**The effects of extraneous load on the relationship between self-regulated effort and germane load within an e-learning environment**

**Abstract**

Within distance learning, instruction quality and self-regulated effort are important aspects of the learning process. Instructors need to deliver instruction that minimizes extraneous load and maximizes germane load, which directly contributes to learning. Additionally, self-regulated effort also contributes to learning. It would be particularly useful to see how effective self-regulated effort is in dealing with various levels of extraneous load. This study analyzed survey responses from a group of university students (n = 1,575) who participated in online learning classes in South Korea to examine the relationship between self-regulated effort and germane load within varying extraneous load conditions. The experimental design included the separation of extraneous load responses into three conditions (low, medium, high). Within each extraneous load condition, self-regulated effort responses were also separated based on levels (low, medium, high). Analysis was performed to determine the relationship between different levels of self-regulated effort on germane load within specific extraneous load conditions. The results generally showed that as extraneous load increased, self-regulated effort had less of an impact on germane load. It was also found that the use of effort-regulation strategies are effective only when dealing with low and mid-level extraneous load situations and that higher use of such strategies within high extraneous load situations is just as ineffective as lower levels of effort-regulation. This study not only provides insight into the processes occurring between online instruction and self-regulated effort strategies, but also promotes effective instruction in concert with self-regulated effort to increase learning within e-learning environments.

**Keywords: e-learning, cognitive load, distance learning, extraneous load, germane load, online learning, self-regulated effort, self-regulated learning**

**Introduction**

Distance learning magnifies the need for not only effective instruction, but also for specific learning strategies that help manage content delivered by instructors. E-leaning require a degree of autonomy, as students are faced with the challenge of selecting relevant content delivered to them through multiple sources of information (Gerjets & Scheiter, 2003; Mayer, 2014). The likelihood of excessive cognitive load may be greater if content used in e-learning is not clearly presented (Gerjets & Scheiter, 2003; Kalyuga, Chandler, & Sweller, 1999). Instructors need to deliver content in a way that will not overload cognitive processing of the learners. Additionally, it is beneficial for learners to self-regulate their effort and show determination to achieve success within online learning environments (Puzziferro, 2008). Acknowledging the importance of both instruction quality and effort-regulation within e-learning, it would be particularly useful to examine the relationship between effort-regulation strategies and learning based on how much extraneous cognitive load students face within e-learning environments.

Cognitive load represents a process of information transfer by learners from their working memory to their long term memory, and addresses this process through the examination of the following three elements: intrinsic load, extraneous load, and germane load (De Jong, 2010; Sweller, 2005; Sweller, Van Merriënboer, & Paas, 1998). Intrinsic load reflects the complexity of the material coupled with prior knowledge of the learners (Sweller & Chandler, 1994). Extraneous load reflects poor instructional delivery that causes unnecessary processing within short term memory to a point where student learning is negatively affected (Cierniak, et al., 2009; Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013). Germane load is the only element of cognitive load theory where high levels are considered positive for the learning experience (Cierniak, et al., 2009). More specifically, germane load directly contributes to learning and represents how well the students understand the content (Sweller, et al., 1998). Additionally, germane load levels are determined by the amount of effort exerted by learners in order to comprehend the content (Homer, Plass, & Blake, 2008). An ideal learning environment is one that promotes high levels of germane load through the reduction of extraneous load (Cierniak, et al., 2009; Sweller, et al., 1998).

Self-regulated learning is defined as the ability to show levels of independent and proactive engagement through self-motivational and behavioral techniques used to accomplish goals (Zimmerman, 2008). Self-regulated learners are persistent when confronted with difficult tasks, and are able to keep away from behaviors that distract them from the learning process (Dabbagh & Kitsantas, 2012). Furthermore, self-regulated learners believe that taking on challenging tasks, developing a deep understanding of content, and using more effort will enhance their learning and ultimately help them succeed in their coursework (Perry, Phillips, & Hutchinson, 2006). Research has conceptualized self-regulated learning through learning strategies for dealing with particular aspects of the learning environment. Specifically, the Motivational Strategies for Learning Questionnaire (MSLQ) was developed to reflect the way learners use their beliefs and cognition to formulate motivational learning strategies based on specific forms of instruction delivered to them (Pintrich, Smith, Garcia, & McKeachie, 1991). MSLQ strategies include self-regulated effort, which has been defined as the amount of commitment dedicated to managing specific instructional tasks that are perceived as difficult to complete (Pintrich, et al., 1991).

