SCAFFOLDING AND ENHANCING LEARNERS' SELF-REGULATED LEARNING: TESTING THE EFFECTS OF ONLINE VIDEO-BASED INTERACTIVE LEARNING ENVIRONMENT ON LEARNING OUTCOMES

A Dissertation

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ERHAN DELEN

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Chair of Committee,	Jeffrey Liew
Co-Chair of Committee,	Ronald Zellner
Committee Members,	Victor Willson
	Bugrahan Yalvac
Head of Department,	Victor Willson

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ABSTRACT

Online learning often requires learners to be self-directed and engaged, and I designed an online video-based interactive learning tool to support or scaffold students' self-regulated or self-directed learning aimed at keeping students actively engaged with the content. Using an experimental design, this study investigates the effects of a newly designed online video-based interactive learning environment with embedded supports for self-regulation strategies on students' learning behaviors and outcomes. In addition, correspondence between students' self-regulation strategies in traditional learning environments and observed self-regulated learning behaviors in the video-based interactive learning environment were examined. Lastly, the unique or joint contributions of the embedded supports for self-regulation strategies to students' learning performance were examined.

A cross-sectional experimental research design with systematic random assignment of participants to either the control condition (non-interactive video environment) or the experimental condition (interactive video environment) was utilized. Undergraduate and graduate students participated in the study (N = 80).

Study results indicate that the newly designed online video-based interactive learning environment was a superior instructional tool than the non-interactive video-based learning environment in terms students' learning performance. In addition, there was correspondence between graduate students' self-reported self-regulation and observed self-regulation, with those high on seeking/learning information and managing their environment/behavior more likely to engage more in interactive note-taking

Importantly, these findings suggest that specific self-regulation strategies in traditional education settings may transfer and become enacted as specific learning behaviors in the online learning environment. Finally, the use of embedded self-regulatory functions did not have a significantly unique contribution to students' performance in the interactive learning environment. In other words, although the interactive learning environment succeeded in scaffolding and supporting students' learning process that resulted in superior performance than the non-interactive learning environment, none of the embedded functions appear to uniquely or individually contribute to this superior performance.

In sum, students benefited from the online video-based interactive learning environment by using embedded self-regulatory functions. However, use of the embedded self-regulatory functions did not uniquely contribute to learning outcomes. Nonetheless, results support the view that interactivity based on self-regulation strategies supports active and engaged learning, which contributes to superior learning outcomes.

To my wonderful wife

Gulsen

and my precious daughter

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for their unfailing love, support, affection, and encouragement.

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CHAPTER I

INTRODUCTION

Learning environments continue to evolve especially with advances in technology, with online learning environments being one such advance that has become increasingly common in the 21st century. Online learning has several components (e.g., Internet and computer technology) and these components have changed and renewed rapidly due to the fast improvements in technology. As the cost of technology decreased without necessarily compromising its quality, the access of wide user groups to new technologies increased. The use of online learning environments in education has increased particularly with the developments and improvements in Internet and computer technology.

Online learning environments offer students the freedom to learn at the location and time of their choice. On the other hand, there are also challenges learners must contend with to be successful in the online learning environment. For instance, learners need to motivate or regulate themselves in order to acquire needed information from online environments because there are many distractive elements that may deter or compromise learning. That is why when online learning tools are designed, learners' attention and engagement should be considered. In order for students to maximally benefit from online learning environments, they must be designed to support students' self-regulated learning because students no longer have reinforcements commonly found in traditional face-to-face learning environments. Thus, online learning environments need to be designed with affordances that provide self-regulating opportunities to the learner.

One of the biggest concerns that researchers have about online learning environments is the effectiveness of teaching/learning when compared to traditional (e.g., face-to-face) learning environments. Given that online learning often requires learners to be self-directed and engaged in their learning, understanding learning theories as well as the role of self-regulation and motivation are necessary for designing effective online learning environments.

The design and development of effective online learning tools need to be built upon learning theories and research-based principles and practices. Self-regulated learning (SRL) is a construct with multiple dimensions that involves effective use of cognitions, behaviors, and emotions to achieve learning goals (Pintrich, 2000). Self-regulated learners know how and when to use meta-cognitive strategies such as self-monitoring and self-evaluation for optimal learning and successful performance (Pintrich & Groot, 1990; Zimmerman & Martinez-Pons, 1990). That is why using self-regulated strategies helps students to attain better performance (Zimmerman & Martinez-Pons, 1990). These strategies "are actions and processes directed at acquiring information or skill that involve agency, purpose, and instrumentality perceptions by learners" (Zimmerman, 1989, p. 329). Although the majority of previous studies on self-regulation and learning have been conducted in traditional learning environments such as schools and classrooms, there is reason to expect self-regulated strategies can be used in the online video-based interactive learning environment to support learners' optimal learning and performance because online learning environments require self-regulated behavior.

According to Zimmerman (1989), there are three key elements of self-regulation: personal processes, the environment, and behavior. In regards to self-regulated learning, some embedded elements (e.g., interactive functions) that support self-regulation can make an online tool more effective. The learners can use these elements to self-regulate themselves during the learning process.

Video has been an essential part of online learning environments that promotes learners' engagement in online learning while supporting visual and auditory modes of learning. The ways of using video in online education have also changed over time with improvements in Internet technology. For example, educational videos have evolved from broadcasting streams without any functions to enriched videos with various functions that are provided for users. Quality and resolution of videos have also been improved in online learning environments besides the embedded new functions.

When learners use an online video resource, they are expected to watch and gain knowledge from it. However, in order to benefit from the video content, learners need to pay attention to the video and not get interrupted or distracted. That is why effective online tools should be designed with learners' individual differences and needs in mind (Greene, Miller, Crowson, Duke, & Akey, 2004), including their interest, attention, and self-regulation. One important factor is keeping learners continuously and actively engaged with the online learning tool and its embedded functions. These functions can have some control to reduce potential distractions while taking online instruction (Ley &

Young, 2001). In addition, it is also crucial to promote learners' sense of self-efficacy, achievement, and mastery while using the learning tool. In conclusion, my tool considers potential constraints in video-based learning environment and tries to reduce them while expecting good academic performance from learners with using self-regulation strategies.

In this study, a newly designed online video-based interactive learning environment that has several embedded components, which aim to keep the learners actively engaged during the learning process, is tested. By itself, a video may not be an excellent learning tool. Supporting elements such as note-taking, viewing additional resources, and answering immediate practice questions can maximize the learning potential of videos. If my tool reduces potential constraints in video-based learning (e.g., distractions) and support self-regulation for learners, it can be used as a video-based interactive tool in the field to effectively promote online learning.

Statement of the Problem

Motivation is necessary for engaging in online learning, as students often need to regulate themselves during online instruction. Previous research indicates that interactive learning environments promote learning. Thus, transferring self-regulation strategies that are used in traditional education settings to online video-based learning environments embedded with interactive functions might help students benefit more from the instruction. There is little data on whether learners who use self-regulated learning strategies in classroom settings also apply or generalize them in an online environment.

That is why it is necessary to design and test an online video-based interactive learning environment in an experimental study with undergraduate and graduate students.

There is reason to expect that learners' general self-regulated learning strategies will be applied and generalized in the online learning environment. Therefore, this study aims to examine whether learners perform better in an interactive learning environment than a non-interactive learning environment. To address study aims, I designed a computer program that records learners' behaviors while using elements in the video-based interactive learning environment.

Purpose of the Study

The purpose of this experimental study was to examine whether interactive functions in an online video-based learning environment scaffold students to transfer their self-regulated learning to online instruction, and enhance their performance. Data was collected on undergraduate and graduate students from a university located in southern Texas.

Specifically my objectives were:

a) To examine the effectiveness of the video-based interactive learning environment as an online learning tool.
b) To examine whether and how learners' level of self-regulation (assessed with questionnaires) is associated with learners' use of the video-based interactive learning environment.

c) To monitor students' use of self-regulation functions or elements of the video-based interactive learning environment and examine their contribution to learners' learning and performance.

Research Questions and Hypotheses

Three broad research questions and hypotheses that will be examined and tested in this study:

1. Does students' performance in online video-based learning differ depending on whether the environment is non-interactive or interactive?

It is hypothesized that students in the interactive environment will recall significantly more information about content presented than those in the non-interactive environment.

2. What is the relationship between students' self-regulation strategies and their situational (context-specific) self-regulatory behaviors when using the online video-based interactive learning tool?

It is hypothesized that students' self-regulation strategies level (using the Self-regulation Strategy Inventory; Cleary, 2006) will be positively correlated with their observed self-regulated learning behaviors (frequency of function use) in the newly designed online video-based interactive learning environment.

3. Do students' self-regulation behaviors in an online video-based interactive learning environment with embedded self-regulatory functions make a unique contribution to their learning and performance, above and beyond that from students' perceived self-regulation (i.e., self-regulatory efficacy)?

It is hypothesized that students' self-regulation behaviors (as scaffolded and supported) in the video-based interactive environment will provide unique prediction of their recall of the content presented.

Definition of Terms

Digital natives – Students who were born during or after the introduction of digital technology and are comfortable with using technology (Prensky, 2001).

Embedded functions – Functions that were added to the online video-based interactive learning environment in order to scaffold students' self-regulatory behaviors.

Interactive video – Refers to video environment that allows users to have control over the video or/and to enter their inputs to the video.

Online video-based interactive learning environment – This term is used in this dissertation as referring to a brand new video-based learning environment that was designed for this study.

Situational self-regulation – Refers to behaviors related to the use of the functions embedded in the online video-based interactive learning environment

Traditional learning environment – Teacher centered learning environment.

Zone of proximal development – According to Vygotsky (1978), zone of proximal development refers to "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86).

Outline of This Dissertation

This study was designed to investigate the effectiveness of a newly designed online video-based interactive learning environment, designed to support self-regulation strategies on students' learning activities and outcomes, compared to a learning environment that presents the same video-based content that without interactive tool. Chapter I has introduced the problem statement, the purpose of the study, research questions, and research hypotheses. In addition, it includes definition of terms of the dissertation. Chapter II provides a review of the literature on the theory of self-regulation, distance education, online learning, and video-based learning. Chapter III discusses the research methodology, participants, instruments used in the study, design and development of the online video-based interactive learning environment. It also summarizes the procedure of data collection procedure and data analysis. Chapter IV covers the results and findings of data analyses. Chapter V provides interpretation of findings for three research questions and evaluation of three hypotheses, followed by limitations and directions for future research. At the last section, a general conclusion and implication are discussed.

CHAPTER II

LITERATURE REVIEW

Self-Regulation

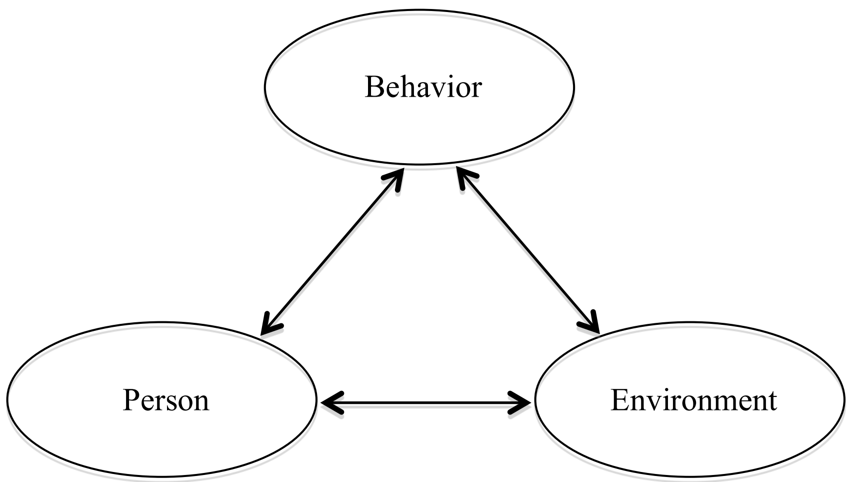
According to Zimmerman (1989), self-regulated learners "personally initiate and direct their own efforts to acquire knowledge and skill rather than relying on teachers, parents, or other agents of instructions " (p.329). In modern educational systems, we need to develop students to be more active and self-regulated in their learning processes than before, because education practices are trending from teacher-centered toward student-centered learning and instruction. With greater emphasis on learner-centered learning and instruction, students need to demonstrate self-regulated learning. When students have meta-cognitive, motivational, and behavioral control in their learning process, they can be described as a self-regulated learner (Zimmerman, 1989). Pintrich (2000) defined self-regulated learning as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior." (p. 453). In a society saturated by information, media, and technology, Liew, Chang, Kelly, and Yalvac (2010) proposed that self-regulated and self-directed learning need to be viewed as the bedrock of 21st century skills for all learners.

