2017

Effects of Metacognitive Monitoring on Academic Achievement in an Ill-Structured Problem-Solving Environment

Naomi Malone
University of Central Florida

EFFECTS OF METACOGNITIVE MONITORING ON ACADEMIC ACHIEVEMENT IN AN ILL-STRUCTURED PROBLEM-SOLVING ENVIRONMENT

by

NAOMI MALONE
M.A., University of South Florida, 2004
M.A., University of South Florida, 2003
B.A., University of Wisconsin-Milwaukee, 1983

A dissertation submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy
in the College of Education and Human Performance
at the University of Central Florida
Orlando, Florida

Summer Term
2017

Major Professor: Atsusi Hirumi

ABSTRACT

Higher education courses are increasingly moving online while educational approaches are concurrently shifting their focus toward student-centered approaches to learning. These approaches promote critical thinking by asking students to solve a range of ill-structured problems that exist in the real world. Researchers have found that student-centered online learning environments require students to have self-regulated learning skills, including metacognitive skills to regulate their own learning processes. Much of the research suggests that externally supporting students while they are learning online, either directly or indirectly, helps them to succeed academically. However, few empirical studies have investigated what levels of support are most effective for promoting students' self-regulated learning behaviors. Additionally, these studies reported conflicting results – some found maximum support to be most effective while others found no significant difference.

The purpose of this study was to investigate the effectiveness of different levels of support for self-regulated learning during a complex learning activity to solve an ill-structured problem-solving situation in an online learning environment. In addition, the role of students' self-efficacy on their academic achievement was examined. A total of 101 undergraduate students from three international studies courses offered at a large urban Southeastern public university in the United States participated in the study. The students were randomly assigned to treatment (minimum support, maximum support) and control groups. Students' academic achievement scores were measured using a conceptual knowledge test created by the professor teaching the courses. O'Neil's (1997) Trait Self-Regulation Questionnaire measured students' self-efficacy. Analysis of Co-Variance (ANCOVA) was conducted to analyze the data.

The ANCOVA results indicated significant improvement of the academic achievement of the minimum support group versus both the maximum support and control groups. Additionally, self-efficacy as a co-variable did not significantly impact students' achievement scores in any of the groups.

The overall results indicated that it is important to consider the level of self-regulated learning support when designing online learning environments promoting students' critical thinking skills. Promoting students' self-regulated learning skills is vital when designing online higher education courses.

Keywords: self-regulated learning, self-efficacy, higher education, metacognitive support

I dedicate this work and give special thanks to my sister, Mary Ann Malone and my friend Dr. Jennifer Vogel-Walcutt for being there for me throughout the entire doctorate program and never giving up on me. Both of you have been my best cheerleaders.

I also dedicate this dissertation to Dr. Atsusi Hirumi and thank him for his unending patience with me throughout this process. You have guided me through one of the most difficult processes of my life and helped me to be more resilient and resourceful.

Finally, I dedicate this work to Dr. Brenda Thompson and Dr. Haiyan Bai. I thank Dr. Thompson for providing many hours of proofreading help and Dr. Bai for her unerring guidance in all matters of statistics. Thank you both for your many words of encouragement.

ACKNOWLEDGMENTS

I would like to thank Dr. Atsusi Hirumi, my dissertation committee chair, for his dedication, guidance, and support over the course of this study. Special thanks go to my committee members, Dr. Haiyan Bai, Dr. Jennifer Vogel-Walcutt, Dr. Brenda Thompson, and Dr. Houman Sadri. I sincerely appreciate their patience, support and constructive feedback in seeing me through the dissertation process.

I would like to thank Dr. Sadri for allowing me to recruit his students for my study. I would also like to thank the students who graciously gave their time to participate in this research and made it possible for me to gather the data for conducting this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Higher education institutions are increasingly offering online education, and the number of students enrolling in distance courses continues to grow rapidly (Allen & Seaman, 2014; Chang, 2007; Croxton, 2014; Kim & Bonk, 2006). Allen and Seaman's (2014) report shows a steady increase in students taking at least one online course, with an increase of over 411,000 to a new total of 7.1 million above the previous year. Spurring this growth is the concomitant enhancement of information and communication technologies, allowing universities to provide access to information resources and communication tools that allow students to research and collaborate online (Moore, 2013). Online communication tools provide more flexibility to learn both asynchronously and synchronously than traditional face-to-face environments (Ku & Chang, 2011; Zhang & Nunamaker, 2003).

Concurrent to the rise in online learning and improvements in educational technology, higher education is gradually shifting from teacher-centered to student-centered approaches (Sungur & Tekkaya, 2006). Many of these approaches emphasize the need for engaging students in learning that fosters complex problem-solving and critical thinking skills (English & Kitsantas, 2013; Hannafin, Hannafin, & Gabbitas, 2009).

Online education offers opportunities to design student-centered learning environments that give students the ability to learn complex subjects (Gerjets, Scheiter, & Schuh, 2008). Because of this, educators and instructional designers are increasingly using these environments to foster learning in complex and challenging topics (Devolder, van Braak, & Tondeur, 2012; Jacobson & Azevedo, 2008; Lajoie, 2008).

Although online learning environments offer opportunities to support learning, research shows that students have difficulty learning in these environments, in large part because they are given more control over and responsibility for their own learning (Bell, Kanar, Liu, Forman, & Singh, 2006; Sungur & Tekkaya, 2006; Winters, Greene, & Costich, 2008). To be successful, students need the necessary metacognitive skills to regulate their own learning processes (Azevedo, Witherspoon, Chauncey, Burkett, & Fike, 2009; Bannert, Hildebrand, & Megelkamp, 2009; Clarebout, 2008). Unfortunately, research shows that learning online in an environment that is relatively more unstructured than traditional university classes puts a high demand on students' self-regulation (Klingsieck, Fries, Horz, & Hofer, 2012). Self-regulation is defined as "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals (Zimmerman, 2000a, p. 14). Self-regulated learning (SRL) refers to self-regulatory processes that learners apply to transform their cognitive abilities into academic performance (Zimmerman, 2002, 2008). Self-regulatory processes include metacognitive strategies (e.g., goal-setting, self-monitoring, self-evaluation), cognitive strategies (e.g., rehearsal, organization, elaboration), environmental management strategies (e.g., time management, study area management), and self-beliefs (e.g., self-efficacy, intrinsic and extrinsic goal orientation, effort regulation) (Hu & Driscoll, 2012, Sitzmann & Ely, 2015). Effective self-monitoring, defined as deliberately attending to an aspect of one's behavior to facilitate improvement, is an essential skill for students to acquire to accurately gauge their learning progress and modify behavior when necessary (Zimmerman & Paulsen, 1995).

Frequently, learners fail to achieve successful academic outcomes because they have problems performing self-regulation processes such as self-monitoring without external support

(Bannert & Mengelkamp, 2008; Zumback & Bannert, 2006). Externally supporting students' self-monitoring skills during learning, either through direct or indirect support has been found to be an effective way to help students improve SRL skills while allowing them to retain some control over their own learning (Ifenthaler, 2012; Bell et al., 2006; Van Gog, Kester, & Paas, 2011). Friedrich and Mandl (1992) distinguish these two types of support as direct instructional support (e.g., training of SRL skills) and indirect instructional support (e.g., instructional prompts embedded into the learning environment). Instructional prompts are defined as techniques to stimulate and encourage cognitive, metacognitive, motivational, volitional and/or cooperative activities during learning (Bannert, 2009). Studies indicate that an effective external support method is to encourage metacognitive strategies such as self-monitoring of performance during learning tasks by providing instruction and/or prompts. (Ifenthaler, 2012; Kauffman, Zhao, &Yang, 2011; Schmitz & Perels, 2011; Van Gog, Kester, & Paas, 2011).

Statement of the Problem

The problem is that although there is evidence that external guidance helps students self-monitor their performance in online learning, there is a dearth of empirical research about what levels of support are most effective for individual students while performing complex learning activities (e.g., ill-structured problem-solving). Ill-structured problems are defined as problems that are complex, ill defined, open ended, and real world (Ge & Land, 2004).