**Theoretical background**

**Relationship between extraneous load and germane load**

Both extraneous load and germane load are associated with effort put forth by learners. While effort associated with extraneous load is a result of poor instructional practices that cause unnecessary processing, effort associated with germane load contributes to processes that are reflective of learning (Kirschner, 2002). When instructional design effectively minimizes extraneous load, learners can effectively construct schema by engaging in relevant activities that contribute to learning, further enhancing levels of germane load (De Jong, 2010; Sweller, et al., 1998). Within e-learning multimedia environments specifically, extraneous load can negatively affect cognitive processes that lead to learning. Mayer (2014) showed that when extraneous material is added to portions of the lecture where the processing of other essential information is simultaneously required, students show lower levels of comprehension. Additionally, splitting learners’ attention between multiple sources of information presented simultaneously has been shown to create extraneous processing, negatively affecting learning (Moreno, Mayer, Spires, & Lester, 2001). Furthermore, reducing extraneous load has been shown to be beneficial to learning, as the elimination of redundant extraneous on-screen text has been shown to lead to better understanding of online multimedia presentations (Mayer, Heiser, & Lonn, 2001).

**Relationship between extraneous load and self-regulated effort**

Students’ use of specific strategies is often determined by the learning environment itself. Self-regulated learning strategies such as effort regulation are not static, but contextually bound through the type of instruction delivered within specific learning environments (Duncan & McKeachie, 2005). The quality of instruction represents a specific environmental factor that may influence students’ effort through the use of self-regulated learning strategies. The amount of effort students employ is often related to their perceptions of how effective that effort would be, given specific circumstances within their environment (Paas, Tuovinen, van Merriënboer, & Darabi, 2005). In other words, if instruction contains elements that lead to extraneous processing, learners may perceive those elements as unnecessary for success, therefore reducing their effort. Additionally, the cognitive processing associated with extraneous load is compounded by further cognitive processing required for self-regulation, which may affect students’ effort, given the limited processing power afforded to individuals at a specific time (Saw, 2011). On the other hand, instruction designed to reduce extraneous load allows for more cognitive processing to be focused on self-regulated learning strategies and may be perceived by students as useful for learning, which in theory, should lead to more effort.

**Relationship between self-regulated effort and germane load**

Germane load is a product of the motivational effort used to construct schema, resulting in a positive learning experience (De Jong, 2010). Reflective of this notion, effort associated with persistence when encountering boring or difficult instruction has been linked to academic achievement (Komarraju & Nadler, 2013; Pintrich et al. 1991). The effort associated with self-regulation, specifically, is a critical aspect of distance learning, as it represents a major determinate of what is learned within those environments (Saw, 2011). For example, student self-regulation through better planning and effort within multimedia e-learning environments has been shown to lead to higher levels of learning (Moos, 2013; Moos & Azevedo, 2008). The use of self-regulation through motivational effort involving memorization, elaboration, and organization has been shown to positively affect learner achievement in e-learning environments (Shih, Ingebritsen, Pleasants, Flickinger, & Brown, 1998). Furthermore, self-regulated effort was found to be associated with an increase in academic performance within a college e-learning course (Puzziferro, 2008).

**Relationship between specific levels of self-regulated effort and germane load within varying extraneous load conditions**

Various studies have examined the effects that different levels of self-regulation have on learning within both high and low extraneous load e-learning environments. Within low extraneous load environments, studies have shown that self-regulation strategies increase and higher levels of learning occur as a result (Moos & Azevedo, 2008; Kramarski & Mizrachi, 2006). Within high extraneous load environments, research has shown that instruction that imposes extraneous load on the learners is associated with less usage of self-regulated learning strategies, and that low levels of self-regulation negatively affect learning (Moos, 2013). Although these studies provide insight into the processes occurring within both high and low extraneous load environments, they are limited in their scope. They are predicated on the fact that low levels of extraneous load increase self-regulated learning and high levels of extraneous load decrease self-regulated learning, essentially disregarding the effect that low self-regulation has on learning within low extraneous load environments and the effect that high self-regulation has on learning within high extraneous load environments.