Theoretical Framework

This study is guided by Bandura's (1986, 2001) social cognitive theory. In social cognitive theory (Bandura, 1986), human behavior is viewed as motivated and regulated by the ongoing influence of self-influence or self-regulatory mechanisms (see Figure 1).

Zimmerman's (1989) model of self-regulated academic learning was based on Bandura's (1986) triadic theory of social cognition, consisting of reciprocal interactions between the person, behavior, and environment (Figure 1).

Figure 1 Bandura's Model of Reciprocal Interactions



Zimmerman stated in his triadic model that personal process, the environment, and behavior are three factors of self-regulation. Self-regulated learners should be aware of the learning environment and try to use appropriate strategies and activities to support their self-regulation. These activities are also key elements of determining students' motivation and action (Bandura, 1989).

Zimmerman (1989) identified self-regulated strategies to "improve students' self-regulation of their (a) personal functioning, (b) academic behavioral performance, and (c) learning environment" (p.337). When these strategies are embedded in instruction, they support learners to self-regulate themselves (Ley & Young, 2001). According to

Zimmerman's model (2002), self-regulation is not an innate personal characteristic and learners can improve their self-regulation abilities and become more self-regulated especially when they are trained with self-regulation strategies (Wang, Quach, & Rolston, 2009). Thus, in the present study, learners' self-regulation strategies are hypothesized to be related to their use of self-regulation behaviors in the online video-based interactive learning environment. A growing body of research on self-regulation and self-regulatory strategies show positive relationship with academic performance (see Ablard & Lipschultz, 1998; Dermitzaki, Leondari, & Goudas, 2009; Magno & Lajom, 2008; Purdie & Hattie, 1996; Vermunt, 2005). For instance, Zimmerman and Martinez-Pons (1986) studied eighth grade students and found that high achievers and low achievers differed on their self-regulation, and their self-regulation strategies contributed to their academic performance. Thus, evidence supports the view that using self-regulation strategies in instruction may help to reduce the achievement gap (Young, 1996). With technology increasingly used to facilitate learning, the use of educational technology that considers individual differences in learners' self-regulation may serve as a powerful tool for all learners, especially low academic achievers. Students tend to self-regulate themselves (and continue doing it) when they experience self-efficacy and a sense of achievement and mastery through successful learning experiences (Cleary, 2006; Greene, Costa, Robertson, Pan, & Deekens, 2010; Zimmerman, 1990).

Self-regulation strategies and skills enable individuals to direct their own learning and to "achieve desired academic outcomes on the basis of feedback about learning effectiveness and skill" (Zimmerman, 1990, p. 7). Self-regulation strategies and skills could be targeted and supported in one or more of the factors in Zimmerman's (1989) triadic model of self-regulation (person, behavior, or environment). Designing learning environments that support learners' self-regulation based on the affordances and capacities or needs of the person, behavior, or environment may maximize learning (Ley & Young, 2001). According to Bandura (1989), "people tend to avoid activities and situations they believe exceed their coping capabilities" (p.1178). That is why it is essential to foster learners' self-efficacy and scaffold learners with successful learning experiences while providing adequate learning challenges (Pintrich, 1999a). Schunk and Zimmerman (2007) stated that students might have different self-regulation skills; therefore, learning environments could be designed to compensate for and scaffold learners with poor self-regulation while also challenging and advancing learners with good self-regulation.

Self-Regulation Strategies

The literature on self-regulation often classifies and clusters self-regulation strategies into three broad groups: personal, behavioral, and environment (Zimmerman, 1989). Each group of self-regulation strategies corresponds to one element in Zimmerman's (1989) triadic model, with some overlap or shared elements between the factors in the model.

a) Personal regulation. It is essential for learners to be aware of what and how they learn (e.g., goal orientation and metacognition). Before and during the learning process, learners may follow some strategies and optimize their personal regulation.

Organizing and transforming, goal setting and planning, rehearsing and memorizing are the self-regulation strategies that support personal regulation (Zimmerman, 1989).

Previous studies show that these metacognitive strategies have positive effects on academic performance when they are properly embedded into learning activity. For example, Zimmerman, Bandura, and Martinez-Pons (1992) stated the usefulness of setting goals in learning process as a self-regulation strategy and found its positive effect on academic outcome. Wolters and Rosenthal (2000) studied five motivational strategies and concluded that setting and focusing on learning goals had very strong correlations with other self-regulation strategies, and it is essential to learn goal orientation in order to keep engaged in assigned tasks and overcome motivational problems. Goal setting is also important for next phase of self-regulation (behavioral functioning) because learners should have some goal or criterion to be able to monitor and evaluate (Pintrich, 1999a).

In addition to metacognition, goal orientation also plays a key role in improving self-efficacy, which is also related to student performance (Greene et al., 2004; Pintrich, 1999a; Schunk, 1991, 2003). Additionally, the way of using these strategies may change according to the subject area and context (Wang et al., 2009). For instance, a student can draw content maps in biology course to organize and transform his knowledge while another student uses a clock to check how much time he spent in writing take home essay.

b) Behavioral functioning. There are some strategies that improve learners' behavioral functioning. Because self-regulated learners have active roles in self-regulation practice, they should perform some activities by themselves such as *self-*

evaluation and self-consequences, and keeping records and monitoring. These strategies are useful for learners to motivate themselves and correct their studying behaviors to perform better (Pintrich, 1999b).

Bandura (1989) mentioned the importance of "self" based activities on personal behavior change as follows: "In acting as agents over themselves, people monitor their actions and enlist cognitive guides and self-incentives to produce desired personal changes" (p. 1181). Researchers have found that personal changes have positive effects on learners' performance. For example, Wolters and Rosenthal (2000) stated that high achievers who also want to perform well used self-consequating strategies (i.e., choosing one's own rewards or consequences based on own performance) more often than low achievers.

Students can be aware of their progress and improve their performance by using self-monitoring strategies. These strategies are not only useful for regular students, but also for students with special needs (Menzies, Lane, & Lee, 2009). In regard to students with special needs, Goddard and Sendi (2008) studied the effects of using self-monitoring strategies in fourth grade students with learning disabilities, and found significant positive effects of self-monitoring on students' writing.

c) Learning Environment. Self-regulated learners influence their own learning through their personal beliefs and behaviors about the environment, but the environment also influences learners' personal beliefs and behaviors (Bandura, 1989). There are some self-regulation strategies that are related to learners' immediate learning environments (Zimmerman, 1989) such as *environmental structuring, seeking information, reviewing,* *and seeking assistance*. Suitability of the learning environment for these strategies is essential and influences personal and behavioral functioning as discussed in the triadic model. According to Bandura (1989), learners "are just as much agents influencing themselves as they are influencing their environment" (p. 1181).

There is a growing body of evidence showing that the environment plays a significant role in supporting self-regulation and academic performance (Garner, 1990; Ley & Young 2001). "Self-regulated learners are those who demonstrate persistence and are able to adapt or modify their learning strategies or their environment in order to achieve their learning goals" (Liew et al., 2010, p. 63). However, for learners who may exhibit poor self-regulation, external supports provided by a well-designed learning tool or learning environment that intentionally embeds self-regulation strategies into instruction may support and enhance students' self-regulatory skills (Bernacki, Byrnes, & Cromley, 2012). For instance, in an online environment, optional additional resources (e. g., image, animation, and graphic) can be provided to learners in order to make them use the seeking information strategy. It can be noted that, most of the self-regulation strategies are voluntarily based and their effectiveness depends on their usage frequency.

Learning environments that allow students to practice self-regulation skills would be able to foster students to gain from and internalize or automatize these skills (Schunk & Zimmerman, 2007). According to Zimmerman (1989), "all learners try to self-regulate their academic learning and performance in some way, but there are dramatic differences in methods and self-beliefs among students" (p. 6). Thus, self-regulation strategies for online learning environments need to recognize and meet the self-regulatory needs of diverse learners. Importantly, methods and strategies that have been found to be important for learners of various ages and backgrounds have been suggested in the literature that will be followed in this study (see Bernacki et al., 2012; Ley & Young, 2001; Liew et al, 2010).

Distance Education and Online Learning

Distance education in the 21st century often relies on educational technology as the primary delivery of teaching to learners. In distance education, the source of the information and the learner do not share the same physical setting; therefore, the information is delivered by a variety of methods (Carswell & Venkatesh, 2002; Keegan, 1986). According to McIsaac and Blocher (1998), the goals of distance education are "to provide degree granting programmes, to battle illiteracy in developing countries, to provide training opportunities for economic development, and to offer curriculum enrichment in non-traditional education settings" (p. 43).

Development of distance education has been linked to improvements in technology, and different delivery methods have been used including "Print materials, broadcast radio, broadcast television, computer conferencing, electronic mail, interactive video, satellite telecommunications and multimedia computer technology" (McIsaac & Blocher, 1998, p.43). Emerging technologies play key roles in distance education, particularly for making the education accessible by learners at any time and from any place (Beldarrain, 2006).

Based on technologies and procedures used in distance education, there are two communication methods of delivery: synchronous and asynchronous. Researchers have discussed the advantages of choosing one method over another (see Branon & Essex, 2001; Carswell & Venkatesh, 2002; Johnson, 2006; Offir, Lev, & Bezalel, 2008). In synchronous learning, learners are supposed to follow and interact with instruction in a specified time, whereas in asynchronous learning, learners are free to choose when to access the educational materials.

Educational institutions have moved toward the use of online delivery systems after computer and internet technology became more accessible, and these online delivery systems provide numerous opportunities for using synchronous and asynchronous delivery systems depending on providers' demand (Beldarrain, 2006).

Online Learning

With the rapid growth of digital technology, students in the 21st century have changed in numerous ways. They are surrounded with digital devices in their daily life, and they do not need to expend extra effort to get used to them because "technology is assumed to be a natural part of the environment" (Oblinger, 2003, p. 38). However, teachers who came from previous generations have some difficulties adjusting to new technologies and using them in their teaching. Prensky (2001) stated, "Our students have changed radically. Today's students are no longer the people our educational system was designed to teach" (p. 2). Prensky (2001) differentiated "Digital Natives" from "Digital Immigrants". Digital Natives include students who were born during or after the introduction of digital technology and are comfortable with using technology, while Digital Immigrants are teachers who try to use technology clumsily like second language learners (Prensky, 2001). In this definition, we can understand that there has been a gap in perceptions of technology among Digital Natives and Digital Immigrants.

Dissemination of online learning environments in the 21th century has given more learning opportunities (e.g., distance education) to *Native Learners* and more responsibilities to course instructors. That is why "technology tools may also change the roles of learners as well as instructors" (Beldarrain, 2006, p. 143). The new emerging tools that are used in online learning have changed the view of pedagogical perspective in distance education as well. Additionally, teachers have taken the role of teaching students how to direct their own learning (Cerezo et al., 2010).

There are many definitions of online learning in the literature and they describe the practice of online learning as a way of instruction via computer or mobile devices with Internet connections. Ally (2004) broadened his view of online learning and defined it as

> the use of the Internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience. (p. 5)

When designing online learning courses, there are several points that should be considered. For example, Oblinger and Hawkins (2006) stated, "Developing and delivering effective online courses requires pedagogy and technology expertise . . . it [online instruction] requires deliberate instructional design that hinges on linking learning objectives to specific learning activities and measurable outcomes" (p. 14). It is not always likely for an instructor to have these two skills (pedagogy and technology) together. That is why, most of the time, responsibilities of online courses need to be shared between an instructor who is pedagogically skilled and a person with technical skills. Otherwise, students will be reading papers and visiting websites that are provided online by the instructors, which is not a satisfactory way of online instruction.

Although online learning shares some elements with traditional classroom environments, the shared elements often take very different forms, and each type of learning environment has distinct limitations and affordances. For example, interaction is a very important part of the instruction process and it is challenging to facilitate the same type of dynamic, collective interaction online (Childers & Berner, 2000; Oblinger & Hawkins, 2006). On the other hand, there are many benefits of online learning environments including flexibility of access regardless of time and place Ally (2004), and these environments can be used effectively after eliminating the potential barriers (see Galusha, 1997; Muilenburg & Berge, 2001).

Because current practices often compare or assess the effectiveness of online learning by comparing it with traditional instruction methods, educators and researchers often find it important to consider the methods and strategies that are used in classroom settings when designing online learning environments. Online environments should provide opportunities for students to master necessary tasks by using appropriate strategies, such as self-regulation (Santhanam, Sasidharan, & Webster, 2008). Well-designed learning environments facilitate improved self-regulatory skills (Boekaerts, 1999), and are needed for successful learning (Azevedo & Cromley, 2004).

