversity condition has a steeper line than the average diversity condition, and the high diversity condition flatter than the other two conditions.

Table 2: Centred effects for self-regulated effort on germane load at each level of diversity

	Diversity	b	t	p
Low diversity	-1.3645	.49	19.01	.000
Average diversity	0.00	.41	20.57	.000
High diversity	1.3645	.33	12.31	.000

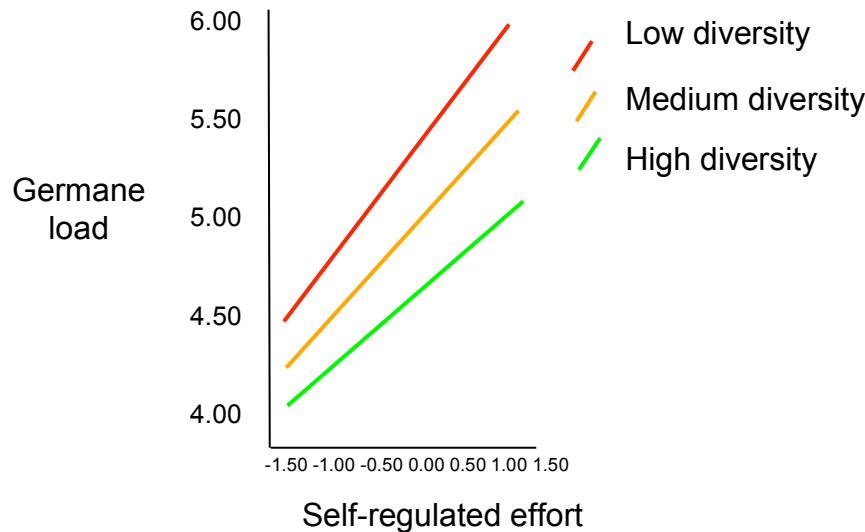


Figure 2: The moderation effect of diversity on self-regulated effort and germane load

Discussion

Examination of survey responses submitted by university students enrolled in e-learning courses in South Korea revealed information concerning relationships between media diversity, student effort, and learning. Using perceived difficulty in processing information represented by simultaneous delivery of text and images as a measurement of diverse media, self-regulated effort as a measurement of student effort, and germane load as a measurement of learning, this study concluded the following: media diversity was negatively correlated with germane load, self-regulated effort was positively correlated with germane load, and media diversity negatively moderated the relationship between self-regulated effort and germane load. The negative correlation found between media diversity and germane load is supported by research that shows diverse forms of media that distract learners and induce extraneous processing negatively affects learning (Mautone & Mayer, 2011; Mayer, 2012; Mayer & Moreno, 2003; Mayer, et al., 2001). The positive relationship found between self-regulated effort and germane load is also supported by research that has shown that effort exerted through self-regulated learning strategies has been associated with higher levels of learning (Koszin, 2007; Lane & Lane, 2001; Lynch & Dembo, 2004; Joo, Bong, Choi, 2000; Puzziferro, 2008; Saw, 2011; Van

Gog, et al., 2011; Wang & Newlin 2002). Additionally, research shows that when specific strategies are used to overcome cognitive demands placed on learners due to environmental distractions and unfavourable study conditions, higher levels of performance occur (Gerjets, et al., 2000; Joo, Bong & Choi, 2000; Komarraju & Nadler, 2013; Leutner & Sumfleth, 2009; Moos, 2011; Lane & Lane, 2001; Linnenbrink & Pintrich, 2002; Lynch & Dembo, 2004; Saw, 2011; Wang & Newlin 2002; Zimmerman, 1990).

The results from Lange, Costley and Han (2017) help support the findings of the current study. Like the current study, they found that self-regulated effort was not enough to overcome a difficult situation within the online learning environment. However, Lange, Costley and Han (2017) implied that distractions brought on by media diversity played a role in the high levels of extraneous load found in the study, but no empirical evidence was provided to support that. The current study extended Lange, Costley and Han's (2017a) research by focusing on a specific source of extraneous load creation: ineffective media diversity. Extant research that most closely relates to the present study supports these findings that effort cannot overcome the negative effects of distractions caused by improper use of media diversity. For example, Renkl (2014), Tarmizi and Sweller (1988) found that the use of self-explanation strategies are less effective when students are distracted by images physically separated from the text within online learning environments. Like the effort used in the self-explanation strategies in that study, the self-regulated effort strategies used in the current study were not enough to overcome confusing content brought on by the simultaneous presentation of both text and images. This is evident in the current study due to the fact that the strength of the relationship between effort and germane load decreased when levels of diversity increased.