Gerjets and Scheiter (2003) acknowledge that specific constraints associated with ineffective instruction do affect learning strategies, but that learners who receive the same instruction still vary in regards to their use of such strategies. Furthermore different levels of learning are evident as a result of variations of strategies within the same instructional design environment (Gerjets, Scheiter, & Tack, 2000; Gerjets & Scheiter, 2003). Based on this assertion, Gerjets et al. (2000) looked at both low and high levels of self-controlled learning strategies within a low extraneous load online environment. The results showed that students who displayed less effort through low levels of processing strategies suffered from lower performance levels than those that utilized more effort through higher levels of processing strategies (Gerjets, et al., 2000). Additionally, Gerjets et al. (2000) looked at high levels of effort within a high extraneous load online environment, and found that performance was not negatively affected as a result of students showing higher levels of effort through the use of self-controlled learning strategies.

**The current study**

Online learning deserves attention from a cognitive perspective, as delivery of instruction often requires a level of strategic effort to deal with aspects of cognitive load that may be imposed on the learner. Research has shown that multimedia online environments are at a greater risk of inducing extraneous load, and that extraneous load is negatively correlated with germane load (Gerjets & Scheiter, 2003; Kalyuga, Chandler, & Sweller, 1999). Additionally, it has generally been found that extraneous load occurring in e-learning leads to lower levels of effort (Moos, 2013; Moos & Azevedo, 2008; Kramarski & Mizrachi, 2006), although levels of effort still occur within high extraneous load environments as some learners attempt to compensate for poor instruction (Gerjets, et al., 2000; Gerjets & Scheiter, 2003). Use of self-regulation within e-learning has proven to be useful, as high levels of self-regulation strategies have been shown to lead to better performance (Moos, 2013; Moos & Azevedo, 2008; Puzziferro, 2008; Shih, et al., 1998).

It is worth investigating to see if cognitive processes occurring as a result of extraneous load coupled with the higher processing involved with self-regulated learning are too overwhelming for students to positively affect their learning. Conversely, it of use to look into whether higher cognitive processes associated with self-regulated learning outweigh the negative cognitive processing associated with extraneous load to a point where learning can be enhanced. To investigate this, the current study analyzed survey responses from university students in Korea and separated their extraneous load responses into three conditions (high, medium, low). Within those conditions, self-regulated effort was also divided into three levels (high, medium, low) to see the effect that different levels of self-regulated effort have on germane load within a high, medium, and low extraneous load condition.

**Research Questions**

1. What is the correlation between extraneous load and germane load?
2. What is the correlation between extraneous load and self-regulated effort?
3. What is the correlation between self-regulated effort and germane load?
4. Is there a difference in germane load means between the self-regulated effort groups in the low extraneous load condition?
5. Is there a difference in germane load means between the self-regulated effort groups in the moderate extraneous load condition?
6. Is there a difference in germane load means between the self-regulated effort groups in the high extraneous load condition?

**3. Methods**

**Context and Participants**

This study surveyed a group of students in South Korea who received multimedia instruction within Open Cyber University (OCU) online courses. This institution first started delivering online instruction in the fall semester of 1998 (Jung & Rha, 2001). The OCU is associated with 23 traditional brick-and-mortar universities who provide both funding and administrative oversight (Jung, 2000). The OCU offers approximately 400 different classes, and services 120,000 students per semester (Han, 2012). The 23 member universities also provide the instructors and course titles for instruction delivered in the OCU (Jung & Rha, 2001). While there are a small amount of courses that include face-to-face tutoring and offline assessment, most instruction in the OCU occurs through web-based lectures and quizzes (Jung & Rha, 2001).

The participants in this study filled out a Google docs form in the spring semester of 2016. 1801 students filled out the survey; however 199 of those surveys were removed from the analysis because they were incomplete. Furthermore, to make the 9 differing groups used in this study equal in size, 1575 participants were required. Therefore, the last 27 valid respondents were removed. Of the 1575 students who completed surveys, 756 (48%) were male and 819 (52%) were female. The youngest participant in this study was 15, and the oldest was 63. The average age of the study participants was 23.5, with a standard deviation of 3.2. Other studies involving online learning environments have found similar distributions of age and gender (Suh & Kim, 2013). The participants responded to the survey based on specific OCU courses they took during the semester. The courses were categorized as follows, with the percentage of participants taking each course-type in parentheses: liberal arts (33%), social science (17%), technology (15%), lifestyle and health (12%), management and business (8%), foreign language (7%), natural science (6%), and design (2%). The distribution of subject areas is similar to the general distribution found in the OCU (Kobayashi & Kim, 2010).