It should also be noted that online course instructors are more likely to have pedagogical and technological problems than face-to-face course teachers (McIsaac & Craft, 2003). Therefore, "online learning materials must be designed properly, with the learners and learning in focus, and that adequate support must be provided." (Ally, 2004, p. 4).

Wide learning groups have been interested in online learning in the first decade of 21st century, because of its potential to serve learners by offering learning with flexible times and reasonable costs (Howell, Williams, & Lindsay, 2003). Because learners come from diverse backgrounds (Rovai & Downey, 2010), and their availabilities vary, they take advantage of comprehensive online learning opportunities with affordable cost. Radford (2011) reported that learners who are over 30 years of age, married or have work obligations (e. g., employed full time) tend to benefit from distance education opportunities more than others. He also stated the following:

> From 2000 to 2008, the percentage of undergraduates enrolled in at least one distance education class expanded from 8 percent to 20 percent, and the percentage enrolled in a distance education degree program increased from 2 percent to 4 percent. (p. 3)

Self-Regulation in Online Learning Environments

Self-regulation is one of the predictors of student performance in both traditional and modern learning environments. In an online platform, when students use strategies that are related to self-regulation, they can regulate their personal functioning and benefit from the online learning environment by changing their behaviors accordingly. In online learning environments, learners are supposed to control their own learning practice in order to benefit from the instruction; hence, self-regulation strategies can help them in this process (Chang, 2005).

Usage and scope of self-regulation in online learning environments have changed with improvements in Internet technology. Although in its nascent stage, online learning environments are increasingly being designed to offer learners with self-regulation support and to foster self-direction in students' use of self-regulation strategies and tools. However, it is very important for learners to be able "to select, combine, and coordinate cognitive strategies in an effective way" (Boekaerts, 1999, p. 447). Examining self-regulation in online learning environments also facilitates obtaining more accurate information from students because students' behaviors could be logged or recorded to identify students' use of strategies or functions and their effectiveness (Bernacki et al., 2012; Biesinger & Crippen, 2010.

In the process of transferring instruction through Internet, several learning management systems (LMSs) (e. g., WebCT, Blackboard, Moodle) that are either commercial or open source have been used. Especially, higher education institutions commonly use these LMSs in their online degree programs. That's why their suitability for self-regulation is essential for students. In this regard, Cerezo et al., (2010) reviewed most commonly used LMSs and found that they have several useful functions that support self-regulation. However, students may not be knowledgeable about the role of these functions in supporting their self-regulation. Therefore, informing and guiding students can increase the benefit of the self-regulation functions during the learning process.

Previous research has investigated the effectiveness of self-regulation strategies in online learning and hypermedia-learning environments from various perspectives. Although there are several researches on hypermedia learning environments, limited research exists on online learning environments in regard to self-regulation. In a study on self-regulation in online learning environments, Chang (2005) examined 28 vocational university students enrolled in a web-based course and focused on their motivation perception and how it changed regarding to self-regulatory activities including recording study time, writing journals, and reflective summaries. Results indicated that using self-regulatory strategies in a web-based instruction increased students' learning motivation after one semester (Chang, 2005).

It is accepted by researchers that learners can improve their self-regulation by using and experiencing activities aimed at training meta-cognitive strategies, executive attention, and emotion regulation. Delfino, Dettori, and Persico (2010) conducted a study with trainee teachers and examined the use of self-regulation activities in an online course. In their study, Delfino and colleagues assigned four different tasks to trainees, which aimed to foster self-regulation. These activities were linked to self-regulatory behaviors including planning, monitoring, and evaluation. The online course was designed properly for course takers and allowed them to accomplish the tasks by using self-regulation strategies. It was reported by Delfino et al. (2010) that online courses could foster learners' self-regulation when relevant activities are embedded into the instruction.

There are some factors that influence the use of self-regulation strategies in online learning environments. For example, Bernacki et al. (2012) studied 160 undergraduate students to investigate the relationship between achievement goals, self-regulation strategy use, and comprehension scores in a hypermedia-learning environment. Students' self-regulation related actions such as note-taking, seek information, and monitoring were recorded. Path model analyses indicated that self-regulation strategy use was a mediating mechanism between achievement goals and academic performance. Specifically, achievement goals predicted self-regulation strategy use, which then predicted the student performance in a hypermedia environment (Bernacki et al., 2012). Thus, use of self-regulation strategies predicts academic performance in an online learning environment.

Student engagement or involvement in the learning process is critical for academic performance, particularly when students are low-achievers and the learning environment is online. In this regard, Lee, Shen, and Tsai (2010) designed an online course that supported self-regulation strategies, and they examined its effects on students' engagement or involvement in learning. At the beginning of the course, students met with the instructors and took advice to develop their self-regulation skills. After one semester long online course, it was found that students increased their involvements in online learning environment by self-regulatory behaviors (Lee, Shen, et al., 2010). This study clearly shows us the need of teaching students the self-regulation strategies and their benefit in online learning environments. In a randomized experiment, Azevedo and Cromley (2004) randomly assigned 131 undergraduate students to one of two conditions (training condition or a control condition). In the training condition, students were trained 30 minutes on the use of self-regulation strategies and control group did not get any training. Then students were given a science course in a hypermedia environment to learn about the circulatory system. Study results indicated that students who were trained to use self-regulation strategies learned more on complex topics in the hypermedia environment than students without training (Azevedo & Cromley, 2004).

In another study that explored whether self-regulation strategies could be taught, and whether self-regulation strategy use could improve students' learning in online learning environments, Santhanam et al., 2008 found that when learners are taught how to use self-regulatory learning strategies, they tend to apply them more in their learning. The authors suggested that self-regulation is critical to successful learning and performance in online learning environments and embedded self-regulation strategies could foster learners' self-regulation learning strategies and this enhance learning outcome.

Video-Based Learning and Self-Regulation

Videos have been used for learning purposes both in distance learning environments and traditional classroom settings. Video-based distance education could be traced back to the introduction of television as an instructional medium as early as the 1940s, with learners taking advantage of instructional video through television broadcastings or video cassette players, and it was continued to be used in different forms, such as CD-ROMs and online streaming. There have been numerous improvements in video technology including its resolution quality and delivery speed (Maniar, Bennett, Hand, & Allan, 2008) with the development of other types technologies such as multimedia and communication (Wieling & Hofman, 2010; Zhang, Zhou, Briggs, & Nunamaker, 2006), and today it is mostly used with online video streaming very easily (Hartsell & Yuen, 2006). Moreover, perceptions of video-based learning have changed. For instance, video-based learning has improved and evolved from linear streaming, which may be difficult for learners to remain engaged and to follow instructional content through television broadcasting to interactive video that actively engages learners in the learning process (Merkt, Weigand, Heier, & Schwan, 2011; Shephard, 2003).

Interactive video, as a term, has evolved over time. Previously, simply being able to play, pause, or forward the video streaming was accepted as using the video interactively. However, with the emergence of new technology, new techniques have been embedded to videos to use them more interactively such as question and feedback features. Petty and Rosen (1987) defined the role of a user in interactive environment as "actively participates in the learning situation and that the user has at least some control of the information presented"(p. 161). With embedded functions, interactive videos would help students in several ways, including increasing attention and involvement (Hannafin, 1985; Hartsell & Yuen, 2006). Students could have more control and actively participate in their own learning through interactive video-based instruction (Kumar, 2010). When instructional videos are non-interactive, they are not user friendly, and users have less control and are not afforded opportunities to be self-directed in their learning. For instance, they don't allow users to "directly jump to a particular part of a video" (Zhang et al., 2006, p. 17).

Using video as an instructional tool has many advantages for students at distance. First, it eliminates the requirement of presenting in a specific place in a specific time. Second, it reduces the cost in a long term because many users, with one production cost, can use a prepared instructional video with its consistent content (Zhang et al., 2006). In distance learning, based on communication methods of delivery, there are two methods: synchronous and asynchronous. When it is synchronous, users need to be ready to watch the video either online or through broadcast in a specific time (e. g., live lecture). In this type of learning method, learners may have a chance to interact with the instructor or other users synchronously, and benefit from live communication. This communication could be in different forms, and students could collaborate remotely and discuss the content (Zhang et al., 2006). On the other hand, in an asynchronous condition, users are not required to watch the video in a specific time. Instead, the video is available for watching in a time period (e. g., one week for each chapter) and they can have access to video from anywhere (Hartsell & Yuen, 2006). In this circumstance, learners use the benefit of time span while losing live interaction opportunity. It needs to be considered that there have been several technical limitations of instructional videos especially when they are streamed online (Hartsell & Yuen, 2006). However, the majority of technical shortcomings are often able to be addressed or resolved over time with continual advances in technology, infrastructure, and supports.

It is important to note that distance learners usually choose distance programs due to constraints or conflicts with timing or scheduling, or not being able to be physically present at specific locations. Therefore, distance learners often prefer to use asynchronous methods when taking distance courses. Nowadays, distance programs are mostly provided by online learning systems, and instructional videos are embedded to these systems directly or indirectly. The simple way for instructors is to upload the instructional video online and share the link with students (e. g, YouTube). This method may not be efficient for all content and all target learners because although it gives users limited flexibility on using the online video stream with control functions (e. g., play, pause), it is also open to distractions. For instance, one could open an online video, and at the same time start doing other things such as visiting other webpages and checking emails.

As with other teaching techniques, students' attention needs to be grabbed in a video-based learning method. Hannafin (1985) pointed that "some potential limitations of video may be minimized through interactive video" (p. 241). Because learners are alone (self-directed) when they learn from video-based content, learners need to be engaged with instructional video in order to learn from its content. As indicated above, video itself may not be enough to engage and to allow learners opportunities for self-efficacy and self-directed learning. Therefore, videos need to be enriched with additional functions and strategies so that the video becomes *interactive*.

For this purpose, useful learning theories, such as self-regulation, could be used when designing video-based learning instruction. Students have been encouraged to use self-regulatory learning strategies in order to have better academic performance through regulating their learning process. Zhang et al. (2006) noted that academic outcome could be increased by self-directed and interactive learning opportunities. Therefore, while designing a video-based interactive learning environment, some strategies that support self-regulation could be embedded into the environment.

These strategies not only make the learning more effective but also transform the environment into a more enjoyable form (Petty & Rosen, 1987) and promote students' skills such as problem-solving (Hartsell & Yuen, 2006; Kumar, 2010; Shyu, 2000) and critical thinking (Zhang et al., 2006). According to Schwan and Riempp (2004), presenting information in different forms such as interactive video helps students to control their learning because "contents can be customized according to the cognitive needs of users" (p. 294). During the instruction, students need to have an active role and self-regulation skills in order to optimally benefit from videos (Merkt et al., 2011). Both the video-based interactive environment and self-regulatory strategies need to fit very well in order to get the high benefit and avoid potential cognitive loads (Schwan & Riempp, 2004). Kozma (1994) indicated this relation as follows: "in good designs, a medium's capabilities enable methods and the methods that are used take advantage of these capabilities" (p. 16). Allowing learners to use these self-regulation strategies in video-based interactive environments is essential because it gives learners the flexibility for self-paced learning while supporting their motivation and engagement (Hartsell & Yuen, 2006).

Well-designed online video-based learning environments could also assist learners in their learning process as instructional scaffoldings. According to Vygotsky's (1978) developmental theory, learners improve their learning skills when they are assisted by more advanced or proficient ones (e. g., teachers, peers) and interact with their environments. He also argued that there is a zone of proximal development, which refers to "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). This external guidance could be in various forms including "prompts, clues, modeling, explanation leading questions, discussion, joint participation, encouragement and control of child's attention" (Miller, 2002, p. 377).

Sociocultural psychologists have used *instructional scaffolding* to explain the relationship and interaction between learners and their guides. It can be described as "process that enables a child or a novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross, 1976, p. 90). The level of assistance needs to be adapted in the learning process depending on learners' need. During this assistance and interaction, participation is expected from the learner in order to facilitate a higher level of thinking and problem solving (Rogoff, 1990). It should be noted that scaffolding is an interactive and reciprocal process that keeps both learner and teacher active in learning (Bull et al., 1999).

In the context of online learning environments in education, Vyotsky's concept of zone of proximal development and scaffolding can be effectively applied to support and optimize students' learning, problem solving, and achievement, or performance. Computer tools have been effectively used as scaffolds for learners (Yelland & Masters, 2007) and as tools to support the process of scaffolding (Bull et al., 1999), such as links to other resources, visual cueing, adaptive presentation of content, and alternative experiences.