Research has stated that processes involved in self-regulation are useful for overcoming confusing instruction within the learning environment (Zimmerman, 1990; Pintrich, et al., 1991). However, this is not the case when looking at the relationship between self-regulated effort and distractions resulting from media diversity as shown in the current study. The current study showed that student effort was not enough to overcome distractions brought on by the simultaneous presentation of both text and images that distracted the learners. Although the findings showed that self-regulated effort is positively correlated with germane load, the strength of the relationship between self-regulated effort and germane load significantly weakens when media diversity confuses the learners. This can be explained by the processes associated with extraneous processing of multiple sources of information as part of cognitive load theory. Unlike germane load, extraneous processing is associated with the effort that is either unnecessary or irrelevant to learning (Cierniak, et al., 2009; Leppink, et al., 2013; Schmeck, et al., 2015). The effort that goes into dealing with multiple media sources may ultimately create extraneous processing, as students are using cognitive effort to make sense of extraneous presentation of content, which does not contribute to learning.

Conclusion

Examining the effects of student effort on germane load when faced with specific types of media diversity is important, due to the autonomy associated with distance learning and the cognitive demands associated with types of instruction within online learning environments (Chandler & Sweller, 1991; Cunningham & Billingsley, 2003; Jung, 2001; Kalyuga et al., 2003; Mayer & Moreno, 2003; McManus, 2000). The results of this study highlight the exceptional negative influence distracting media has within an e-learning environment, as it was shown that self-regulated effort is not as effective in aiding students to learn when they have to deal with distractions brought about by diverse forms of media. These implications are helpful for both instructors and learners within online learning environments. Although effort regulation is useful under certain circumstances, students who face media distractions may need to use other learning strategies effectively to assess and adjust to their current learning situation. From an instructional perspective, instructors need to present diverse media in a way that does not distract the learners. For example, when presenting content with the use of text and images, instructors should not only avoid the presentation of content represented by physically separated sources, but also avoid the presentation of extraneous and redundant content. Presenting images and text that complement each other without creating extraneous processing by the students should allow effort strategies to be more efficient.

Although the results of this study contribute to discourse of online learning research through evidence that student effort may not always overcome certain distractions associated with online learning, there are some limitations. This study quantitatively examined relationships involving media diversity, self-regulated effort, and germane load through a survey. However, a qualitative approach may provide further explanation as to the reasoning behind these results. Perhaps detailed interviews with the participants would reveal precise self-regulated learning techniques taken at specific points in the lecture where multiple forms of media were used, which may also provide insight into the effect on their comprehension at that specific time in the lecture. Also, as this study used subjective measurements involving self-regulated effort, media diversity, and germane load, designing controlled environmental conditions may strengthen the current results, by allowing for examination of specific instances where self-regulation would be used during parts of the lecture containing multiple sources of media. Although there are some limitations, the results of this study provide new insight into the effects of media distractions on the relationship between student effort and learning.

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Appendix: Student survey, online May-June 2017

성별: Gender M/F

연령: Age

학년: Grade in university

온라인 강의 수강 여부 : () 개 강좌를 수강하였음

현재 수강 중인 교과명 : ()

(please only answer one class, which you think is the most important class to you.)?

다음의 각 질문에 대하여 “매우 그렇다” ⑥, “비교적 그렇다” ④, “보통이다” ③, “별로 그렇지 않다” ②, “전혀 그렇지 않다” ①을 선택해 주세요.

⑥ “매우 그렇다”, ④ “비교적 그렇다”, ③ “보통이다”, ② “별로 그렇지 않다”, ① “전혀 그렇지 않다”

Self-regulated effort

강의를 듣는 중 집중하지 못해서 계획한 만큼 수강하지 못하고 중간에 중단하는 경우가 종종 있었다: I often lose focus when I study so I quit before I finish what I planned to do.
 난 머리가 혼란스러울 때에도 학습에 충실하고자 노력하였다: I work to do well at school even if I get confused.

강의내용이 난해한 경우는 나는 쉬운 부분만 공주하거나 수강을 중도 포기하였다:

When coursework is unclear, I give up or only study the easy parts.

학습자료가 복잡 난해한 경우라 하더라도 나는 마지막까지 열심히 공부하고자 하였다:
 Even when study materials are complex, I manage to keep working until I finish.

E-learning personalization

나는 이번 이러닝 강좌에서 나에게 필요한 내용을 학습할 수 있었다. The e-learning system used for this course enabled me to learn the content I need.