**Research procedures and data collection**

This study began with qualitative interviewers of 10 students who had participated in OCU classes in the fall semester of 2015. These interviews were focused on learner-to-learner interaction and the students’ general perceptions of the OCU and their learning experiences. These interviews helped define and generate questions for a broad survey covering all aspects of the OCU that were given to 92 students in January of 2016. This survey was very general and had questions regarding lesson quality, watching lectures, academic honesty, learner-to-learner interaction, instructor interaction, and learning materials. From this survey, it was evident that the learning experience of students was variable and a decision was made to generate a more specific survey and distribute it to a larger sample of OCU students.

The survey used in this research was initially written in English, and then translated into Korean. An expert in both the OCU and online learning checked the translation and found it to be accurate. A link to the survey was sent to the OCU’s central administrative offices, where it was checked for errors or issues. The link along with a message inviting students to participate in the research was then posted on the OCU’s main information board, and was active from April 20th to May 20th, 2016.

**Instruments**

To measure germane load, four items from Leppink et al.’s (2013) paper *The development of an instrument for measuring cognitive load* were adapted. The four items used to measure germane load in the present study were: *The lecture really enhanced my understanding of the topic, the lecture really enhanced my knowledge and understanding of the 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*. Cronbach’s Alpha was measured and found to be .961, which is acceptable for this research. The three items measuring extraneous load were also adapted from Leppink et al. (2013). The three items used in this study to measure extraneous load were: *The explanations during the lecture were very unclear; the explanations were, in terms of learning, very ineffective; the explanations were full of unclear language.* The Cronbach’s Alpha was calculated and found to be .946, which is also acceptable for this type of research.

The measurements used to calculate self-regulated effort come from the *Motivated Strategies for Learning Questionnaire* (MSLQ) that is used to assess college students' motivational orientations and their use of different learning strategies (Pintrich et al. 1991). From the MSLQ, the following four items were adapted for use in this study to measure self-regulated effort: *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 was calculated and found to be .727, which is acceptable for this type of research.

**Experimental design**

To create the different groups for examining the effects of extraneous load and self-regulated effort, the study participants were separated into three different groups (low, medium, high) in both cases. This means that there were a total of nine separate conditions that were compared as the main part of this study. The 1575 participants’ levels of extraneous load were calculated and ordered. The 525 subjects with the highest levels of extraneous load represented the “high” extraneous load group, the next 525 subjects represented the “medium” extraneous load group, and the lowest 525 subjects represented the “low” extraneous load group. This method of dividing participants is similar to the method used in Chang and Yang’s (2009) cognitive load study. The grouping procedure for self-regulated effort also included dividing the groups into thirds, with 525 participants with the highest levels of self-regulated effort being the “high” group, the next 525 participants being the “medium” group, and the 525 participants with the lowest levels of self-regulated effort being the “low” group. This method of dividing subjects into groups based on their relative levels of self-regulated effort is the same method used in McManus (2000) and Wang (2011).

**4. Results**

The first step in understanding the relationships between the three main variables was to look at their direct correlations. Table 1 shows that all of the variables have a statistically significant positive or negative relationship. Extraneous load is negatively correlated with both self-regulated effort (-.261) and germane load (-.602). Also, self-regulated effort is positively correlated with germane load (.437). All of these correlations were significant at the .01 level using Spearman’s correlation coefficient.

Table 1. Correlations between extraneous load, self-regulated effort, and germane load (*n* = 1575)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | 1 | 2 | 3 |
| 1 | Extraneous Load | 1 |  |  |
| 2 | Self-Regulated Effort | -.261\*\* | 1 |  |
| 3 | Germane Load | -.602\*\* | .437\*\* | 1 |

\*\* Correlation is significant at the .01 level.

The first stage of examining the relationships between the variables was to separate them into different groups to be used for analysis in this study. First, the overall mean levels for the three variables were examined Table 2 shows that extraneous load had a mean value of 3.48, self-regulated effort had a mean value of 6.85, and germane load had a mean value of 6.29.