In traditional instruction methods, students interact with teachers in order to benefit from instructional scaffolding. In video-based learning environments, the condition is different. Therefore, several techniques that support self-regulation could be embedded into the video-based learning environment. Scaffolding could be delivered to students via these self-regulatory actions such as providing additional information or encouragement when needed. Hadwin and Winne (2001), for example, suggested using an electronic notebook to scaffold students by using several embedded functions (e. g., glossary and note-taking) that support self-regulation in reading.

There is a growing body of research on interactive video that examines its benefit in various areas including medical education (Whitten, Ford, Davis, Speicher, & Collins, 1998), teacher education (Marsh, Mitchell, & Adamczyk, 2010; Sariscsany & Pettigrew, 1997), health and security training (Cherrett, Wills, Price, Maynard, & Dror, 2009), motor skill practice (Shyu & Brown, 1995). However, there is a limited amount of research that studied interactive video with the concept of self-regulation.

Zhang et al. (2006) examined the effectiveness of four different learning settings including three e-learning platform with interactive video, with non-interactive video, without instructional video and a traditional classroom. The authors focused on whether students' performance and their satisfaction level differ under different learning conditions. The results showed that students in the interactive video group performed better than students in the other groups and had the higher satisfaction level when compared to others. Students had positive opinions for interactive video environment because of available interaction (Zhang et al., 2006). The results also provided strong support for the study of Sariscsany and Pettigrew (1997). In their study, they used interactive video training methods for undergraduate teacher training program and found that when preservice teachers are trained via interactive video, they gained more on declarative knowledge of classroom management when compared to other settings which were teacher-directed video tape and traditional lecture instruction (Sariscsany & Pettigrew, 1997). In a similar study, Merkt et al. (2011) studied secondary school students to compare interactive videos and traditional textbook in history content. The results indicated that students in video groups could perform as well as students in textbook group. It was reported by authors that students in video groups tend to use simple embedded activities (e. g., stopping the video or browsing) rather than advance activities (e. g., referring to a table of contents). Merkt et al. (2011) also argued that the comparable success of students in video groups was due to embedded functions that supported self-regulated information processing.

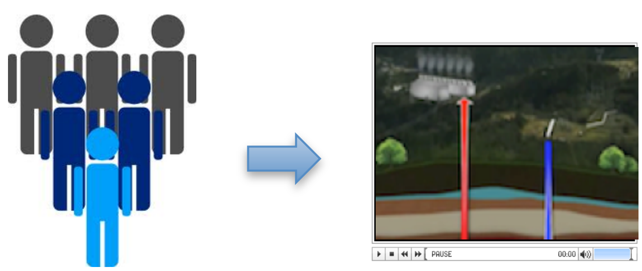
In another study, Schwan and Riempp (2004) used both interactive and non-interactive video method to investigate their effectiveness in learning how to tie nautical knots. This study was aiming to see video-based instruction's role in motor skill practice. As expected, learners in interactive group were more successful than non-interactive group. It was also found that, students tend to use interactive functions during the more difficult parts of the task process (Schwan and Riempp, 2004). This result supports the idea that interactive video could be used to achieve complex topics. In summary, studies suggest that video-based learning, particularly when embedded with interactive functions, enhance student learning and engagement.

CHAPTER III

METHOD

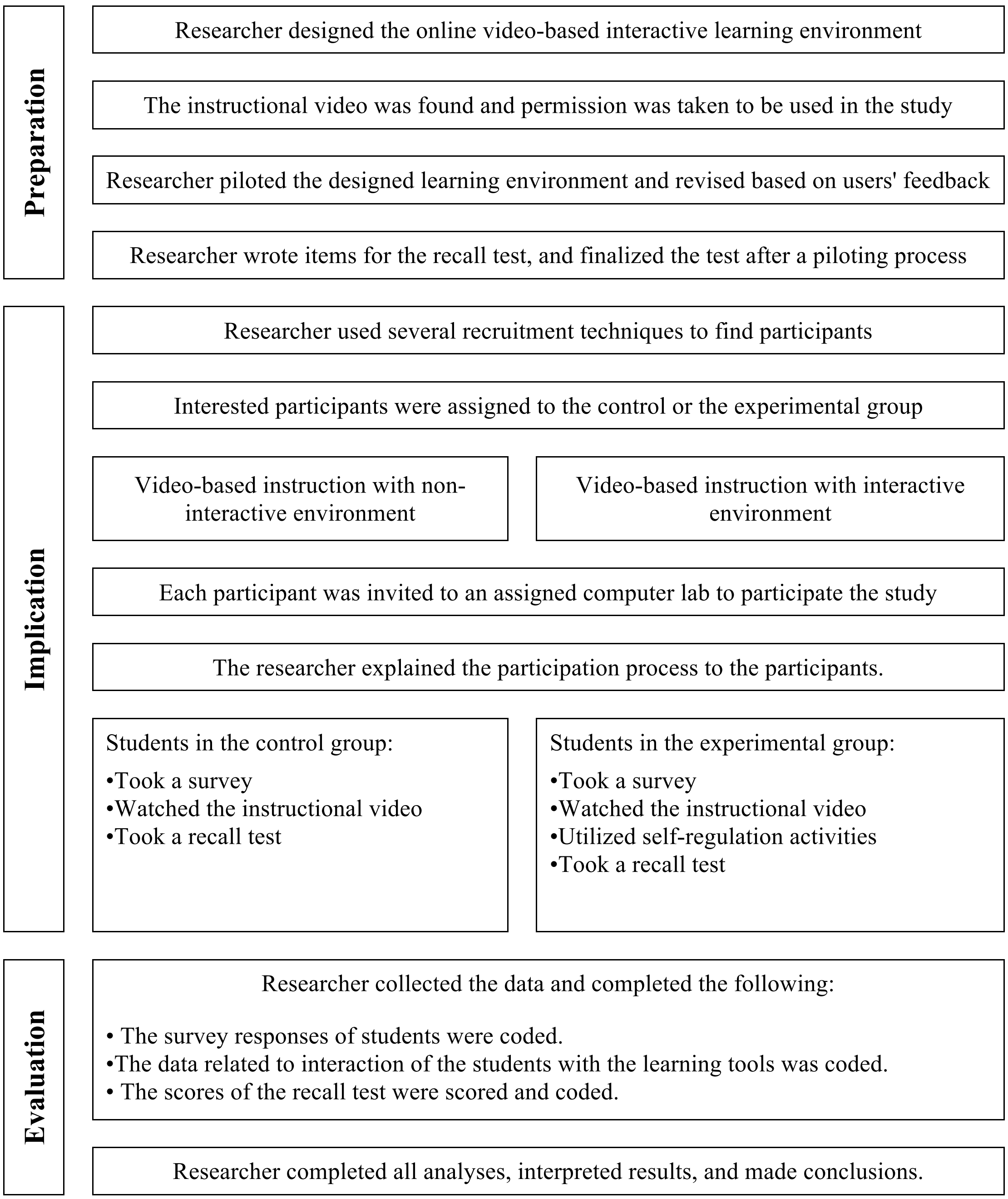
To address research questions and test the study hypotheses proposed in this dissertation, I utilized a cross-sectional experimental research design with one control group (CG) with a non-interactive video environment (see Figure 2) and one experimental group (EG) with an interactive video environment. For the EG, I designed a brand new online video-based interactive learning environment (see Figure 5) that aimed to foster student' self-regulatory activities through embedded interactive functions, and tested the effectiveness of the environment by comparing students' performance in both conditions. The study was conducted in the spring semester of 2013, and the data collection procedure took around three months. Figure 3 shows the sequence of activities that implemented for this study.

Figure 2 The Control Group With Non-Interactive Video



Approval from the Institutional Review Board (IRB) was obtained prior to data collection. The remainder of this section will describe the participants, instruments, design and development of the online video-based interactive learning environment, procedures, as well as the conducted analyses.

Figure 3 The Sequence of Activities of This Study



Participants

The participants of this study were undergraduate and graduate students from a university located in southern Texas. Several recruitment methods were used to invite students to the study including class visits, emailing faculty members, and posting flyers. Participation was voluntarily. Interested students contacted the author and set up a time to come to an assigned computer lab to participate the study. Informed consent was obtained from all participants prior to the data collection process. Table 1 displays the detailed demographic information about the participants including gender, age, education, and major.

Table 1

Gender, Age, Education, and Major of the Participants

	Frequency	*Percent*
Gender		
Male	30	38%
Female	50	63%
Age		
18-25	46	58%
26-30	27	34%
>30	7	9%
Education		
Undergraduate	39	49%
Graduate	41	51%
Major		
Educational Psychology	30	38%
Interdisciplinary Studies	17	21%
Psychology	8	10%
Teaching, Learning & Culture	8	10%
Civil Engineering	3	4%
English	2	3%
Physics	2	3%
Other	10	13%

Note. n=80.

Systematic random assignment procedure was utilized to assign participants into one of the two groups. The names of the students interested in the participating in the study were stored in a spreadsheet according to their contact time, and every 5^{th} student was assigned to the control group. As a result, 16 students were assigned to the control group, and 64 students were assigned to the experimental group. The reason of keeping the number of students higher in the experimental group was to acquire sufficient data from the group to use in the analyses for the second and the third research questions. Data from two of the participants were excluded from analyses because they had taken a course related to renewable energy and their majors were in fields related to the content of the video that was used in the study, which would bias their performance in the study.

Instruments

Data was collected using three primary measures: (a) a survey of student self-regulation level (using the Self-regulation Strategy Inventory (SRSI); Cleary, 2006), (b) recall test of video-based content, (c) the frequency of students' usage of the functions embedded in the online video-based interactive learning environment (situational self-regulation).

The SRSI was developed by Cleary (2006), consisting of 28 items with three subscales: (a) Seeking and Learning Information (8 items: α for this study = .724), a sample item: "I think about the types of questions that might be on a test", (b) Managing Environment/Behavior (12 items: α for this study = .823), a sample item: "I quiz myself to see how much I am learning during studying", and (c) Maladaptive Regulatory Behaviors (8 items: α for this study = .64), a sample item: "I give up or quit when I do not understand something” Cleary (2006). Items in the Maladaptive subscale were reverse, thus they were reverse scored and the subscale was renamed as “Adaptive“ during the data analysis. The SRSI aims to measure students’ general self-regulation level by asking them questions (see Appendix A, for more details) about their study habits. The scale has been used in various studies with different languages and subject contexts (see Cleary, 2006; Cleary & Chen, 2009; Cleary, Platten, & Nelson, 2008; Madjar, Kaplan, & Weinstock, 2011).

In order to assess students’ performance after video-based instruction, a recall test was developed based on the video-content (renewable energy sources). First, the author made several sample items, and a professor with test development expertise reviewed the questions. After the review process, some items were revised, and some other items were removed from the test. As a result, 20 items were included to the test (see Appendix B, for more details). Then, the test was piloted among several students. After the pilot, the results were satisfactory. The reliability (Cronbach’s alpha) of the recall test was .74.