There were conflicting results between the few studies that have investigated optimal levels of support. One study comparing four levels of support (from minimal to broad) applied during the learning of complex conceptual knowledge concluded SRL was so difficult that students required broad support (Rodicio, Sánchez, & Acuña, 2013). However, research

conducted to compare two self-regulation support conditions – monitoring and no monitoring - on students performing two types of tasks – simple problem-solving and complex problem-solving found that although monitoring while solving a simple problem did not lower learning performance, monitoring during complex problem-solving resulted in significantly lower performance. (Van Gog et al., 2011). Moreover, a set of studies investigated the effects of self-regulation prompts and self-regulation prompts with training, finding no significant difference compared to control groups receiving no SRL support. It is unclear from these studies whether standalone training might have been sufficient (Bannert & Reinman, 2012).

Purpose of the Study

The aim of the present study was to investigate the effectiveness of different levels of support for self-regulated learning during a complex learning activity – solving an ill-structured problem-solving situation online.

Research Question

The following question guided this study:

Do levels of self-monitoring support during ill-structured problem-solving have differential effects on students' academic achievement after controlling for individual differences of prior knowledge and self-efficacy beliefs? If yes, what are they?

Research Hypothesis

The research hypothesis is:

There is no significant effect of self-monitoring support (maximum, minimum, and no support) on a concept knowledge test, controlling for self-efficacy beliefs and pre-test.

Operational Definitions

The following terms, variables, and treatments were used to conduct this study.

Levels of support refer to the amount of self-monitoring support research participants received during the study and constitute the research treatment. There were two treatment groups; one received minimum support in the form of a self-monitoring tutorial and the other received maximum support with the same tutorial plus self-monitoring question prompts during learning. A control group did not receive any self-monitoring support.

Academic achievement refers to concept knowledge performance as the dependent variable in this study. Concept knowledge was measured by a test given after the problem-solving activity.

Individual difference refers to the ways that individuals differ in their behaviors. This term focuses on two aspects of the research participants' differences: prior knowledge and individual self-efficacy beliefs and they are the covariables of this study. Prior knowledge was measured by a concept knowledge test. Self-efficacy beliefs were measured by a trait self-regulation questionnaire. Both measures were given prior to the problem-solving activity.

Conceptual Framework

The conceptual framework of the study was based on Zimmerman's (2000a, 2000b) social cognitive SRL model combined with the metacognitive monitoring and control processes theorized in Winne and Hadwin's (1998) Information Processing Model of self-regulation to emphasize the importance of self-monitoring during SRL. Figure 1 illustrates the conceptual framework and the relationships among the variables and SRL theories used in this study. There

are three learning inputs hypothesized to affect learning outcome, one independent variable and two covariables. The independent variable is the treatment consisting of three levels of SRL support (minimal, maximum, and no support). The two covariables of pretest and self-efficacy beliefs are controlled for in the study. The learning outcome is the posttest, the dependent variable of the study.

The framework includes Zimmerman's three cyclical phases of forethought, performance, and reflection, with metacognitive monitoring and control occurring during each phase, conducted within the learning space of an online ill-structured problem-solving environment. Research and literature related to the framework will be reviewed in further detail in CHAPTER 2.

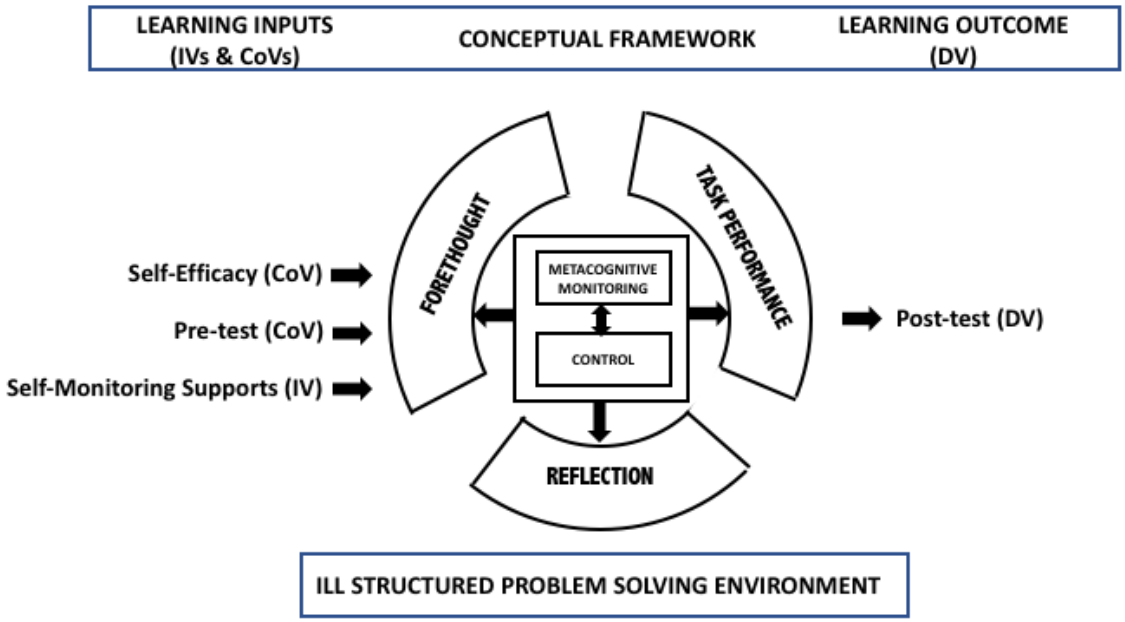


Figure 1: Relations Among Variables with the SRL Conceptual Framewor

Theoretical Foundations

Self-regulated learning (SRL) is an aspect of self-regulation that describes ways in which students regulate their cognitive and metacognitive processes within educational settings (Puustinen & Pulkkinen, 2001). Although there are many theoretical models of SRL, Puustinen and Pulkkinen reviewed SRL models found in the literature for the previous decade (1990-2000), finding five that met two criteria: the models were actively being developed and included several empirical studies. Their list included Boekaert's model of adaptable learning (Boekaerts & Niemivirta, 2000), Borkowski's process-oriented model of metacognition (Borkowski et al., 2000), Pintrich's (2000) general framework for SRL, Winne and Hadwin's (1998) information processing model of SRL, and Zimmerman's social cognitive model of self-regulation (2000a). All five models agree that SRL is an active and constructive process during which students regulate different cognitive, metacognitive, motivational, volitional, and behavioral processes during learning (Bannert & Reinman, 2012; Efklides, 2008). Although not explicitly stated (except in Winne's and Zimmerman's model), all include at least three phases: a preparatory, performance, and reflective phase (Puustinen & Pulkkinen, 2001).

Theorists mainly disagree on which processes should be emphasized to facilitate learning outcomes. Puustinen and Pulkkinen list two main points of difference. First, Winne's information processing model diverges from the other models, which postulate monitoring solely as a performance phase activity while feedback occurs during the reflective phase. In contrast, Winne's information processing model conceptualizes an overarching set of iterative processes - metacognitive monitoring and control, which provide the learner with internal feedback to revise performance during each of the three phases. Second, Zimmerman's social cognitive model

posits a cyclical nature of the three phases (forethought, performance, reflection) that is highly influenced by the student's level of self-efficacy (Zimmerman, 2000a, 2000b).

A systematic review of SRL empirical research specific to online learning within higher education between 2006 to 2016 (see Figure 1 in CHAPTER 2) revealed that researchers frequently employed Zimmerman's cyclical three phase model, used as the theoretical framework in this study (e.g., Azevedo, Greene, & Moos, 2007; Bannert & Reinmann, 2012; Kauffman, Zhao, & Yang, 2011; Ifenthaler, 2012; Kramarski & Michalsky, 2009). Research and literature related to the framework will be reviewed in further detail in CHAPTER 2.

Overview of Method

An experimental design was used to conduct the research. The study was conducted with undergraduate students at a university in an urban area in the southeast of the United States of America. A total of 101 students from three political science courses were randomly assigned using stratification to three groups – two treatment groups and one control group. The study was approved by the Institutional Review Board (IRB) at the University of Central Florida. A copy of the approval letter is provided in APPENDIX A. Further details regarding the method will be discussed in CHAPTER 3.

Significance of the Study

Increasing advances in educational technology for online education make it critical to study instructional interventions designed to provide students with the ability to implement strategies to improve academic performance while learning in online learning environments. The results of this study are significant for researchers because they add to an under-researched

aspect of SRL literature by examining the effects of different levels of SRL support within an online learning environment. Although there are some studies that have examined the effects of providing different levels of support, they provide conflicting results. Researchers also benefit from this study by learning about (a) the main theoretical frameworks and SRL processes examined in current SRL empirical research provided in the literature review in CHAPTER 2, and (b) recommendations for future studies generated by the results of the study.