Table 2. Means for extraneous load, self-regulated effort, and germane load (*n* = 1575)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Min | Max | Mean | Std. Deviation |
| 1 | Extraneous Load | 0.00 | 10.00 | 3.48 | 2.56 |
| 2 | Self-Regulated Effort | 3.00 | 10.00 | 6.85 | 1.64 |
| 3 | Germane Load | 0.00 | 10.00 | 6.29 | 2.78 |

After the three main variable descriptive statistics were examined, the participants were split into three groups based on their levels of perceived extraneous load. These groups were low, medium, and high. Table 3 shows that the low extraneous load group had a mean extraneous load of 0.62, the medium extraneous load group had a mean extraneous load of 3.59, and the high extraneous load group had a mean extraneous load of 6.20. After the high, medium, and low extraneous load groups were created, the participants were also divided based on their self-regulated effort scores. Table 3 shows that there were three self-regulated effort groups created within each extraneous load group, with 175 participants in each. In the low extraneous load group, the low effort group had an effort mean of 5.605, the medium group had a mean of 7.604, and the high effort group had mean of 9.472. The medium extraneous load group also had three groups with the low effort group having an effort mean of 4.930, the medium group having a mean of 6.164, and the high group having an effort mean of 8.044. In the high extraneous load condition, the low effort group had an effort mean of 5.080, the medium group had a mean of 6.235, and the high group had a mean of 8.354.

Table 3: Mean levels by groups

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | *n* | EL Mean | SD |  | *n* | Effort Mean | SD |
| Low EL | 525 | 0.62 | 0.72 | Low Effort  Medium Effort  High Effort | 175  175  175 | 5.60  7.60  9.47 | 0.65  0.62  0.65 |
| Medium EL | 525 | 3.60 | 0.99 | Low Effort  Medium Effort  High Effort | 175  175  175 | 4.93  6.16  8.04 | 0.31  0.48  0.85 |
| High EL | 525 | 6.20 | 1.61 | Low Effort  Medium Effort  High Effort | 175  175  175 | 5.08  6.24  8.35 | 0.29  0.42  1.03 |

This created nine potential combined conditions as can be seen in Table 3 above and Table 4 below. Next, using the nine different combined groups, the germane load means for each of the conditions were examined (Table 4). The condition with the highest germane load mean was the low extraneous load, high effort group with a germane load mean of 9.328 and the condition with the lowest germane load mean was the high extraneous load, low effort group with a mean germane load of 4.815. The means for the other conditions can be seen in Table 4.

Table 4. Mean germane load by extraneous load and effort groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ELgroups | Effort groups | *N* | Germane Load Mean | Std. Deviation |
| Low EL | High Effort | 175 | 9.33 | 1.22 |
| Low EL | Medium Effort | 175 | 8.14 | 1.42 |
| Low EL | Low Effort | 175 | 6.43 | 2.51 |
| Total for Low EL | | 525 | 7.99 | 2.16 |
| Medium EL | High Effort | 175 | 6.84 | 1.64 |
| Medium EL | Medium Effort | 175 | 5.80 | 1.28 |
| Medium EL | Low Effort | 175 | 5.13 | 0.97 |
| Total for Medium EL | | 525 | 5.93 | 1.50 |
| High EL | High Effort | 175 | 5.14 | 2.66 |
| High EL | Medium Effort | 175 | 5.04 | 1.57 |
| High EL | Low Effort | 175 | 4.82 | 1.26 |
| Total for High EL | | 525 | 4.99 | 1.94 |
| Total for whole sample | | 1575 | 6.30 | 1.87 |

After examining the germane load means for each of the nine conditions, ANOVA was used to test if there was a statistically significant different between the high, medium and low effort groups within each of the extraneous load conditions. Table 5 shows both the low and medium extraneous load groups showed a significant difference in germane load depending on whether the participants were in the high, medium or low effort group. However, in the high extraneous load condition, there was no statistically significant difference based on which self-regulated effort group the participant belonged to.

Table 5. ANOVA for the different effort groups by extraneous load group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Sum of Squares | Df | Mean Square | F | Sig. |
| Low EL | Between Groups | 772.988 | 2 | 386.494 | 119.008 | 0.001 |
| Within Groups | 1737.475 | 523 | 3.248 |
| Total | 2510.462 | 525 |
| Medium EL | Between Groups | 266.808 | 2 | 133.404 | 75.342 | 0.001 |
| Within Groups | 952.61 | 523 | 1.771 |
| Total | 1219.418 | 525 |  |
| High EL | Between Groups | 27.569 | 2 | 6.785 | 1.696 | 0.344 |
| Within Groups | 1969.478 | 523 | 3.73 |
| Total | 1997.047 | 525 |  |

After the overall difference in each of the extraneous load conditions was established, the Scheffe test was used to examine the specific difference of germane load means between each effort group, and whether or not those differences were statistically significant. Table 6 shows that in the low extraneous load condition, the high effort group’s germane load mean was 2.894 higher than the low effort group and 1.192 higher than the medium effort group. The medium effort group’s germane load mean was 1.702 higher than the low effort group. All of those differences were statistically significant.