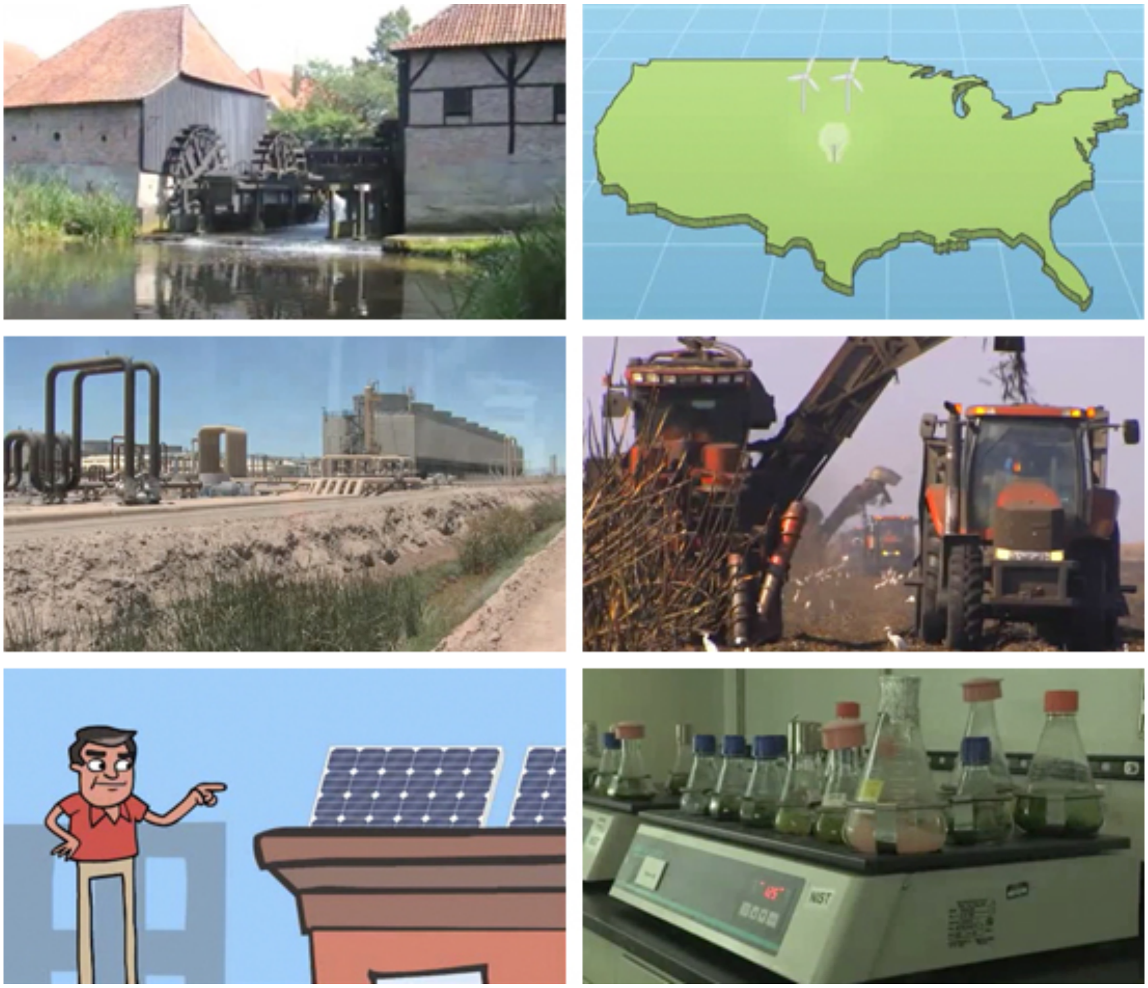
Students’ situational self-regulation, which referred to their behaviors while using the online video-based interactive learning environment, was measured by continuously tracking their frequency of usage of the embedded functions during the instruction. For students in the experimental group, three situational self-regulation scores were calculated based on (a) frequency of viewing additional resources, (b) frequency of answering practice questions, and (c) number of added interactive notes.

Additionally, data on spent time using the video-based learning environments was tracked during the instruction

The Instructional Video

During the study, an instructional video was used, which consisted of the combination of several educational videos related to renewable energy sources. The length of the final video was approximately 16 minutes. These videos were taken from eneryNOW!, a website designed to inform and engage Americans on energy issues using an online news magazine format. Permission to use the instructional video for academic and research purposes was granted from energyNOW!. The video content was selected for this study because it contained many facts that could be learned by the participants during the instruction. The video covered six different renewable energy sources including hydropower, wind energy, geothermal energy, biomass energy, biofuel energy, and solar power. Figure 4 shows several sample scenes from the video. After the instruction, students' performance in the control and experimental groups was evaluated based on recalling the information gained from the video.

Figure 4 Scenes From The Instructional Video



Design and Development of The Online Video-Based Interactive Learning Environment

According to Zimmerman (1989), learners utilize self-regulation strategies that are in one of three categories: personal, behavioral, and environmental. Guided by the research by Bandura (1989) and Zimmerman (1989), the interactive learning tool was designed to support and scaffold student' self-regulatory skills in the personal, behavioral, and environmental categories. Taking individual differences in learners' self-regulation into consideration, functions were embedded into the environment to meet diverse needs or styles of learners while limiting the number of functions to avoid potential cognitive load (Schwan & Riempp, 2004). Thus, functions were designed to be simple and effective.

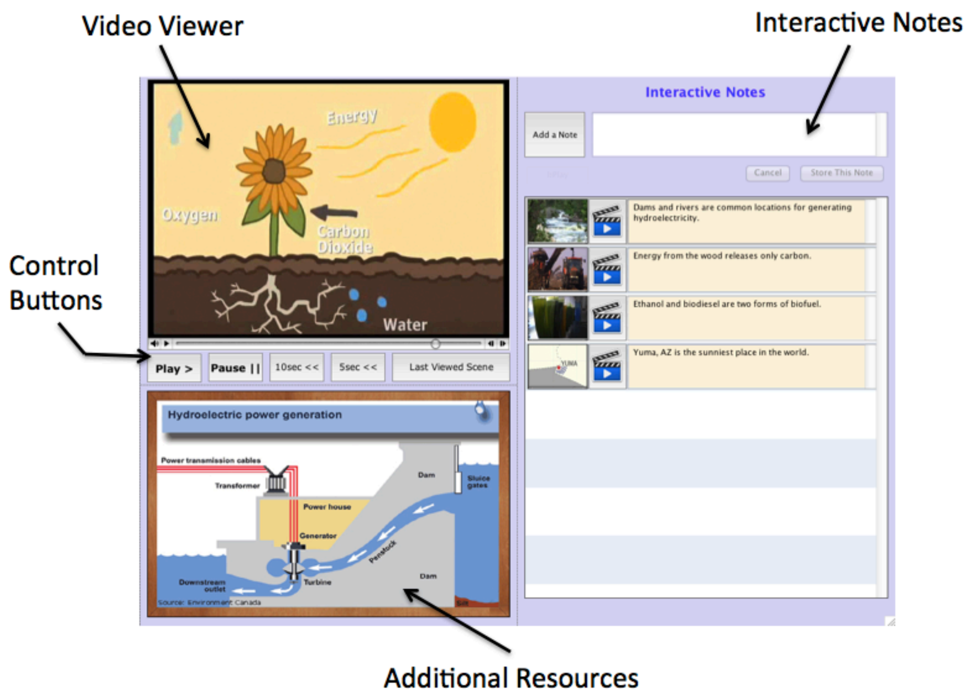
In order to design a user friendly and effective learning environment, a software development tool named LiveCode 5.5.2 was used. LiveCode was selected because it has a comprehensive coding library especially for programming educational and data collection tools. Moreover, programs built using LiveCode can operate in all popular platforms including Apple, Windows, Linux, iOS, and Android.

After the online video-based interactive learning tool was designed and developed, it was pilot tested with several students and programing experts, and modifications were made based on users' feedback. The final version of the tool was saved as a standalone application to be run in Apple platform.

Integrated Components and Their Goals in The Online Video-Based Interactive Learning Environment

a) Video Viewer. There was a video viewer in the environment that showed the video content to the students. This player was enriched with several embedded control buttons (play, pause, 5 sec backward, 10 sec backward, and last viewed scene). The video became more interactive with these additional control buttons (see Figure 5), which also afforded control to the students over the video, and supported their self-directed learning and self-efficacy (Kumar, 2010). For instance, they were able to jump to the last viewed scene just by clicking to a button.

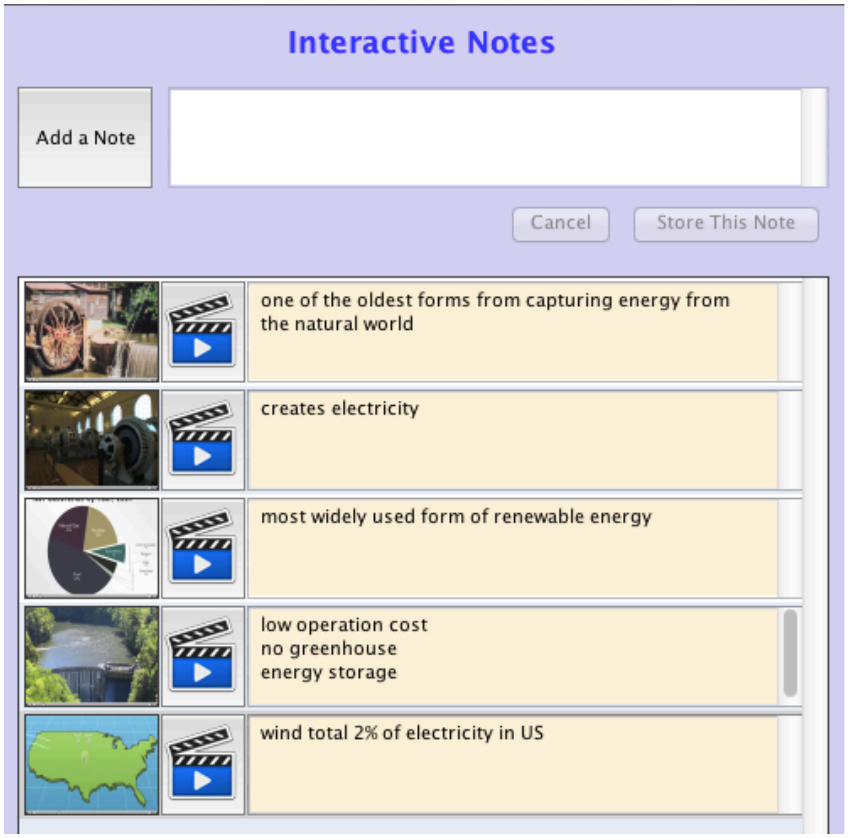
Figure 5 The Online Video-Based Interactive Learning Environment



The video content was the main instructional source for learners during the instruction. In addition, the video player guided and scaffolded students to perform self-regulatory activities during the instruction. These activities afforded students opportunities to engage with the video content.

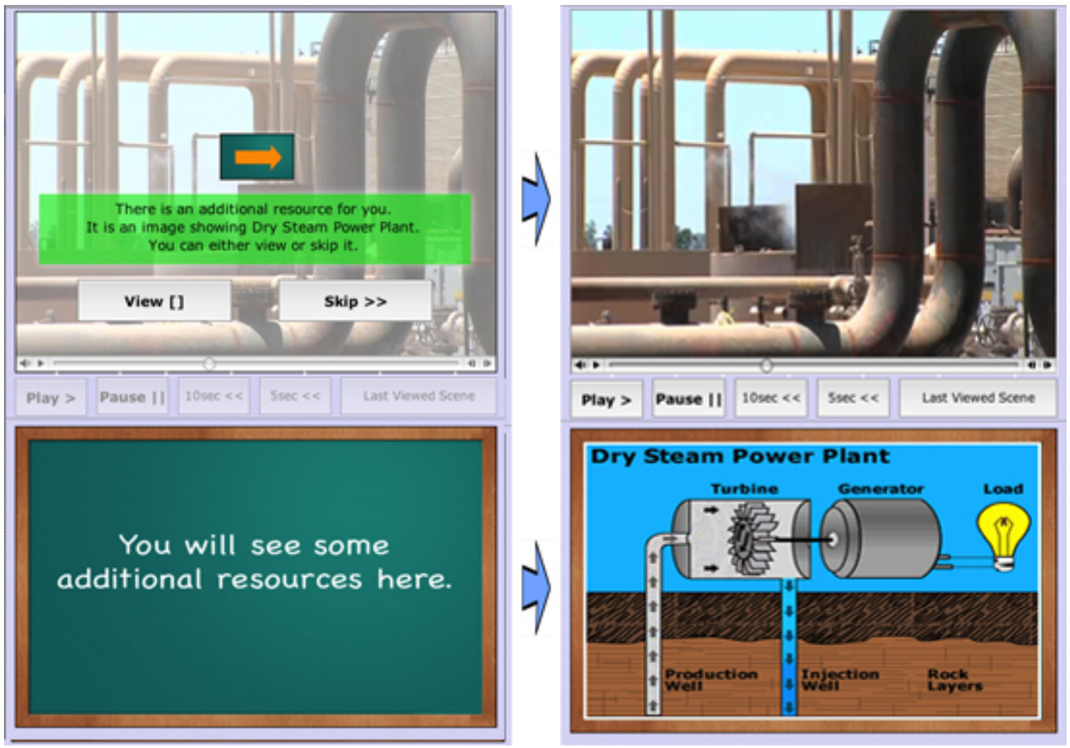
b) Interactive Notes. There was an interactive note-taking component in the designed learning environment. Learners were able to make interactive notes while watching the instructional video. As they clicked the *Add a Note* button, the tool captured the scene in the video and mapped it to the interactive notes component with a play button and a text box next to it. As students typed their own notes in the text box and clicked the *Store This Note* button, the note was added to the interactive notes list and sorted or synchronized according to its corresponding video-frame. I named these notes interactive because by clicking the play button in each note, students become actively engaged in their learning by acting on their learning environment by accessing specific parts in the video. Note-taking is one of the self-regulation strategies that help students to keep themselves active during the instruction (see Bernacki et al., 2012; Hadwin & Winne, 2001). The interactive note component made note-taking more effective and engaging. The listing of the notes also helped students to organize the learned information, which is also a self-regulation strategy. Figure 6 shows some added notes by a participant during the study.