This study also benefits instructional designers by providing information that can guide he design of different levels of SRL support during online problem-solving learning activities. Although several studies examined SRL during problem-solving, few addressed the need to consider levels of support.

CHAPTER 2: LITERATURE REVIEW

Background

Web-based learning is growing at a record rate in American higher education (Kauffman, Zhao, & Yang, 2011). According to the 10th in a series of annual reports produced by the Babson Survey Research Group, the proportion of students in higher education taking at least one online course has steadily increased since 2002, reaching 32% by 2012 (Allen & Seaman, 2013). Although online learning is gaining in popularity, only 30% of academic leaders believe their faculty accept the value and legitimacy of online education. Additionally, almost 90% of leaders surveyed are concerned about students' lack of discipline in online environments leading to lower retention rates (Allen & Seaman, 2013). One reason for faculty and administrators' concerns regarding student learning outcomes in online environments is that students find it hard to regulate their own learning (Azevedo, 2009; Bannert, Sonnenberg, Mengelkamp, & Pieger, 2015; Winne & Hadwin, 2008; Zimmerman, 2008). Researchers have shown that fostering SRL in higher education students can improve academic performance in traditional learning environments (Dignath & Büttner, 2008; Pintrich, 2004; Richardson, Abraham, & Bond, 2012; Zimmerman, 2008). However, there are still many questions regarding the effectiveness of different types and levels of support in online environments (Broadbent & Poon, 2015; de Bruijn-Smolders, Timmers, Gawke, Schoonman, & Born, 2016).

Organization of the Literature Review

The literature review is organized into eight main sections: prior reviews of self-regulated learning in higher education online, review method, three sections for the review questions, , conceptual framework, and conclusion.

Prior Reviews of Self-Regulated Learning

Two prior systematic reviews of literature related to self-regulated learning in online higher education environments have been completed (Broadbent & Poon, 2015; de Bruijn-Smolders et al., 2016). Broadbent and Poon's (2015) systematic review endeavored to discover whether there was a positive correlation between SRL interventions and academic outcomes. Twelve studies were examined. Findings indicated that time management, metacognition, effort regulation, and critical thinking were positive correlations between interventions and academic outcomes whereas rehearsal, elaboration, and organization had less empirical support. Positive weighted mean correlations (r) ranged from .05 to .14, smaller than correlations previously found in traditional university settings (.18 to .32, Richardson, 2012).

In the second systematic review, De Bruijn-Smolders, Timmers, Gawke, Schoonman, & Born (2016) examined effective self-regulatory processes (SRPs) in higher education for learning outcomes, guided by Sitzmann and Ely's (2015) categorization of SRPs into regulatory mechanisms involving metacognitive strategies (or goal setting, planning, monitoring), learning strategies (or elaboration), attention, time management, environmental structuring, motivation, effort, and self-efficacy. Included studies addressed metacognitive strategies, motivation, and self-efficacy, while goal-setting, attention, time management, environmental structuring, and

effort were not addressed. Of the 10 studies examined, de Bruijn-Smolders et al. (2016) found seven studies that benefited learning outcomes in these SRPs: metacognitive strategies, motivation, self-efficacy, handling task difficulty, and resource management. Within the metacognitive strategies category, studies revealed that planning and monitoring influenced learning outcomes and the authors recommended future reviews to categorize these separately.

Together, these reviews suggest that specific learning-focused interventions can be effective for promoting the use of SRL strategies to help students improve academic outcomes. However, they also indicate that examining and making conclusions from self-regulation research findings is difficult because the studies emanate from multiple disciplines and theoretical approaches (as described in Sitzmann & Ely, 2015). These many approaches have generated a wide range of constructs related to self-regulation that have been interpreted and categorized in different ways. This is evident when comparing the two reviews. Broadbent and Poon grouped studies solely by the SRL strategies employed in the research interventions, leaving out discussion of SRL constructs such as self-beliefs that many SRL researchers consider important. DeBruijn et al. included discussion of motivation and self-efficacy, using a modified version of Sitzmann and Ely's (2015) heuristic framework of SRL processes that divides the processes into SRL initiators (goal-level), goal achieving processes (including metacognitive strategies, learning strategies, motivation, and effort), and learning beliefs (attributions and self-efficacy). Some researchers suggest that processes such as motivation and self-efficacy are important indicators of successful academic achievement (e.g., Zimmerman, 1995). Due to this framework, DeBruijn et al.'s review discussed motivation and self-efficacy separately. However,

the authors acknowledged that self-efficacy is often measured as a sub-scale within motivation (e.g., Herl et al., 1999).

For future research, Broadbent and Poon recommended exploring how mediating factors (e.g., motivation or self-efficacy) interact with SRL strategies to improve understanding of their effects on student achievement. DeBruijn et al.'s review included four studies on motivation that indicated a positive effect on achievement, but three of them included a subscale of self-efficacy. The authors contended that further research should address motivation, defined as a willingness to learn, separately from self-efficacy. The authors also noted that although the SRL literature claimed SRL was effective in multiple types of online environments, only e-learning and hypermedia environments were specifically mentioned in included studies. As of their review, there was a lack of empirical evidence on the relationship of SRL strategies to academic achievement in other SRL-supported environments such as problem-based or portfolio-based learning. Thus, while difficult to compare these two recent reviews, the complementary information from each suggests that externally supporting students to use self-regulated learning strategies can improve academic achievement.

To expand on the findings of the two existing reviews of literature, the current review has two aims: to reveal theories underpinning SRL research to aid in illuminating the differences in terms and focus and to create a conceptual framework for the current study that draws from multiple approaches, and to further examine which interventions have previously been successful in fostering academic outcomes in higher education online learning environments. Accordingly, the current review of literature sought answers to:

1. Which theories relevant to SRL underpin current SRL empirical research?

2. Which SRL processes are examined in current SRL empirical research?
3. What are some avenues for further research in supporting SRL processes for academic achievement during online learning in higher education?

Review Method

Petticrew and Roberts's (2006) method for conducting systematic reviews (as described by de Bruijn et al., 2015) was followed for the current review and included five phases:

1. Determine criteria for inclusion
2. Formulate appropriate search terms and databases
3. Conduct extensive literature research
4. Analyze and synthesize data by SRL theory, targeted SRL processes, and SRL interventions found to be effective for improving student academic achievement.
5. Following de Bruijn et al., a meta-analysis was not performed due to the heterogeneity of the SRPs found in the studies. Therefore, the different effect sizes were not computed.

Eligibility criteria

Principles for inclusion were based on the following criteria:

Types of studies. Empirical studies focused on direct (e.g., strategy instruction) and indirect (e.g., strategy prompts) interventions supporting students' use of self-regulated learning strategies to improve academic performance. This criterion included only studies that examined academic performance as a dependent variable operationalized as a grade or score given by the researcher or instructor measured against SRL treatment(s) as independent variable(s). Therefore, studies operationalizing academic performance as a score based on student

perceptions of their SRL strategy use were excluded (Ibabe & Jauregizar, 2010). Studies that did not include a control group were excluded. Studies that did not include random assignment of participants were excluded.

Types of participants. Participants were university, college, or equivalent students.

Types of learning environments. Participants' learning activities were performed while taking a course offered substantially online by a university, college or equivalent institution to include both online courses and blended (or hybrid) learning environments. According to Allen and Seaman (2013) online courses deliver most (over 80%) of their content online.

Search strategy

Papers were restricted to peer reviewed journals published within the last decade in English language journals between the years 2006 to December 2016. An initial search of the databases Education Resource Information Center (ERIC), Education Full Text (H.W. Wilson), PsycINFO, and PsycARTICLES was performed to obtain peer-reviewed papers published within the last decade. The search included papers that researched SRL strategies and academic achievement in online higher education settings. The key search terms are shown in Table 1.

Table 1: Search Terms

Search term 1 AND	**Search term 2 AND**	**Search term 3 AND**	**Search term 4 AND**	**Search term 5**
Student Learner Undergraduate student Graduate student	Online Web based Internet Distance education	University College Higher education	Self regulated learning strategies Metacognitive strategies Self regulation strategies	Academic outcome Academic achievement Score Grade Performance

Selection process

Figure 2 details the process of elimination used to remove all studies not meeting the selected criteria. Out of 769 studies found in the initial search, with 2 added from other sources, 26 matched all criteria and were chosen for further analysis.