Table 6. Scheffe test for the low extraneous load group (*n* = 525)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Low Effort | Medium Effort | High Effort |
| High Effort | 2.894\* | 1.192\* | 1 |
| Medium Effort | 1.702\* | 1 |  |
| Low Effort | 1 |  |  |

\* Correlation is significant at the .05 level

The Scheffe test was also used in the medium extraneous load group to examine the specific difference of germane load means between each effort group, and whether or not those differences were statistically significant. Table 7 shows that in the medium extraneous load condition, the high effort group’s germane load mean was 1.706 higher than the low effort group and 1.037 higher than the medium effort group. The medium effort group’s germane load mean was 0.669 higher than the low effort group. All of those differences were statistically significant.

Table 7. Scheffe test for the medium EL group (*n* = 525)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Low Effort | Medium Effort | High Effort |
| High Effort | 1.706\* | 1.037\* | 1 |
| Medium Effort | 0.669\* | 1 |  |
| Low Effort | 1 |  |  |

\* Correlation is significant at the .05 level

Finally, the Scheffe test was used to examine the specific differences of germane load means between each effort group in the high extraneous load condition, and whether or not those differences were statistically significant. Table 8 shows that in the high extraneous load condition, the high effort group’s germane load mean was 0.326 higher than the low effort group and 0.106 higher than the medium effort group. The medium effort group’s germane load mean was 0.22 higher than the low effort group. Unlike in the medium and low extraneous load conditions, there was no statistical difference between the groups.

Table 8. Scheffe test for the high EL group (*n* = 525)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Low Effort | Medium Effort | High Effort |
| High Effort | 0.326 | 0.106 | 1 |
| Medium Effort | 0.22 | 1 |  |
| Low Effort | 1 |  |  |

\* Correlation is significant at the .05 level

**Discussion**

The results showed that extraneous load had a negative relationship with both germane load and self-regulated effort, and that self-regulated effort had a positive relationship with germane load. The main purpose of this study was to examine the relationships between varying levels of self-regulated effort (low, medium, high) and germane load within specific extraneous load conditions (low, medium, high). Results generally indicated that as extraneous load increased, the effect that self-regulated effort had on germane load decreased. Additionally, within the low and medium extraneous load conditions, germane load levels significantly differed among the three self-regulated effort groups. This shows that within those conditions, self-regulated effort had a significantly different impact on germane load based on effort levels, with more effort leading to higher levels of germane load. However, no significant difference was found between germane load means among the three self-regulated effort groups within the high extraneous load condition. This shows that within high extraneous load online environments, higher levels of self-regulation not only have less of an impact on germane load than in medium and low extraneous load environments, but that using more self-regulated effort is generally no more effective than using less self-regulated effort.

The negative correlation found between extraneous load and germane load is supported by cognitive load theory, which states that extraneous load leads to unnecessary cognitive processing, negatively affecting comprehension and ultimately germane load (Cierniak, et al., 2009; De jong, 2010; Leppink, et al., 2013; Sweller, et al., 1998). Experimental conditions involving ineffective use of multimedia within online learning environments have shown that learners who are forced to manage extraneous load as a result of such instruction, generally show lower levels of comprehension (Mayer, et al., 2001; Moreno, et al., 2001). The negative relationship found between extraneous load and self-regulated effort is also supported by research, as use of self-regulated learning strategies within e-learning has been found to be negatively affected by extraneous load within the environment (Moos, 2013). Additionally, the positive relationship between self-regulated effort and germane load is not surprising, in that research has shown that self-regulation has been attributed to higher levels of learning within e-learning environments (Moos, 2013; Moos & Azevedo, 2008; Puzziferro, 2008; Shih, et al., 1998).