담당교수는 이번 이러닝 강좌에서 내가 공부하고 싶은 것을 선택해서 공부할 수 있도록 다양한 자료들을 제공해 주었다. The e-learning system used for this course enabled me to choose what I want to learn.

당당교수는 이번 이러닝 강좌에서 학생들이 필요에 따라 서로 다른 학습순서에 따라 학습할 수 있도록 해 주었다. The e-learning system used for this course enabled me to control my learning progress.

Sequencing of content

이번 이러닝 강좌의 학습내용은 단순한 것을 먼저 공부하고 나중에 보다 복잡한 것을 공부할 수 있도록 순서화 되었다. The content was presented from simple to complex.

이번 이러닝 강의에서 교수님은 강의 초반에는 단순한 내용에서 시작하여 강의 후반에는 보다 복잡한 내용들을 다루어 주셨다. The content in the beginning of the lectures were simpler than at the end of the lectures.

이번 이러닝 강의는 강의 초반에는 특정 요소에 대한 설명과 같은 개별적인 내용들이 다루어졌으나 강의 후반에는 보다 큰 그림을 설명하기 위하여 여러 관련된 요소들을 함께 다루는 서로 연관된 내용들이 다루어졌다. The beginning of the lectures contained isolated elements (basic explanation of one part of the content), while the later stages contained interacting elements (multiple parts of the content coming together to explain the big picture).

Intrinsic load

강의에서 다루는 주제들은 매우 복잡하였다: The topics covered in the lecture were very complex.

그 강의에서 다른 콘텐츠는 나에게 매우 난해한 것들이었다: The lectures covered information that I perceived as very complex.

그 강의에서 다룬 개념이나 정의들은 나에게 매우 난해한 것들이었다. The lectures covered concepts and definitions that I perceived as very complex.

Fading technique

이번 온라인 강의에서 교수님은 강의 초반에 공부해야 할 중요한 내용들에 대하여 강조해 주셨다. In the early stages of the lecture, emphasis was placed on understanding instructions.

강의가 본격적으로 진행되면서 교수님은 해당 내용에 대한 실천적 사례들을 제시해 주셨다. In the middle stages of the lectures (heart of the lectures) worked examples were provided by the instructor.

강의의 정리단계에서 교수님은 학습 내용과 관련한 가능한 문제 상황을 제시하고 스스로 해결해 보도록 하였다. In the later stages of the lectures a full problem or task was presented with no instructional help.

Diversity

이번 온라인 강의에서 나는 그림으로 제시된 정보와 텍스트로 제시된 정보를 서로 관련시키기가 어려웠다. It was difficult for me to relate textual and pictorial information to each other.

온라인 강의에서 제공된 그림이나 도표 등과 같은 멀티미디어 자료들은 내가 설명문을 이해하는데 오히려 방해가 되었다. The illustration distracted me from textual information.

온라인 강의에서 제공된 설명문은 내가 그림이나 도표 등과 같은 멀티미디어 자료들을 이해하는 데 오히려 방해가 되었다. The textual information distracted me from the illustration.

Extraneous load

온라인 강의에서 교수님의 설명은 상당히 난해하였다: The explanations during the lecture were very unclear.

온라인 강의에서 교수님의 설명은 학습하기에 매우 비효과적이었다: The explanations were, in terms of learning, very ineffective.

온라인 강의에서 교수님의 설명은 난해한 말들 뿐이었다: The explanations were full of unclear language.

Maintained situational interest

나는 이 강좌에서 공부한 내용이 중요하다고 생각한다. I think what we are learning in this course is important.

나는 이 강좌에서 공부한 내용을 유용하게 사용할 수 있다고 생각한다. I think what we are studying in this course is useful for me to know.

솔직히 말해 나는 이번 온라인 강좌에서 별로 재미있는 점을 발견할 수 없었다.

To be honest, I just don't find this course interesting (reversed).

나는 이 강좌에서 공부한 것을 나의 실생활에 어떻게 활용할 수 있을지 알 수 있었다.

I see how I can apply what we are learning in this course to real life.

Germane load

- 그 강의는 해당 주제에 대하여 내가 잘 이해할 수 있도록 하였다. The lecture really enhanced my understanding of the topic(s) covered.
- 그 강의는 해당 과목에 대한 나의 지식과 이해를 크게 증진시켰다: The lecture really enhanced my knowledge and understanding of the class subject.
- 그 강의는 해당 교과와 관련된 개념들을 잘 이해할 수 있도록 하였다: The lecture really enhanced my understanding of the concepts associated with the class subject.
- 그 강의는 개념들이나 설명에 대하여 내가 잘 이해할 수 있었다: The lecture really enhanced my understanding of concepts and definitions.

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