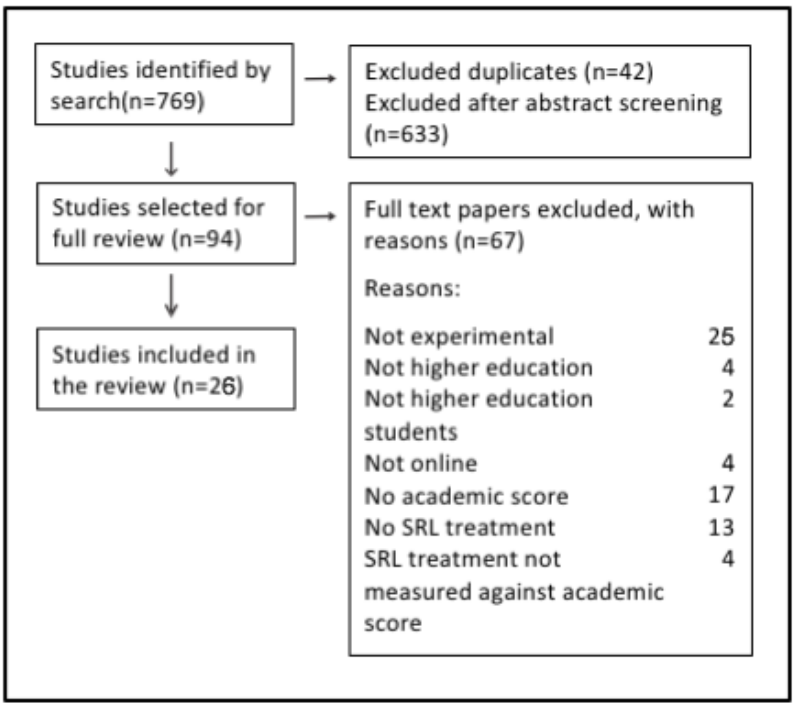


Figure 2: Flow Diagram of Selection of Studies Included in the Review.

Description of Included Papers

Table 2 lists the 26 studies alphabetically by author, with columns describing the main theoretical approaches used for each study, the SRL process or processes targeted for intervention, the SRL interventions examined, and the online learning environment used for the study. The theoretical model column lists the main theoretical approach that informed each study. The SRL processes column, describes the activities the studies are encouraging students to engage in to regulate their own studies. The SRL interventions column describes the specific

method employed to foster engagement. The learning environment column describes the type of online learning environment. Finally, the instructional method column describes the main instructional methods or strategies used in the study. Like deBruijn et al's review, the current review includes many studies conducted within hypermedia and e-learning environments. However, it also includes a number of studies investigating SRL support for other types of learning environments (e.g., problem-solving, Chen & Bradshaw, 2007, Crippen & Earl, 2007; Ifenthaler, 2012, Kim & Ryu, 2013, Kramarski & Michalsky; inquiry learning, Graesser et al., 2007; experiential learning, Kondo et al., 2012).

Table 2: List of Reviewed Studies Including Author/Date, Theoretical Framework, SRL Processes, Interventions, & Learning Environments

#	Author(s)	Theoretical Model(s)	SRL Processes	SRL Interventions	Learning Environment	Instructional Method
1	Azevedo et al. (2007)	SCM/COPES	Metacognitive strategies; time management; effort	Adaptive scaffolding	Hypermedia learning environment (HLE)/	Hypermedia learning
2a	Bannert & Reimann (2012)	SCM	Metacognitive strategies; motivation	Training; Prompting; T	HLE	Hypermedia learning
2b						
3	Bannert et al. (2015)	SCM; MF	Metacognitive strategies	Self-directed metacognitive prompting	HLE	Hypermedia learning
4a	Bednall & Kehoe (2010)	SCM	Metacognitive strategies	Strategy instruction	HLE	Self-directed hypermedia learning
4b			Learning strategies (Explanation, summarization)	Reflection prompts		
4c			Planning	Question prompts		
4d			Self-monitoring	Reflection questions		

#	Author(s)	Theoretical Model(s)	SRL Processes	SRL Interventions	Learning Environment	Instructional Method
5	Chang (2007)	Not specified	Monitoring; Time management; Environmental structuring; Motivation	Self-monitoring recording form	Web-based learning	Web-based learning
6	Chang (2010)					
7	Chen & Bradshaw (2007)	Not specified	Monitoring; Metacognitive strategies	Question prompts	Web-based learning	Ill-structured problem-solving
8	Crippen & Earl (2007)	SE	Learning strategies	Self-explanation prompts	Web-based learning	Well-structured problem-solving
9	Duffy & Azevedo (2015)	COPES	Goal level; Learning strategies	Embedded SRL tools; prompts and feedback	Adaptive HLE	Hypermedia learning
10	El Saadawi et al. (2010)	COPES	Monitoring	Immediate feedback	Intelligent tutor system (ITS)	Hypermedia learning
11a 11b	Graesser et al. (2007)	General, no specific model	Learning strategies	Training; Reflection prompts	Google search and websites	Inquiry learning
12a 12b	Hathorn & Rawson (2012)	Not specified	Monitoring	Self-monitoring instruction and prompts; Reflection questions	HLE	Text-based learning
13	Hodges (2008)	SE	Self-efficacy	Efficacy-enhancing messages	Asynchronous online course	Asynchronous learning
14	Hu & Driscoll (2013)	Pintrich model SCM	Metacognitive strategies, motivation	SRL strategy training	Web-enhanced course	Asynchronous learning
15	Ifenthaler (2012)	General, no specific model	Metacognitive strategies	Reflection prompts	Online problem-solving activity	Problem-solving
16	Kauffman et al. (2011)	COPES	Note-taking; Self-monitoring	Note-taking tools; self-monitoring prompts	Online note-taking activity	Web-based learning
17	Kim & Ryu (2013)	Not specified	Metacognitive strategies	Peer assessment	Blended learning	Peer learning; ill-structured problem-solving

#	Author(s)	Theoretical Model(s)	SRL Processes	SRL Interventions	Learning Environment	Instructional Method
18	Kondo et al. (2012)	SCM	Metacognitive strategies	SRL strategy prompts	Mobile learning module	Experiential learning
19	Kramarski & Michalsky (2009)	General, no specific model	Metacognitive strategies	Metacognitive questioning	HLE	Problem-solving
20	Lee et al. (2010)	Not specified	Learning strategies	Strategy prompts	HLE	Generative learning strategy
21	Lehmann et al. (2014)	SCM	Metacognitive strategies; motivation	Preflection and reflection prompts	Online problem-solving activity	Problem-solving
22	Moos & Azevedo (2008)	Pintrich model	Metacognitive strategies; time management; motivation	Scaffold conceptual understanding	HLE	Hypermedia learning
23	Reid et al. (2016)	Not specified	Metacognitive strategies	cognitive and metacognitive strategy tools	HLE	Hypermedia learning
24	Rodicio et al. (2013)	Pintrich model	Metacognitive strategies	Metacognitive tools and prompts	HLE	Hypermedia learning
25	Trevors et al. (2014)	COPES	Metacognitive strategies	Pedagogical agent	ITS	Hypermedia learning
26	Van den Boom et al. (2007)	Elaborated SCM	Metacognitive strategies	Reflections; tutor and peer feedback	Distance learning course	Web-based learning

SCM: Social Cognitive Model; COPES: Conditions, Operations, Products, Evaluations, Standards; MF: Metamemory Framework; SE: Self-efficacy;

Review Question 1: Which theories relevant to SRL underpin current SRL empirical research?

The theoretical models/frameworks underpinning the reviewed studies are listed in Table 2. This section discusses which theories relevant to SRL underpin current SRL empirical research to answer the first review question. The social cognitive model (SCM) of self-regulated learning (Zimmerman, 2000a) was the main theoretical basis for six studies (Bannert &

Reimann, 2012; Bednall & Kehoe, 2010; Kondo et al., 2012; Lehmann et al., 2014; Van den Boom et al., 2007). Additionally, SCM was paired with the COPES and Pintrich models in two other studies (Azevedo et al., 2007; Hu & Driscoll, 2013 respectively). The Conditions, Operations, Products, Evaluations, Standards (COPES) model (Winne & Hadwin, 1998) was the central theoretical basis for four studies (Duffy & Azevedo, 2015; El Saadawi et al., 2010; Kauffman et al., 2011; Trevors et al., 2014) and paired with SCM in Azevedo et al., 2007. The Pintrich model (1995; 2000) was the main theoretical support for two studies (Moos & Azevedo, 2008; Rodicio et al., 2013) and underpinned the Hu and Driscoll (2013) study with the SCM model. The Metamemory Framework (Nelson & Narens, 1990) was paired with the SCM model in one study (Bannert & Reimann, 2012). Three research studies relied on a general discussion of the self-regulation literature rather than implementing an explicit theoretical framework (Graesser et al, 2014; Ifenthaler, 2012; Kramarski & Michalsky, 2009). Graesser et al. (2014) posited inquiry learning as a subset of self-regulation and borrowed ideas from both metacognition and self-regulated learning research to design a web tool called SEEK Tutor. SEEK Tutor supported readers' 'critical stance' to foster their ability to rate the reliability of information found on the internet, using the phases found in prevalent SRL theories (planning, metacognitive monitoring, control, and reflection). Ifenthaler used SRL literature as justification for the use of reflection prompts during problem-solving. Finally, Kramarski and Michalsky reviewed SRL literature to surmise four areas for regulation: cognition, metacognition, motivation, and context condition. They designed a web tool called the IMPROVE metacognitive self-questioning method that addressed these four conditions.