The results of the current study involving the effects of varying levels of self-regulated effort on germane load within specific extraneous load conditions are revealing in light of other research. Regarding the low extraneous load condition, it is can be said that when clear instruction is presented, self-regulated effort is an effective strategy and that those that use it will show greater success than those that do not. Similar results regarding the difference between germane load means of the three self-regulated learning groups were found within the medium extraneous load environment, however higher levels of self-regulated effort had a somewhat smaller effect on germane load than they did within the low extraneous load condition. Thus it can be concluded that within mid-level extraneous load environments, higher levels of self-regulated effort can still have a greater effect on learning than lower levels of self-regulated effort, although the use of more effort may not be as successful as it would be when managing lower levels of extraneous load. Studies addressing similar circumstances have revealed that learning is increased through the use of higher self-regulation as a result of low extraneous load instruction (Moos & Azevedo, 2008; Kramarski & Mizrachi, 2006). However, these studies differ from the current study in that they did not examine learning differences between different self-regulated learning levels within their low extraneous load environments. This was addressed by Gerjets et al. (2000), with results providing support for the current study in that both high and low levels of effort used for processing strategies were examined within a low extraneous load e-learning environment, and that low-effort learners were outperformed by high-effort learners.

The current study’s results from the high extraneous load condition are much more significant in terms of exposing the exceptional negative influence that high levels of extraneous load have on the learning experience within e-learning environments. This is evident within that condition by the fact that higher levels of self-regulated effort had less of an impact on germane load compared to the low and medium extraneous load conditions. Additionally, similar germane load means were found among the three self-regulated effort groups, showing that high extraneous load was so significant that high levels of self-regulated effort were just as ineffective as lower levels of self-regulated effort in overcoming poor instruction. Moos (2013) showed that high extraneous load within an e-learning environment decreases effort, leading to lower levels of learning. However, Moos (2013) did not look at the use of high self-regulated learning strategies within high extraneous load environments to see if self-regulation can be effective in overcoming poor instruction. To examine this phenomenon, Gerjets et al. (2000) showed that students displaying high levels of effort within a high extraneous load environment showed no difference in performance compared to students in a low extraneous load condition, effectively overcoming poor instruction.

Gerjets et al.’s (2000) results differ from the current study in a couple of ways. In particular they only examined high strategy use within the high extraneous load environment, stating that learners within that environment used more effort by adjusting their strategies in a way that did not negatively affect their performance, allowing them to effectively manage extraneous load through the use of their strategies. The current study, however, compared different groups within the same high extraneous load condition to see if there was any difference between learners with varying levels of effort, with results showing that high-effort learners did not effectively manage the extraneous load any better than mid and low-effort learners. Furthermore, Gerjets et al. (2000) examined the relationship between high effort and learning within a high extraneous load situation involving a specific task during a particular point of an e-learning lecture. The current study looks at the bigger picture to examine the effects of extraneous load over the course of a semester. Within e-learning, more self-regulated effort may be useful in managing extraneous load occurring over a short period of time involving a specific task. However, using higher amounts of self-regulated effort to deal with poor instruction throughout the entirety of an online course may contribute to substantial cognitive overload, basically rendering such effort ineffective.

**Conclusion**

Results from this study show that the effort put forth by students to overcome challenging situations may not always lead to successful learning. Although higher levels of effort are often needed when dealing with extraneous processing caused by poor instruction within e-learning environments, the self-regulation needed to extend such effort creates further cognitive demands on the learner (Saw, 2011; Zimmerman, 2008). This notion helps to explain the results of the current study, which showed that higher levels of self-regulated effort were not enough to effectively manage high extraneous load. The additional cognitive demands required to regulate effort, coupled with the existing demands from extraneous load may have been simply too much for students to effectively deal with poor instruction. However, the results of this study also revealed that when students face lower levels of extraneous load within an e-learning environment, higher levels of self-regulated effort have a more positive effect on the learning experience. The implications of this research are useful for both instructors and learners within multimedia e-learning environments. While e-learning instructors need to present instruction in a way that avoids the creation of extraneous processing by students, e-learning students should self-regulate their effort to gain a better understanding of the content. Based on the findings of the current study, however, it is important to note that performance gains are more likely to occur within e-learning when both of those conditions are simultaneously met.

Although the results of this study provide important implications regarding the complex processes involved with cognitive load and self-regulated effort within an e-learning environment, there are some limitations. This study was based on survey responses of subjective measurements involving cognitive load and self-regulated effort. The results can be strengthened by examining the same relationships within a controlled experimental environment. Specifically, creating online instruction containing various levels of extraneous load and having students modify their use of self-regulated learning strategies within specific extraneous load environments, may further support these results. Given that, the results of the current study build on what previous research has done regarding the conceptualization of complex relationships between cognitive load and self-regulated learning within multimedia e-learning environments.

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