Figure 6 A Participants' Interactive Notes



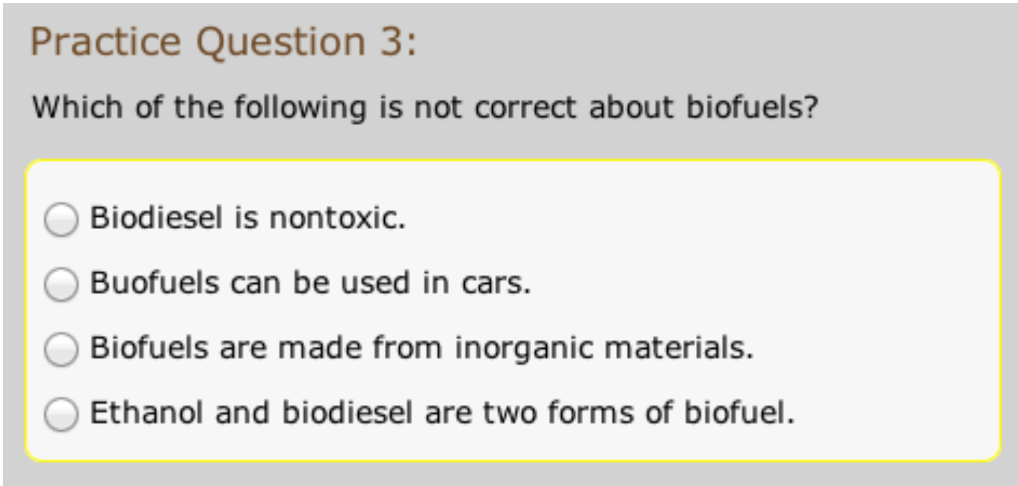
c) Additional Resources. In some parts of instructional period, the video stopped and the video player asked students whether they wanted to view an available additional resource related to video content. Viewing the additional resources was voluntarily based. Thus, this allowed learners to exert choice, sense of autonomy, and self-direction in their learning. Self-regulated students are more likely to seek for additional information (see Zimmerman, 1989). Therefore, embedded additional resources were a good opportunity for self-regulated students. Types of these resources were graph or image. By viewing these resources, addition to the video, students were able to enrich their knowledge and increase permanency of gained information. Figure 7 shows a sample of viewing an additional resource.

Figure 7 Viewing An Additional Resource



d) Practice Questions. Students were asked several practice questions while watching the video. These questions were related to video content, and immediate feedback was given after each question. Again, answering these questions was optional. Students had the choice of whether they wanted to answer or skip these questions. Embedded questions addressed to self-evaluation that is a very essential part of self-regulation. Thus, students were able to evaluate their learning with embedded questions during the instruction. Figure 8 shows a practice question.

Figure 8 A Practice Question



Assessing The Quality of Use of Embedded Functions

From the beginning of the instruction, all behaviors of students in EG and CG were recorded to the server via MYSQL database system. The frequencies of each function's use were the main data stored for statistical analyses.

Procedures

Participants were randomly assigned into the control and experimental groups, and all participants provided information on their perceived self-regulation using the SRSI – Self-report (Cleary, 2006). Control and experimental sessions were conducted separately. Students in CG were instructed via regular non-interactive video (Figure 2) while students in EG via newly designed online video-based interactive learning tool (Figure 5). After the instruction ended, each student took a recall test about the video content. During the study, data on self-regulation strategies, students' observed self-regulated learning behaviors, and recall test performance were recorded by the computer for data analysis.

Data Analysis

The data was analyzed by using IBM SPSS statistical software. Means, frequencies, and other descriptive statistics were calculated and reported for major variables. Potential differences in the major variables depending on students' demographic characteristics were tested. To examine whether performance differed across the CG and EG, an independent-samples *t*-test was calculated based on the recall test scores to compare students' performances in the CG and EG. Furthermore, the relationships between students' test scores and spent time during the instruction were explored by correlation analyses.

To examine whether self-regulation strategies was associated with observed self-regulated learning behaviors, Pearson correlation coefficients were computed for students in the experimental group. Reported self-regulation levels coming from a survey and self-regulatory behaviors (situational self-regulation) were the major variables used in this analysis. In addition to general analysis, the correlations were also computed for sub-samples including undergraduates and graduates to examine if results significantly differed for these different types of students (based on education or developmental level).

To examine whether or how the three types of self-regulation functions contributed to student performance, a multiple regression analysis was conducted with the data from the experimental group to examine whether embedded self-regulation functions in the interactive learning environment had unique contributions to the students’ performance.

CHAPTER IV

RESULTS

In this chapter, descriptive statistics are presented (see Table 2) and potential differences on the means of major variables conditioned on participants' demographic information (gender, age, and education) are tested followed by testing of the three major research questions. Data on self-regulation strategies, recall test, and time were available from all participants (n=80), whereas data on self-regulatory behaviors (in the experimental condition) was drawn from those in the experimental group (n=64).

Table 2
Means and Standard Deviations of Major Variables

			95% CI of the Difference	
	Mean	*SD*	Lower	Upper
Self-Regulation[a]				
Manage	3.60	0.57	3.47	3.72
Seek Info	3.77	0.57	3.64	3.90
Adaptive	3.88	0.43	3.78	3.97
Recall Test[a]				
Total Score	16.16	2.33	15.64	16.68
Time[a]				
Total Time (Minutes)	22.20	6.27	20.80	23.60
Self-Regulatory Behaviors[b]				
Additional Resources	5.42	1.62	5.02	5.83
Practice Questions	3.78	0.90	3.56	4.01
Interactive Notes	11.64	10.86	8.93	14.35

Note. [a]n=80, [b]n=64.

Significant Differences in Major Variables Based on the Demographics

By Gender

For gender, females exhibited significantly more self-regulation than males on all three self-regulation subscales including Manage ($F(1,78) = 6.968$, $p < .05$), Seek Info ($F(1,78) = 4.290$, $p < .05$), and Adaptive ($F(1,78) = 5.489$, $p < .05$).

By Age

In order to examine the major variables among the three age groups (i.e., 18 to 25, 26 to 30, and over 30 years), a one-way analysis of variance (ANOVA) was conducted, and it revealed significant differences in Manage ($F(2,77) = 3.202$, $p < .05$), and Adaptive ($F(2,77) = 4.610$, $p < .05$) self-regulation subscales. Post-hoc analyses explored differences among the three age groups. When Manage and Adaptive subscales were considered, students in 18-25 age group had significantly higher self-regulation scores than students in 26-30 age group.

Furthermore, to assess whether there were any significant differences among the age groups for spent time, an ANOVA was conducted. There were significant differences across age groups on time spent to complete the video-based instruction ($F(2,77) = 3.766$, $p < .05$). Post-hoc analyses indicated that students over 30 year-age spent significantly more time than students in other age groups.

Another ANOVA test was conducted among age groups to explore significant difference in recall test scores. The analysis revealed a significant difference ($F(2,77) = 3.286$, $p < .05$), and according to post-hoc analyses, students who were 30 year-old or older performed significantly better than students in 26-30 age group.

By Education Level

For education, only a significant difference between undergraduate and graduate students on the Manage subscale was found at $F(1,78)=6.589$, $p < .05$. Undergraduate students exhibited higher self-regulation score in the Manage subscale than graduate students.

By Language Status

Among eighty participants, 22 of them were not native English speaker. When participants' language status was taken into account and major variables compared, they only differed in recall test performance. Native speaker students performed significantly better than non-native speaker students ($F(1,78)=2.032$, $p < .05$).

Research Question 1

The first research question for this study was: Does students' performance in online video-based learning differ depending on whether the environment is non-interactive or interactive? After students in both groups completed the video-based instruction, students' performance on presented video content was measured by a 20-item recall test. In order to answer the first research question, control and experimental group's recall test scores were evaluated. Table 3 shows the descriptive statistics of recall test scores for two groups.

Table 3
Descriptive Statistics for the Recall Test Scores

	N	*M*	*SD*	Skewness	Kurtosis
Control	16	14.81	2.880	-.991	.909
Experimental	64	16.50	2.063	-.392	-.010

As shown in Table 3, there were 16 students in the control group with the average score of 14.81 (*SD* = 2.880), whereas 64 students were assigned to the experimental group with an average score of 16.50 (*SD* = 2. 063). The skewness and the kurtosis statistics of recall test scores for both groups were within the range of ± 1, supporting the assumption of normality for the *t*-test.

An independent samples *t*-test was conducted to compare two groups' recall test scores. Students' test scores were calculated based on the number of correct items. As shown in Table 4, there was a statistically significant difference between students' recall test scores when their instruction conditions (interactive or non-interactive) were taken into consideration.

Table 4

Comparison of the Recall Test Score for the Control and Experimental Group

		Mean Difference	*Std. Error Difference*	95% CI Lower	95% CI Upper	*t*	*df*	Sig. (2-tailed)
Recall Test	Control - Experimental	-1.688	.627	-2.936	-.439	-2.692	78	.009*

Note. CI = confidence interval.
*$p < .05$ (2-tailed).

According to the results, students in the experimental group (with the interactive environment) performed significantly better on the recall test than students in the control group (with the non-interactive environment). According to Thompson (1994), *p*-values are very sensitive to sample size. That is, just considering a significant *p*-value sometimes may lead researchers to misinterpret the study results. Thus, according to the APA Task Force on Statistical Inference (Wilkinson, & APA Task Force, 1999), reporting an effect size estimate along with *p*-values is recommended. Thus, *Cohen's* standardized effect size value was also calculated ($d = .67$), which suggested a moderate to high practical significance for this study's finding (Cohen, 1992).

In order to explore more about the two groups' conditions, students' time spent was taken into consideration for further analyses. Based on an independent samples *t*-test, it was found that students in the experimental group spent significantly more time than students in the control group, $t(71.335) = -9.311$, $p < .05$, $d = 1.69$ (see Table 5).

Table 5

Comparison of Spent Time for the Control and Experimental Group

		Mean Difference	*Std. Error Difference*	95% CI Lower	95% CI Upper	*t*	*df*	Sig. (2-tailed)
Recall Test	Control - Experimental	-7.438	.799	-9.030	-5.845	-9.311	71.335	.000*

Note. CI = confidence interval.
*$p < .05$ (2-tailed).

In addition, a one-way analysis of covariance on recall test scores was conducted, with spent time as the covariate to see whether spent time had any significant effects on students' performance. The result indicated that spent time did not have a significant effect on students' recall test scores, $F(1,77) = 1.770$, $p = .187$.

Furthermore, to examine the relationship between spent time and students' test scores, a Pearson product-moment correlation coefficient was computed. As indicated in Table 6, the relation was positive but not significant $r(80) = .145$, $p = .199$.

Table 6
Correlation Results for the Spent Time and Recall Test Scores

	Spent Time	Test Score
Spent Time	1.000	.145*
Test Score	.145*	1.000

*p = .199 (2-tailed).

Participants of this study consisted of native speakers (n = 58, 72.5%) and non-native speakers (n = 22, 27.5%). Thus, their spent time might have been affected by their native or non-native language status. In order to explore the relationship between spent time and test score, a partial correlation analysis was conducted in which effects of students' native or non-native language status was controlled. Table 7 shows the partial Pearson product-moment correlation coefficient.

Table 7
Partial Correlation Results for the Spent Time and Recall Test Scores

Control Variables		Spent Time	Test Score
Language Status	Spent Time	1.000	.219*
	Test Score	.219*	1.000

*p = .053 (2-tailed).

After controlling students' native or non-native language status, the relationship between spent time and test score increased, and was approaching significance, $r(80)$ = .219, p = .053. This suggests that, students who spent more time during the video-based instruction performed better than those who spent less time when students' language status was accounted for.

Research Question 2

The second research question for this study was: What is the relationship between students' self-regulation strategies and their situational (context-specific) self-regulatory behaviors when using the online video-based interactive learning tool? In order to answer this question, three subscale scores of SRSI (Seek Info (α=.724), Manage (α=.823), and Adaptive (α=.64)) and frequencies of students' situational self-regulatory behaviors in the video-based interactive learning environment condition (Additional Resources, Practice Questions, and Interactive Notes) were considered. It needs to be noted that only data from the experimental group were included for analyses from this point because only the experimental group had observed data for observed self-regulated learning behaviors (as exhibited in the video-based interactive learning environment). Descriptive statistics of corresponding variables are shown in Table 8.