Seven studies did not base their research on a self-regulation theoretical approach (Chang, 2007; 2010; Chen & Bradshaw, 2007; Hathorn & Rawson, 2012; Kim & Ryu, 2013; Lee, Kyu, & Grabowski., 2010; Reid et al., 2016). In Lee et al's (2010) study, comprehension of science topics during learning was examined using generative learning theory, which posits that learners need to make their own meaning by integrating new information with prior knowledge. Like SRL, the theory assumes the need for cognitive and metacognitive control during learning. Although Bandura's theory of self-efficacy is not considered a theoretical model of self-regulated learning and usually placed within the category of SRL processes, it was used as the theoretical basis for two studies included in the review (Crippen & Earl, 2007; Hodges, 2008). Self-efficacy will be discussed more fully in the next section.

The three prevalent SRL models found in the reviewed studies are examined in more detail below.

Social Cognitive Model (SCM) of Self-Regulated Learning

The most widely recognized and used model was derived from Bandura's (1977) social cognitive theory. Based on this earlier work, Bandura (1991) hypothesized self-regulation as a triadic process of self-observation, judgment, and self-response. Zimmerman (1998, 2000b, 2008) worked with Bandura and others to develop the social cognitive theory of self-regulation (SCM, Figure 3), framed within cognitive, metacognitive, and motivational dimensions and including three cyclical phases: the forethought phase, the performance phase, and the reflection phase.

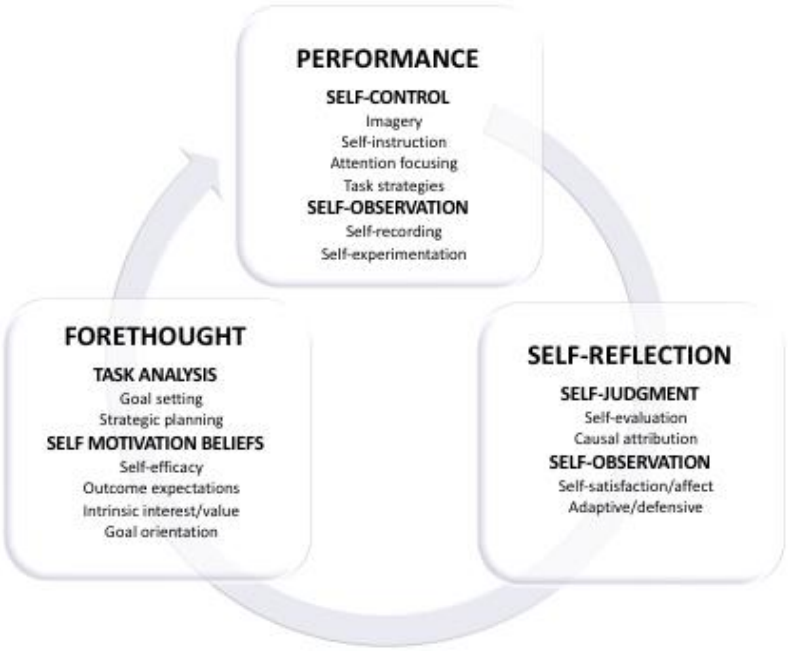


Figure 3: Social Cognitive Model of Self-Regulated Learning (Zimmerman, 2000)

Conditions, Operations, Products, Evaluations, Standards (COPES) Model

Winne and Hadwin's (1998) COPES model (frequently called the Information Processing model) incorporates four iterative and weakly sequenced phases of learning: task modeling, setting goals and planning, applying tactics and strategies, and monitor and adapt features of the other phases to complete the task successfully. One main difference between COPES other SRL models is the conception of control and monitoring as processes occurring throughout the four phases. Other models (such as SCM) include control and monitoring processes within the performance phase. Figure 4, depicts control and monitoring as key processes that are central to the operation of the four iterative phases.

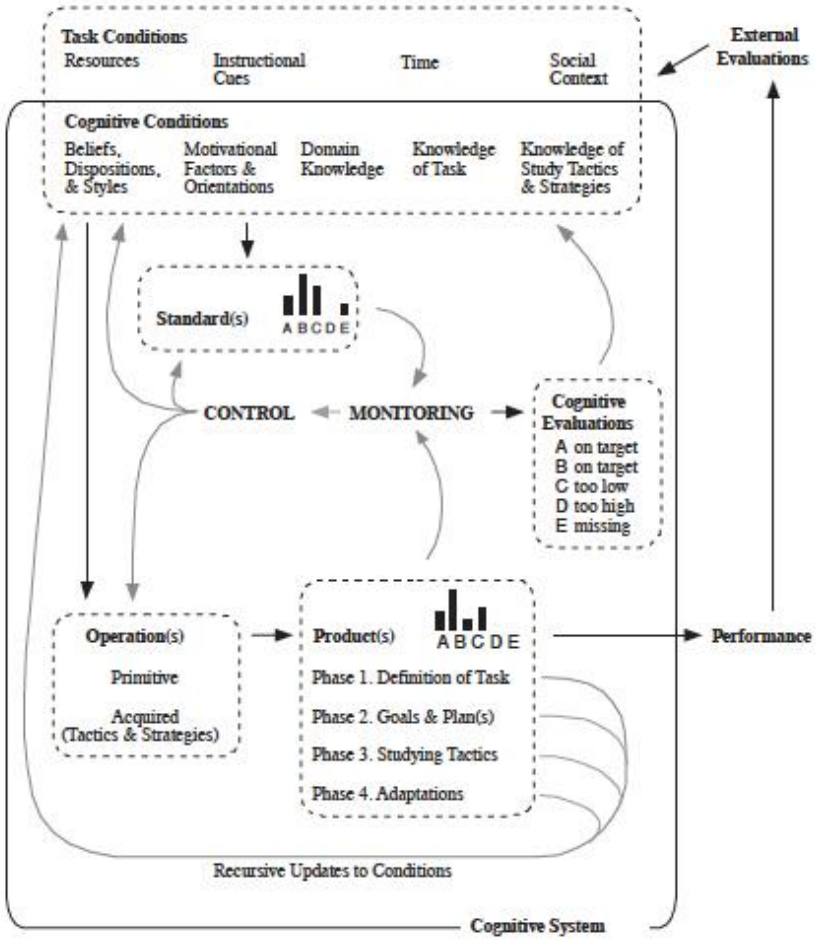


Figure 4: Information Processing Model of Self-Regulated Learning (Winne & Hadwin, 1998)

Pintrich's Framework

In agreement with Zimmerman's view of self-regulated learning, Pintrich's (1990, 2000, 2004) interpretation of SRL highlights three – metacognitive, motivational, and cognitive – components of learning that predict academic success. First, students use metacognitive strategies to plan, monitor, and modify their cognition; second, they manage and control the effort they put into their academic tasks; and third, students use cognitive strategies to learn, remember, and understand the material (Pintrich, 1990). Like Zimmerman and Winne & Hadwin, he posits phases of self-regulation, developing a framework of four phases. Phase 1

includes planning, goal setting, and activation of knowledge and motivation relevant to the task. Phase 2 involves monitoring of oneself, the task, and the task context. In phase 3, the learner controls and regulates learning based on the monitoring. During Phase 4, students reflect on their learning.

Section Summary

Although the models vary in language and number of phases, they all assume that SRL proceeds from a preparation phase through performance or application phase into an appraisal and adaptation phase (see Puustinen & Pulkkinen). Table 3 compares the main phases of the three models, consolidating the four phases in the COPES and Pintrich models into the three main phases of preparation, performance, and adaptation.

Table 3: Components of SCM, COPES, and Pintrich model

Model	Phase 1	Phase 2	Phase 3
SCM	Forethought (task analysis, self-motivation)	Performance (self-control, self-monitoring)	Self-Reflection (self-judgment, self-reaction)
COPES	Task definition, goal setting, planning	Applying tactics and strategies	Adapting metacognition
Pintrich Model	Forethought, planning, activation	Monitoring, control	Reaction, reflection

Review Question 2: Which SRL processes are examined in current SRL empirical research?

To answer the second review question, this section discusses the SRL processes targeted by the reviewed studies. Two schemes for categorizing SRL processes were found in the review (Sitzmann & Ely, 2015; Azevedo et al., 2005). Both categorizations were devised to include

processes examined in prior SRL research. Sitzmann and Ely's (2015) framework of regulatory mechanisms drew from multiple disciplines while Azevedo et al's (2005) categorization scheme derived 33 SRL processes from the three main theoretical models that informed most of the studies in the current review (Zimmerman, 2000; Winne and Hadwin, 1998; Pintrich 1995). The current review revealed that generally, most researchers targeted a combination of SRL processes (e.g., Azevedo et al., 2007; Bannert & Reimann, 2012, 2015; Hu & Driscoll, 2013; Kim & Ryu, 2013) rather than focusing on one specific process. Though several researchers focused on specific processes such as monitoring (e.g., Chang, 2007; 2010) or self-efficacy (e.g., Crippen & Earl, 2007; Hodges, 2008), researchers most often implemented interventions for improving a set of metacognitive strategies and/or cognitive strategies provided before, during, and after learning.

Section Summary

A combination of metacognitive and cognitive strategies were most commonly applied together and studied for effects on academic performance, especially in hypermedia learning environments. Self-monitoring strategy was most often employed when researchers focused on a particular strategy. Self-beliefs (motivational beliefs, self-efficacy beliefs) were seldom used as interventions but were studied or controlled for (Hu & Driscoll, 2013; Lehmann et al., 2014) as possible influences on metacognitive and cognitive strategy interventions. However, one study, Hodges (2008) used motivating email messages to promote self-efficacy as an SRL intervention during learning.

Review Question 3: What are some avenues for further research in supporting SRL processes for academic achievement during online learning in higher education?

This section examines each study in detail, indicating whether the SRL treatment researched had a significant effect on the learning outcome measure and when available, the size of the effect.

Table 4 describes the number of participants, the treatment and control groups, and the learning outcome measures for each study. The last column describes findings relevant to the effects of the SRL support conditions on academic outcomes.

Table 4: Number of Participants, Treatment and Control Groups, Learning Outcome Measures, and Findings

#	n	Group Conditions		Learning Outcome Measures	Findings
		Treatment (n)	**Control (n)**		
1	82	Human tutor (n=41)	No tutor (n=41)	Matching task Labeling task Flow Diagram	Sig. diff., Labeling (ES=.32)
2a	40	SRL prompts (n=20)	No prompts (n=20)	Knowledge test Comprehension test Transfer test	Sig diff, transfer (ES=.43)
2b	40	Training and SRL prompts (n=20)	No prompts (n=20)	Knowledge test Comprehension test Transfer test	Sig diff, transfer (ES=.44)
3	70	Self-directed metacognitive prompts (n=35)	No prompts (n=35)	Free recall task Comprehension test Transfer task	Sig diff, transfer (ES=.44)
4a	96	Study strategies (n=49)	No strategies (n=47)	Near transfer task Far transfer task	Sig diff, far transfer (ES=.69)
4b	145	Explanation generation (EXPL, n=48); summarization (SUM, n=47); EXPL + SUM (n=47)	No strategies (n=50)	Near transfer task Far transfer task	Sig diff, near transfer EXPL, EXPL + SUM), (ES=.68)
4c	191	Planning (PLN, n=47); Domain knowledge activation (DKA, n=48); PLN + DKA (n=46);	Control (n=50)	Near transfer task Far transfer task	Sig diff, far transfer, PLN only (ES=.79)
4d	142	Judgment of learning (JOL, (n=46); True/false (T/F , n=49)	No questions (n=47)	Application test	Sig diff (ES=.66)

#	n	Group Conditions		Learning Outcome Measures	Findings
		Treatment (n)	**Control (n)**		
5	99	Self-monitoring (n=47)	No self-monitoring (n=52)	Course grade	Sig diff (ES=.73)
6	90	Self-monitoring (n=45)	No self-monitoring (n=45)	English proficiency; Reading comprehension	Sig diff, English prof. (ES=.17)
7	51	Prompts: Knowledge integration (KI, n=13); problem-solving (PR, n=13); KI + PR (KP, n=13)	No prompts (n=11)	Conceptual knowledge test; *Problem-solving score* Develop and justify solutions; Monitor and evaluate plan of action	Sig diff, KI only, overall problem-solving (ES=.21); develop and justify solutions (ES=.18); monitor and evaluate plan of action (ES=.29)
8	64	Worked example (WE, n=24); Worked example/self-explanation prompts (SE, n=24)	No intervention (C, n=18)	Mid-course Exams (4) Final exam	No sig diff
9	83	Prompts/feedback (n=39)	No treatment (n=44)	Knowledge test; Sub-goal relevancy; Learning gains	No sig diff
10	23	Immediate feedback Fading feedback	No feedback	Test 2 Test 3	No sig diff
11a	33	Web tutor (n=16)	Navigation (n=17)	Essay Verification test	No sig diff
11b	118	Tutor with instruction Tutor without instruction	Navigation with instruction Navigation without instruction	Essay Verification test	No sig diff
12a	60	Global monitoring; Inference questions	Text only	Diagrams; Concept Maps Factual Questions Inference Questions	Sig diff, global monitoring only, diagrams (ES=.79); concept maps (ES=.73)
12b	84	Global monitoring (GM); Specific monitoring (SM)	Adjunct questions (C)	Diagrams; Concept Maps Factual Questions Inference Questions	Sig diff, GM, concept maps to SM, C (ES=.72, .57) Sig diff, GM, inference questions to SM, C (ES=1.84, 1.46)

#	n	Group Conditions		Learning Outcome Measures	Findings
		Treatment (n)	**Control (n)**		
13	196	Self-efficacy enhancing emails (n=98)	Informational emails (n=98)	Math achievement	No sig diff
14	21	SRL strategy training (n=8)	No training (n=13)	Course grade	Sig diff (ES=.71)
15	98	Direct prompts (DP, n=40) Generic prompts (GP, n=32)	No prompts (CG, n=26)	Domain knowledge test *Concept map* Structural Semantic	Sig diff, generic prompts, all tests
16	30	Matrix (n=10) Outline (n=10);	Conventional (n=10);	Knowledge test	Sig diff, matrix (ES=.27)
	119	Matrix; Matrix + self-monitor(SM); Outline; Outline + SM Conventional + SM	Conventional	Declarative test Procedural test Application test	Sig. diff. all notetaking methods +SM, declarative test; Sig. diff. matrix over outline and conventional
17	122	Formative peer assessment system (WFPAS, n=42); Traditional peer assessment (n=39)	Self-assessment (n=41)	Ill-structured problem-solving task	Sig diff, WFPAS to conventional (ES=.70); traditional over conventional (ES=1.43)
18	88	Embedded SRL help (n=42)	No help (n=46)	Reading test Listening test Overall score	Sig diff, reading test (ES=.46), overall (N/A)
19	194	e-learning (EL) + SRL (n=47) face-to-face (F2F) + SRL (n=48)	EL (n=53) F2F (n=46)	Comprehension Design Skill	Sig diff, both EL+SRL and F2F+SRL, comprehension (ES=.78, .67) Design skill (ES=1.71, 1.00)
20	223	Generative learning strategy prompts (T2); Generative learning strategy prompts + metacognitive feedback (T3)	Control (T1)	Recall test Comprehension test	Sig diff, T3 to control, both tests
21	67	Generic prompts (n=23) Directed prompts (n=22)	No prompts (n=22)	Knowledge test; Essay;	Sig diff, essay, generic only (ES=.25)