Table 8
Descriptive Statistics for SRSI and Self-Regulatory Behaviors

		N	*M*	*SD*	Skewness	Kurtosis
SRSI	Seek Info	64	3.76	.593	-.368	-.382
	Manage	64	3.60	.599	-.215	-.548
	Adaptive	64	3.90	.407	-.355	.247
SR Behaviors	Add. Resources	64	5.42	1.621	-2.312	5.081
	Pract. Questions	64	3.78	.899	-3.063	10.107
	Int. Notes	64	11.64	10.856	1.919	5.630

Self-regulatory behaviors were coded as the frequencies of cases that students used the embedded self-regulatory functions of Additional Resources, Practice

Questions, or Interactive Notes during the instruction. It is important to note that there was very little variation in *Additional Resources* and *Practice Questions* variables. On the other hand, the variety of *Interactive Notes* was very large (*min* = 0, *max* = 60). For these reasons, there were normality issues in data distributions. Logarithmic data transformation, a way to improve normality of variables (Osborne, 2002), was utilized, and new variables were computed for self-regulatory behaviors. From this point, transformed variables were used in analyses.

Initial Pearson product-moment correlations of SRSI subscales and situational self-regulatory behaviors were calculated and presented in Table 9. The highest correlation was between Seek Info and Interactive Notes variables ($r = .214$). However, it was not statistically significant.

Table 9
Correlation Results of SRSI Subscales and Situational Self-Regulatory Behaviors

		Add. Resources	Practice Questions	Interactive Notes
Seek Info	Correlation	-.211	-.033	**.214**
	Sig. (2-tailed)	.094	.795	.089
Manage	Correlation	.008	.122	.188
	Sig. (2-tailed)	.953	.337	.137
Adaptive	Correlation	.018	.007	.185
	Sig. (2-tailed)	.890	.955	.144

Note. The highest correlation coefficient is boldface. No correlations were statistically significant.

In the experimental group, undergraduate students ($n = 32$) and graduate students ($n = 32$) were represented equally. It was worthy to make subgroup analyses. Therefore, further correlation analyses were conducted to explore if there was any association between students' situational self-regulatory behavior in using the video-based interactive learning environment and their SRSI subscales when students' education level is taken into consideration. As indicated in Table 10, among graduate students, number of added Interactive Notes was positively and statistically significantly correlated at $r = .417$, $n = 32$, $p < .05$, with SRSI Seek Info subscale and at $r = .357$, $n = 32$, $p < .05$, with Manage subscale. In regards to undergraduate students, there was no significant and meaningful correlation between corresponding variables.

Table 10
Correlation Results of SRSI Subscales and Self-Regulatory Behaviors for Undergraduate and Graduate Students

		Add. Resources	Practice Questions	Interactive Notes
Undergraduates				
Seek Info	Correlation	-.270	-.322	-.039
	Sig. (2-tailed)	.135	.072	.834
Manage	Correlation	.182	.094	.014
	Sig. (2-tailed)	.319	.608	.940
Adaptive	Correlation	.185	.067	.057
	Sig. (2-tailed)	.311	.715	.758
Graduates				
Seek Info	Correlation	-.114	.261	.417*
	Sig. (2-tailed)	.536	.149	.018
Manage	Correlation	-.192	.204	.357*
	Sig. (2-tailed)	.292	.262	.045
Adaptive	Correlation	-.246	-.062	.335
		.174	.735	.061

Note. *$p < .05$ (2-tailed).

Research Question 3

The third research question for this study was: Do students' self-regulation behaviors in an online video-based interactive learning environment with embedded self-regulatory functions make a unique contribution to their learning and performance, above and beyond that from students' perceived self-regulation (i.e., self-regulatory efficacy)? In order to explore how students' self-regulatory behaviors predicted their learning performance, a simultaneous multiple regression analysis was conducted with additional resources, practice question, and interactive notes as predictor variables and students' recall test scores as the predicted variable (*n* = 64). As indicated in Table 11, the coefficient of determination is very weak (R^2 = .025) and shows very low strength in predicting students' recall test scores.

Table 11
Model Summary[b] of the Multiple Regression Analysis

Model	R	R Square	Std. Error of the Estimate
1	.159[a]	.025	2.087

a. Predictors: (Constant), Log10AddRes, Log10AddedNotes, Log10PractQue
b. Dependent Variable: QTOTAL

According to the multiple regression model with all three predictors, use of self-regulatory functions in video-based interactive learning tool does not explain variances in students' recall test scores $F(3,60)$=.518, p = .672. Table 12 shows predictor variables' unique contribution to students' performance. Beta weights for Added Notes, Practice Questions, and Additional Resources are -043, .132, and .046, respectively. None of them was significant, and it can be concluded that independent variables do not have unique significant contribution to students' performance.

Table 12
Coefficients[a] of Predictor Variables

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	14.993	1.379		10.869	.000
Added Notes	-.193	.587	-.043	-.329	.744
Practice Questions	1.974	2.308	.132	.855	.396
Additional Resouces	.479	1.584	.046	.302	.763

a. Dependent Variable: QTOTAL

CHAPTER V

DISCUSSION AND CONCLUSION

This chapter provides interpretation of findings for three research questions and evaluation of three hypotheses, followed by limitations and directions for future research. At the last section, a general conclusion and implication are discussed.

The Role of Interactivity in Video-Based Instruction on Learning Outcomes

In the first research question, students' performance in two instruction conditions (interactive and non-interactive) was examined. It was hypothesized that students in the interactive environment would recall significantly more information about the content presented than those in the non-interactive environment based on a recall test administered at the end of the instruction. As indicated in Table 3, in general, students in the experimental group ($M = 16.50$, $SD = 2.\ 880$) performed significantly better than students in the control group ($M = 14.81$, $SD = 2.063$). This difference was significant at $p < .05$ level, and revealed a moderate effect size ($d = .67$).

The results suggest that the newly designed online video-based interactive learning environment was a more effective and superior instructional tool when compared to the non-interactive video-based learning environment. The reason that the analysis yielded a significant difference may be due to students' self-regulatory behaviors during the instruction, which helped students to be actively engaged and better retain the information from the video. This result also provides support for studies done by Sariscsany and Pettigrew (1997) and Zhang et al. (2006). These researchers also found that interactivity in video-based instruction benefits students' learning.

Interactivity of the tool in this study was supported with several embedded functions, which aimed to keep students active during the instruction and scaffold them to perform self-regulatory strategies while watching the instructional video. As expected, students in the experimental group kept themselves more engaged with the instruction in order to gain more information from the presented content. As shown in Table 2, students used the embedded functions very effectively. In particular, most of the students followed the tools' suggestions for viewing additional resources and answering practice questions. This also supports suggestions of Santhanam et al. (2008) that when students are supported and guided to use self-regulatory learning strategies, they tend to apply them more to their online learning processes. In addition, each student took an average of 12 interactive notes while watching the instructional video. In other words, students actively sought and processed information using the interactive learning environment by utilizing embedded self- regulatory functions. These findings echo Merkt et al. (2011), who argued that students performed comparably better with video-based instruction due to embedded functions that supported self-regulated information processing. Using these functions, of course, produced some other valuable results to consider such as spent time difference between two groups.

As displayed in Table 5, students in the experimental group spent significantly more time than students in the control group in their learning process, with 7.4 minutes difference between the groups. Because use of embedded functions was expected from students in the experimental group, this finding was supportive of the purpose of the newly designed tool, which aimed to increase students' engagement during the instruction. In the experimental condition, although it was optional, students were scaffolded to perform self-regulatory activities. These activities prompted students to invest significantly more time in their learning when compared to the non-interactive learning environment. However, it was not clear how students had allocated spent time during the instruction because they were not physically observed. For instance, some participants may have stopped the video or checked their email account or used their cell phone during the experiment, which may have increased the instruction time. In addition, to investigate the association of spent time and student performance, partial correlation was conducted controlling for students' native or non-native language status. According to partial correlation, the relationship between spent time and recall test scores was positive ($r = .219$) and approaching significance ($p = .053$). This result suggests that prompting students to invest more time in the learning process through interactive functions embedded in video-based instruction may yield modestly (albeit marginally) better academic performance.

With regard to the first research question, it might be concluded that online video-based learning environments may have some limitations when compared to face-to-face instructions. For instance, learners become more passive in online learning when they are just provided non-interactive video-based instruction. Moreover, students might be affected by distractions when they study online. Thus they need to be self-directed and self-regulated learners. For these reasons, embedding self-regulatory functions in video-based learning environments may scaffold students to become more self-regulated learners by having interactive role in video-based instruction. It is important to note that integrating self-regulatory activities into online learning may be more time consuming. On the other hand, using those strategies and investing more time in the learning process may yield better learning outcomes for online learners.

Correspondence Between Self-regulation Strategies in Traditional Learning Environments and Observed Self-Regulated Learning Behaviors in The Video-Based Interactive Learning Environment

The relationship between students' self-regulation strategies in traditional learning environments and their situational (context-specific) self-regulatory behaviors when using the online video-based interactive learning tool was examined. It was hypothesized that students' self-regulation strategies level (using the Self-regulation Strategy Inventory; Cleary, 2006) would be positively correlated with their observed self-regulated learning behaviors (frequency of embedded function use) in the newly designed online video-based interactive learning environment. As shown in Table 8, scores coming from three subscales of SRSI and frequencies coming from students' three situational self-regulatory behaviors were taken into account in correlational analyses.

First, the correlational coefficients for all students in the experimental group were calculated. As indicated in Table 9, there was no significant correlation between two sets of variables. The highest relation was between Seek Info and Interactive Note variables (r = .214).

Second, further separate correlation analyses were conducted for undergraduate and graduate students in the experimental group. The results of these analyses indicated that relationships between variables were quite different for undergraduates and graduates. Although there was no significant correlation coefficient in the undergraduate students' analysis, there were two positive relationships in graduate students' analysis. As Table 10 shows, Interactive Notes had significant relations with Seek Info ($r = .417$) and Manage ($r = .357$) for graduate students.

Based on the findings, I can conclude that graduate students, who rated themselves highly on the Seeking and Learning Information and Managing Environment/Behavior subscales of the Self-regulation Strategies Inventory, were those who took more interactive notes during the instruction.

"Seeking and Learning Information" was a composite score of eight items in SRSI. Two items were directly relevant to using notes, and the remaining items were inquiring about other types of learning strategies: 1- I use my class notes to study, 2- I try to see how my notes from science class relate to things I already know. In addition, "Managing Environment/Behavior" was a composite score of twelve items, which formed another subscale in SRSI. In this subscale, items were about study habits and study organization. A sample item: I think about the best way to study for each science test.

These results confirmed that graduate students' self-regulatory behaviors in the online video-based interactive learning environment were somehow correlated to their self-regulation strategies. This result was expected because self-regulation strategies have some influence on enacted learning behaviors. Importantly, the present study's results imply that students' specific self-regulation strategies in traditional education settings will transfer and become enacted as specific learning behaviors in the online learning environment.

According to Pintrich (2002), note-taking is an organizational strategy that is highly preferred by self-regulated students to elaborate what they learn by making connections between presented contents. Researchers have studied potential benefits of note-taking in both traditional (Peverly, Brobst, Grham, & Shaw, 2003) and computer-based or online (Hadwin & Winne, 2001; Lee, Lim, & Grabowski, 2010; Winters, Greene, & Costich, 2008) learning environments. Moreover, students use other self-regulation strategies, such as seeking and learning information, and managing environment/behavior to understand information in a way that they prefer. That is, students utilize their personal techniques/strategies to comprehend the most important details, and these techniques/strategies are most likely interrelated. It is important to note that being capable of using multiple strategies is an advantage for students and may permit them to choose the most appropriate or effective strategy during the learning process. Thus, learning environments need to offer opportunities to use various self-regulated strategies.

When students take notes, they process and organize the presented information so that the learning process becomes active and embodied through the action of note-taking. Thus, interactive note component was embedded to the online video-based interactive learning environment in order to scaffold students' self-regulation. As hypothesized, specific types of self-regulation strategies were associated with greater use of the note-taking function in the online video-based interactive learning environment.

However, self-regulation strategies were unrelated to the Additional Resources and Practice Questions functions, perhaps because they are less active and less embodied forms of learning relative to the action of note-taking. Furthermore, most of the students viewed the additional resources and answered the practice questions regardless of their self-regulation level. The reason might be the way these functions were embedded into the learning environment. Viewing additional resources and answering practice questions were suggested and directed by video viewer. In contrast, taking interactive notes was not reminded or suggested by the video viewer. Thus, note-taking was more self-directed than other two strategies.

These findings also confirmed that, if online video-based learning environments were designed by considering students' need, students could take advantage of the well-designed learning environment regardless of their personal differences. Hence, necessary strategies need to be embedded to online learning environments to scaffold students' learning process.

Unique Roles of the Embedded Self-regulatory Functions in Learning Outcomes

In the third research question, the embedded self-regulatory functions' potential unique contributions to students' learning performance were examined. It was hypothesized that students' observed self-regulated learning behaviors (as scaffolded and supported) in the video-based interactive environment would provide unique prediction of their recall test performance. This research question aimed at investigating whether the enacted self-regulated learning behaviors that were scaffolded by the embedded functions contributed to students' learning outcome in the online video-based interactive learning environment.