#	n	Group Conditions		Learning Outcome Measures	Findings
		Treatment (n)	Control (n)		
22	43	Conceptual scaffolding (CS, n=22)	No scaffolding (NS, n=21)	Declarative knowledge test; Conceptual knowledge test	No sig diff
23	80	Mixed; Metacognitive strategy prompts; Cognitive strategy prompts	No embedded support	Comprehension test	No sig diff
24	89	Broad support (n=20) Med. Support 1(n=21) Med. Support 2(n=20)	Minimal support (n=24)	Retention test Transfer test	Sig diff, broad only, retention and transfer (ES=1.00, 1.63)
25	60	Agent scaffolding	No agent	Knowledge test	No sig diff
26	49	Peer feedback (n=16) Tutor feedback (n=15)	Control (n=18)	Course exam	Sig diff, tutor over peer feedback (ES=.12)

As Tables 3 and 4 illustrate, there are many different areas of research, SRL processes and types of interventions researchers are currently examining to gain knowledge about the effects of SRL on academic performance in online higher education learning environments. Interventions have frequently been categorized as direct (direct instruction) and indirect (e.g., prompting, scaffolding), and applied either individually or together (Ifenthaler, 2012). Some researchers of SRL assume higher education students have already acquired knowledge of SRL strategies, which might explain the paucity of studies examining the effects of strategy instruction in this review (Graesser et al., 2007, Hu & Driscoll, 2013, Bannert & Reimann, 2012). Generally, prompts are delivered as questions that guide the students during learning. There has been some debate about the comparative effective of generic or directed prompts (Ifenthaler, 2012, Lehmann et al., 2014). Both studies found that generic prompts were more effective than directed within the context of learning by solving problems.

As noted by deBruijn et al. (2016), prior reviews of SRL in higher education online have not included many studies outside the purview of hypermedia learning. The current review contains a number of studies into the effects of SRL interventions during problem-based, inquiry, and experiential learning. The rest of this section will examine each study in more detail, categorized by online learning environment (see Table 3, column 6).

Section Summary

This review synthesized 10 years of research from 2006 to 2016, focusing on research into self-regulated learning strategies as they relate to academic achievement in online higher education learning environments. As with the other reviews of literature discussed previously (Broadbent & Poon, 2015; DeBruijn et al., 2016), external support of SRL generally has positive effects on students' academic achievement online. Eighteen of the twenty-six studies reviewed in the current study (69%) reported a significant effect of intervention on academic achievement.

Levels of SRL Support

One unanswered question found in the literature is that given the effectiveness of providing direct and indirect support for SRL processes, it is not clear whether learners may be supported effectively with lower levels of SRL support (Rodicio et al., 2013). Some researchers have surmised that learning tasks (e.g., learning difficult topics or solving ill-structured problems) requiring more cognitive resources than others might suffer from higher levels of support. Moos and Azevedo's (2008) study indicated that students receiving maximum SRL support (a combination of both cognitive and metacognitive strategies) did not perform better than those receiving less support, or the control group that received no support. One possible

reason the researchers discussed was that students receiving higher levels of support were cognitively overloaded. The researchers found that the maximum support group self-reported more cognitive load than the other groups. Further, Bednall and Kehoe (2010) found that when students were merely provided a list of strategies to use and allowed to choose the ones they preferred (or not use them at all), they performed better than when they were required to use a specific strategy (explanation and summarization) during study. As with Moos and Azevedo, cognitive overload was given as a possible reason for students performing less well under high support conditions. However, Rodicio et al.'s (2013) study found that the highest level of SRL support was required for significant improvements in academic achievement scores testing conceptual knowledge after learning a complex topic within a hypermedia environment. Finally, Bannert and Reimann (2012) conducted two studies, one examining the effects of providing SRL prompts, the other investigating the effects of providing both instruction and prompts. They found that both conditions improved a far-transfer task. However, they did not test whether providing instruction alone would have been sufficient to produce the same effects. Future work should address questions about how much SRL support is necessary for improving academic achievement in higher education. Therefore, it may be useful to consider what level of support provides enough support while not overtaxing students' resources and possibly affecting their level of performance and consequently, their academic outcome.

One parameter affecting level of self-regulated learning support in online environments is the amount of control given to the student on using or not using the SRL support provided during learning. As noted, Bednall and Kehoe (2011) found that simply listing a variety of strategies yielded more positive learning effects than controlled, targeted strategies. Kondo et al.'s (2012)

English learning mobile application inserted an SRL framework into their five step process of learning and did not find significant gains in achievement although there were some gains, such as improvement in students' self-study behavior.

Another parameter affecting support level was the range of SRL support strategies offered during instruction. Some researchers have explored providing a combination of strategies in support of multiple SRL processes. Azevedo, Greene, and Moos (2007) provided a human agent within a hypermedia environment that monitored, evaluated, and provided feedback to students regarding a wide range of self-regulatory skills (e.g., planning, monitoring progress) as well as prompting them to use effective cognitive strategies (e.g., hypothesizing, drawing) and facilitating time and effort planning. However, Rodicio et al. (2013) noted that less support might prove to be as effective. Their study examined the effects of broad, intermediate, or minimal self-regulation support for learning a new complex topic. However, results indicated only broad support provided enough SRL support to affect learning achievement, corroborating earlier research that showed broad support was effective (e.g., Bednall & Kehoe, 2011).

Studies focusing on specific SRL strategies have also been shown to be effective. As discussed previously in the review, self-monitoring is an essential process and central to the self-regulated learning framework. The self-monitoring strategy was found to positively affect learning in a number of studies in this review that used varying levels of support, although none specifically addressed the issue. High-level self-monitoring support (Chang, 2007, 2010) built a required students to fill in an embedded self-monitoring form during certain phases of the learning activity. The authors found significant achievement effects for the treatment group over a control group who did not have to fill out the form. However, Bednall and Kehoe (2012,

Experiment 4) found no significant effects on learning achievement for students who were required to complete judgment of learning (JOL) questions. Hathorn and Rawson (2012) required treatment students to answer self-monitoring questions and found significant effects on mental models measured by asking students to draw diagrams and concept maps of the concepts they learned in the hypermedia environment. Level of support was not specifically examined in the self-monitoring studies in this review.

Other SRL Factors

There were two other factors of interest in considering the design of SRL supports in online learning environment within higher education. First, the current review found that most of the current research investigating SRL effects on academic performance in online environments was performed in e-learning or hypermedia environments. Although research into other types of learning, such as problem-based or project-based learning environments is increasing (e.g., Chen & Bradshaw, 2007; Crippen & Earl, 2007; Ifenthaler, 2012), it would be worthwhile to study the effects of SRL in other environments such as problem-based learning. This conclusion is corroborated in deBruijn et al., 2015, as discussed at the beginning of CHAPTER 2.

Finally, most researchers suggest the need for researching the interrelationship between SRL processes rather than focusing only on one process (e.g., Azevedo, 2007, Duffy & Azevedo, 2015, Hu & Driscoll, 2013) because the SRL process requires an iterative process of monitoring (using metacognitive strategies) and control (using cognitive strategies) to foster students' awareness of where they are in their learning and where they should go next. Additionally, other processes important to SRL are the student's self-beliefs, such as how much effort they believe they must expend to succeed, or how confident they are in their ability to succeed. These are all

processes that affect each other during learning and have an effect on students' ability to self-regulate as well as achieve academically. Many of the reviewed studies considered the relationship between metacognitive and cognitive strategies, and a several measured motivation (or sub-scales within motivation) using self-report tools such as the Motivated Strategies for Learning Questionnaire (MSLQ). Two studies considered the concept of self-efficacy, which is also often included as a subset of motivation, as a correlate of self-regulated learning that has been shown to have a positive relationship to academic achievement in traditional learning environments. However, more research is needed to understand its relationship to SRL and achievement in online higher education environments (Hodges, 2008).

Conceptual Framework

A clearly articulated framework helps guide the development of hypotheses and assumptions about the nature of processes, mechanisms, and constructs relevant to self-regulated learning (Azevedo, 2014). The three review questions aided in the formulation of this study's conceptual framework. A review of the major SRL theoretical models revealed three main theoretical models in current use: the SCM, COPES, and Pintrich models. A comparison found main points of agreement between the models. First, all three theories posited an iterative phase model of at least three main phases that included a preparation, performance, and appraisal/adjustment phase. Second, the three theories recognized the interaction of monitoring and control as a key force for helping students change their behavior when necessary to improve learning performance and outcomes during. The COPES model best visualized these constructs as processes occurring outside of but interacting with the iterative SRL phases.