As indicated in the first research question, research results confirmed that learning outcomes were superior in the interactive than the non-interactive learning environment. Thus, results suggest interactivity was important to learning performance and outcomes. However, it is unknown which, if any, of the embedded functions were responsible for superior learning performance.

Results from multiple regression analyses (Table 12) indicate that the use of embedded self-regulatory functions did not have a significantly unique contribution to students' performance in the interactive learning environment. In other words, although the interactive learning environment succeeded in scaffolding and supporting students' learning process, which resulted in superior performance than the non-interactive learning environment, none of the embedded functions appear to uniquely or individually contribute to this superior performance.

In sum, students benefited from the online video-based interactive learning environment by using embedded self-regulatory functions. However, use of the embedded self-regulatory functions did not uniquely contribute to learning outcomes. Nonetheless, results support the view that interactivity supports active and engaged learning which contributes to superior learning outcomes. Furthermore, the finding that graduate students who tend towards high self-regulation in regards to seeking/learning information and managing their environment/behavior engage more in interactive note-taking (perhaps because it is a more self-directed and student-centered learning behavior).

Limitations and Future Directions

There are several noteworthy limitations of the current study. This section covers these limitations and suggests possible solutions for further research. First of all, participants in this study were undergraduate and graduate students who volunteered to participate. Thus, although assignment of the participants to the groups was random, participation was not random as it is possible there might be self-selection bias from participants who volunteered. In addition, some of the participants were not native English speakers, which may have resulted in some difficulty in understanding the content presented in the study. In addition, the author did not administer a pretest before the study. It was assumed that students in both the experimental and control group had the same experience with regards to instructional video content (renewable energy). Thus, students' recall test scores were considered as their gain from the video-based instruction. *In future studies*, homogeneity of groups may be improved by using methods such as increasing the sample size, recruiting participants across a broad array of fields and majors, and administering a pretest to explore any significant differences between the control and experimental groups. However, the present study did attempt to address this issue indirectly by asking participants whether they had background knowledge of the instructional content.

Second, it is also important to note that this study was not a part of a regular class activity. Therefore, some participants might have not been able to motivate themselves during the study. Although the students' recall test score was a major variable, there was no obligation for them to get a good score. Moreover, the data was collected in a cross-sectional experimental research design. As a result, there was a limitation that concerned the extent to which the findings can be generalized beyond an experimental setting. *Future studies* could be conducted with students who are already registered for an official online course. Thus, participants' are more likely to be motivated to take the tasks seriously. In addition, having a semester-long data collection process with several sessions would yield multiple data points that would be more representative of student behavior than a single session.

Third, the small sample size of the present study is a limitation because it limits statistical power to detect potential effects. *Future studies* that include sample sizes that are adequate to statistically detect embedded functions' joint or interactive effects in a video-based interactive learning environment are needed. In addition, multiple group designs can be conducted in which each group is assigned to use just one embedded function. Thus, embedded functions' effects could be compared among the groups. The same amount of time could be provided to participants regardless of control or experimental conditions in order to clearly examine conditions' benefit on student performance. Another methodology to detect embedded functions' potential contribution to students' learning could be using mixed method. Along with having quantitative data, interviewing the participants could yield qualitative information to understand the benefits or drawbacks of interactive video-based instruction.

Fourth, in this study, students' function use was coded as their frequency of usage. That is, their quality was not taken into account while coding procedure. *Future* *studies* could utilize new scoring techniques to assess students' self-regulation strategy use. For example, students' interactive notes could be examined and scored individually for the quality or length of note content, which may yield more accurate information for data analyses.

Finally, *future research* could incorporate methodologies that provide finer-grained observations of students' motivations and behaviors in online learning environments. Although students' behaviors were continuously tracked in this study, students could also be video-recorded to observe users' behaviors and examine what users actually do with their time during instruction and how users allocate time. Moreover, additional techniques and measures could also be incorporated in future studies to detect and understand motivational and attentional factors that are important for informing the design of learning environments. For instance, eye-tracking technologies that focus on human-computer interaction (see Jacob & Karn, 2003, for more details) could be used with online video-based interactive learning environments for two purposes. First, students' interest/motivation and cognitive or attentional processes could be monitored with eye-tracking technology while they are using the interactive tool. Afterward, association of use of embedded functions in video-based environment and students' cognitive and attention activity could be investigated.

Second, well-designed video-based interactive learning environments in which advanced eye-tracking technologies are embedded could be designed for students with special needs (e. g., disabled people). For example, Hyrskykari (2006) studied eye-tracking techniques to help second language readers in reading with an application named iDict. The iDict was developed to provide relevant assistance to readers while they were reading on the screen. The software analyzed readers' eye movements during the reading process and detected in a section of the text the user had understanding difficulty. Afterward, translation of the word/s was provided to the reader in his/her own language. With the same idea, interactive video-based learning environments could be developed to provide immediate assistance to the learners during the learning process. For instance, additional resources could be displayed automatically to the user as it is detected with eye-tracking that the user has difficulty in understanding the presented content. These are directions that future studies need to explore.

Conclusion and Implications

Taken together, study results highlight the importance of interactivity and self-directed (student-centered) learning features in online learning environments. The general findings suggest that when an online video-based learning environment is designed and developed, embedding additional functions, with potential users' needs in mind, could enhance learning by making the environment interactive. Instructional designers need to keep interactivity in mind when designing learning environments. Study results suggest that interactive learning environments provide students with affordances to become actively engaged in their learning and to invest or spend more time in the learning process, resulting in enhanced or superior learning outcomes. Especially when the content is delivered via video, it is essential that students maintain visual and/or auditory engagement in order to benefit from instruction. Thus, embedded functions served primary purposes of keeping students attentive and actively engaged via scaffolding and prompting students to use self-regulated learning behaviors.

Although no unique contribution to learning outcomes from embedded functions were found, the embedded functions undoubtedly were part of what made the learning environment interactive, with interactivity being a primary cause of superior learning performance in this study. Interestingly, the use of the embedded functions was associated with graduate (but not undergraduate) students' self-regulation strategies in traditional learning environments. This suggests correspondence between graduate students' self-regulation strategies in traditional learning environments and their self-regulated learning behaviors in an online video-based learning environment. For undergraduate students, such correspondence was not found. It is plausible that this difference may be related to cohort effects. Furthermore, it is plausible that undergraduate students may have substantially different learning experiences from graduate students due to generational differences resulting in less transfer or correspondence between traditional and online learning for undergraduate than graduate students do.

It is also important to note that self-regulation strategy use could be increased by training (Azevedo & Cromley, 2004) and giving students chance to practice self-regulatory activities. Thus, using some teaching techniques as Keller's (1968) method may improve students' self-regulation in online learning. In his teaching method, also known as personalized system of instruction (Keller, 1974), students are assigned to achieve a course that its materials are broken into modules. In addition, instead of having a group lecturing, students are responsible for learning each module by working at their own pace. Students need to be successful in each module in order to study the next one. Self-regulation strategies could also be embedded to online instruction individually, and students could be scaffolded to learn, practice, and perform each strategy at one time. For example, in one module note-taking strategy could be expected from students while self-evaluation strategy is expected in the other one. Using this approach, students could get used to utilize self-regulatory activities in their learning process even when the environment is online.

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APPENDIX A

Self-Regulation Strategy Inventory

Things I do when doing homework or studying for SCIENCE tests	1 Almost never	2 Not very often	3 Somewhat often	4 Very often	5 Almost always
1. I tell myself to keep trying hard when I get confused	○	○	○	○	○
2. I give up or quit when I do not understand something.	○	○	○	○	○
3. I try to study in a quiet place.	○	○	○	○	○
4. I ask my science teacher about the topics that will be on upcoming tests.	○	○	○	○	○
5. I use my class notes to study.	○	○	○	○	○
6. I study hard even when there are more fun things to do at home.	○	○	○	○	○
7. I quiz myself to see how much I am learning during studying.	○	○	○	○	○
8. I lose important dittos/worksheets that I need to study.	○	○	○	○	○
9. I make a schedule to help me organize my study time.	○	○	○	○	○
10. I use binders or folders to organize my study materials.	○	○	○	○	○
11. I think about the types of questions that might be on a test.	○	○	○	○	○
12. I try to see how my notes from science class relate to things I already know.	○	○	○	○	○
13. I try to identify the format of upcoming tests (e.g., multiple-choice or short-answer questions).	○	○	○	○	○
14. I try to study in a place that has no distractions (e.g., noise, people talking).	○	○	○	○	○
15. I forget to ask my teacher questions about things that confuse me.	○	○	○	○	○
16. I wait to the last minute to start studying for upcoming tests.	○	○	○	○	○
17. I try to forget about the topics that I have trouble learning.	○	○	○	○	○
18. I ask my teacher questions when I do not understand something.	○	○	○	○	○
19. I make pictures or diagrams to help me learn science concepts.	○	○	○	○	○
20. I make sure no one disturbs me when I study.	○	○	○	○	○

21. I tell myself exactly what I want to accomplish before studying.	○	○	○	○	○
22. I let my friends interrupt me when I am studying.	○	○	○	○	○
23. I look over my homework assignments if I don't understand something.	○	○	○	○	○
24. I carefully organize my study materials so I don't lose them.	○	○	○	○	○
25. I think about the best way to study for each science test.	○	○	○	○	○
26. I avoid asking questions in class about things I don't understand.	○	○	○	○	○
27. I finish all of my studying before I play video games or play with my friends.	○	○	○	○	○
28. I forget to bring home my study materials when I need to study for science tests.	○	○	○	○	○

APPENDIX B

Recall Test

1. What is the name of the power/energy produced by water spinning turbines?
   a. Solar Power
   b. Wave power
   c. Hydropower
   d. Geothermal Energy

2. The tidal power is created by the gravitational force between the sun and the moon on the earth. That is why it is ....
   a. Cheap
   b. Abundant
   c. Unreliable
   d. Predictable

3. Which of the following is a characteristic of hydropower?
   a. It stores energy.
   b. It releases chemical gases.
   c. It has high operation cost.
   d. It increases the area of animal habitats.

4. When did the Three Gorges Dam open in China?
   a. 2006
   b. 2008
   c. 2010
   d. 2012

5. In 2010, of all the electricity generated in the United States, what percentage was generated by wind power?
   a. 2%
   b. 4%
   c. 8%
   d. 16%

6. What is the purpose of implementing wind farms?
   a. To save electricity
   b. To store generated electricity
   c. To generate electricity on a large scale
   d. None of the above

7. Which of the following is not a reason for choosing offshore areas for wind power?
   a. They have plenty of space
   b. They are closer to major cities.
   c. In offshore areaas the wind is reliable
   d. In offshore areas storing energy is easier

8. Which country is the leader in geothermal power generation?
   a. China
   b. Brazil
   c. Canada
   d. United States

9. Which of the following ingredients are needed for geothermal electricity?
   a. Sun and heat
   b. Wind and heat
   c. Heat and water
   d. Water and solar

10. What could be another use for geothermal technology, other than generating electricity?
   a. To run cars
   b. To clean the air
   c. To heat buildings
   d. None of the above

11. Which is not a biomass source?
   a. Coal
   b. Forestry crops
   c. Animal residuals
   d. Industrial residuals

12. Wood is the most common form of biomass. Which of the following is released when generating energy from wood?
   a. Water
   b. Carbon gas
   c. Natural gas
   d. Methane gas

13. Which of the following is not a biofuel source?
   a. Rice
   b. Corn
   c. Wheat
   d. Sugarcane

14. Which of the following is used most in Brazil to produce ethanol?
    a. Rice
    b. Corn
    c. Wheat
    d. Sugarcane

15. Why was the use of ethanol prohibited in 1919?
    a. Because it was harmful to car engines.
    b. Because ethanol was considered as liquor.
    c. Because it was not safe to extract ethanol.
    d. Because producing ethanol was very expensive.

16. Which country is the leader in ethanol production?
    a. USA
    b. Brazil
    c. Canada
    d. Australia

17. Which country is the leader in ethanol use?
    a. USA
    b. China
    c. Brazil
    d. Costa Rica

18. Which of the following is the most abundant source?
    a. Wind Power
    b. Wave Power
    c. Solar Power
    d. Water Power

19. Which one is the sunniest place in the world?
    a. Yuma, AZ, USA
    b. Atlanta, GA, USA
    c. Portland, OR, USA
    d. New York, NY, USA

20. Which of the following is a way to use solar power?
    a. Using solar panels
    b. Using solar thermal plants
    c. Using photovoltaic devices
    d. All off the above