Figure 5 incorporates the concept of a three-phase model consisting of forethought, performance and self-reflection while visualizing control and monitoring as interacting processes that continually check and adjust student behavior throughout the three-phase process. The examination of SRL theories also indicated that self-efficacy is an SRL process that needs more research in online learning environment. The construct is included as a co-variable to test whether it has a positive relationship with SRL and academic outcome in online as well as traditional learning environments. Mainly, the study examines the effects of adding SRL supports (training and prompts) administered prior to and during each SRL phase on academic achievement. Therefore, the SRL supports are independent variables and the achievement test measure is the dependent variable.

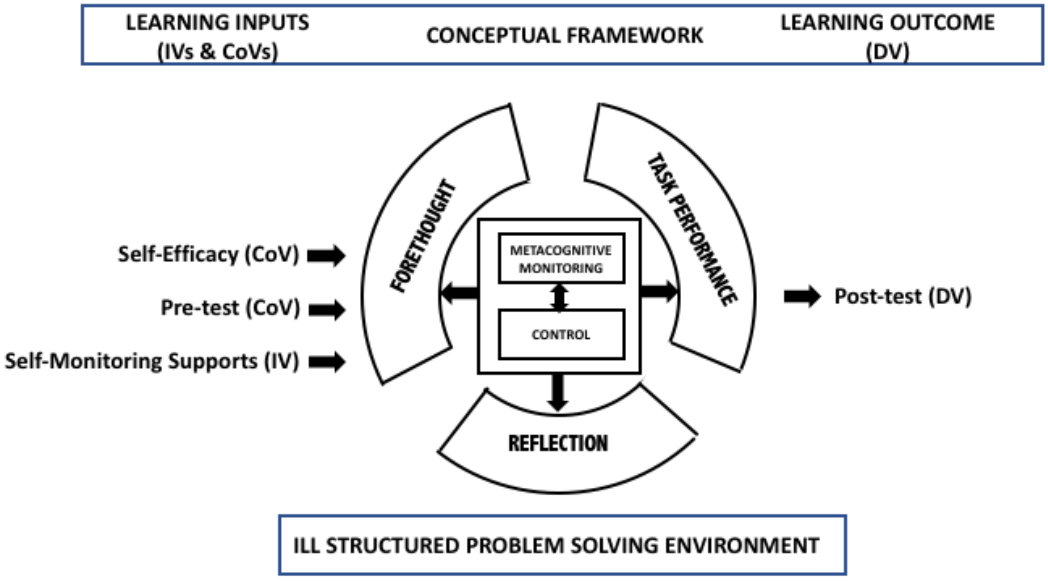


Figure 5: Conceptual Framework for the Study

Conclusion

A review of prevalent SRL theories and processes informed the creation of the conceptual model created for embedding the interventions for this study. Reviewing the results of previous empirical studies, the SRL processes targeted and SRL interventions used to foster those processes for improving student learning outcomes revealed avenues for further study. The current study focuses on how much SRL support is optimal for student achievement. CHAPTER 3 describes the Method used to answer the research questions formulated to provide more insight into this area of research.

CHAPTER 3: RESEARCH DESIGN AND METHOD

CHAPTER 3 describes the study method and design, including participants, research design, treatments, instruments, procedure, data analysis, and limitations.

Participants

An a priori power analysis indicated that a total sample size of 130 was needed to have 80% power for detecting a medium sized effect when employing the .05 criterion of statistical significance.

The research participants were 134 undergraduate students at an urban research university in a southeast state in the United States of America. Students in three undergraduate Political Science courses, INR 4035 (International Political Economy), POS 3703 (Scopes and Methods of Political Science) and GEO 3471 (World Political Geography) were given the chance to participate and receive 10 extra credit points in their respective courses. Students enrolled in two or more of the courses were informed that they could only participate in the extra credit option in one course. The study was approved ethically by the University of Central Florida Institute Review Board (see APPENDIX A). The students were informed about the study and the extra credit problem-solving exercise by the professor during class. The students who were interested in participating were randomly assigned to one of three groups: two treatment groups and a control group. An email providing a link to the online problem-solving environment was sent to them with a unique login and password that logged them in to their particular group. The email asked them to read and consent to the study on the website (see APPENDIX B). A total of 134 students consented and initially participated in the study but 23

participants did not complete all of the required elements of the study and were eliminated, with a final total of 101 students.

Demographics

For the entire sample (N=101), 90 (89%) of the participants were between 18 – 29 years old, 8 (7.9%) were between 30-44 years old and 3 (3%) were 45 or older. Participants' genders were 52 (51.5%) female and 49 (48.5%) male. Ethnicities were 53 Caucasian (52.5%), 10 African-American (9.9%), 8 Asian-American (7.9%), 18 Hispanic (17.8%) and 12 (11.9%) listed themselves as Other. Because the three courses were higher level courses in the International Studies program, 46 (45.5%) participants were seniors, 41 (40.6%) juniors, 11 (10.9%) sophomores, and 3 (3.0%) freshmen. English was the primary language for 95 (94.1%) of the participants, with 2 (2%) primary Spanish speakers and 4 (4%) whose primary language was listed as Other.

Research Design

The study employed a pre-post-test control group experimental design, using quantitative instruments. Systematic bias was primarily reduced by randomizing assignment of participants to each of three instruction conditions.

Treatments

De Bruijn et al. (2015) pointed out in their literature review of effective SRL processes in higher education that more experimental research on the effectiveness of SRL processes in problem-based environments was needed. It was also suggested that confounding variables such as self-efficacy and motivation should be examined for their effects on SRL strategies (de Bruijn

et al., 2015; Hu & Driscoll, Moos & Azevedo, 2007). Therefore, there were two treatment groups, the minimum self-monitoring support group (MIN) and the maximum self-monitoring support group (MAX) and control group (C), who received no support. Minimum support was provided by the self-monitoring instruction intervention detailed in APPENDIX C. The intervention was a tutorial that defined and described self-monitoring as a self-regulated learning strategy, then provided a set of questions to ask while performing a learning task. The tutorial asked students to answer three sets of self-monitoring questions divided into the three Social Cognitive SRL phases of forethought, performance, and reflection while they did the problem-solving exercise. The maximum self-monitoring support (MAX) group included the self-monitoring instruction intervention prior to the exercise and three sets of prompts coinciding with the three phases of Zimmerman's SCM model: forethought, performance, and reflection. The prompts used the same questions that were provided in the self-monitoring tutorial for both the MIN and MAX groups.

Table 5: Frequency Table for Groups

Groups	**N**
MAX	39
MIN	31
C	31
Total	101

Online Learning Environment

A Moodle website, titled Iran Nuclear Program Negotiation Simulation Design, was created for the purposes of the study. The author created three separate courses within the Moodle site to house the different required steps for each of the groups.

Figure 6: Ill-structured Problem-Solving Environment in Moodle

Instruments

Data were collected through the quantitative instruments of the professor-designed concept knowledge test and the self-regulation questionnaire shown in Table 6.

Table 6: Measurement Instruments

Measure	Measurement Instrument	Citation
Domain-specific concept knowledge Test	Professor-designed knowledge test	Sadri, H. (2014)
Self-Regulation Trait Self-Report Questionnaire	Trait Self-Regulation Scale	Herl et al. (1999)

Since learner characteristics are essential factors in self-regulated learning (Bannert & Reimann, 2012), pretest measures included measures for prior knowledge and trait self-efficacy. Prior knowledge of the concepts pertaining to the assignment was measured using a professor-

developed true-false test and face-validity is assumed through the expert reviewing process. At the end of the exercise, students' knowledge of the concepts was measured again using the same test. Due to the subject matter expertise of the test creator, the test had content validity. However, because the test format was true-false and there were only 28 items, the scores are less reliable (due to guessing) than those based on 5-choice items (Grosse & Wright, 1985). Test scores are available in APPENDIX G.

Data on self-efficacy traits were obtained prior to the learning exercise by means of the Self-Regulation Trait Self-Report Questionnaire (Herl et al., 1999). O'Neil and Abedi (1996) developed the trait self-regulation questionnaire, which has been used in research on self-regulation during problem-solving and tested for construct validity (Hong & O'Neil, 2001). APPENDIX D includes a copy of the questionnaire that was administered to all student participants prior to the study. There were eight Likert scale questions related to self-efficacy with four answer options: almost never, sometimes, often, and almost always (Table 7).

Table 7: Self-Efficacy Questions from Trait Self-Regulation Questionnaire

#	Scale Item Number	Question
1	2	I check how well I am doing when I solve a task.
2	6	I ask myself questions to stay on track as I do a task.
3	10	I check my work while I am doing it.
4	14	I almost always know how much of a task I have to complete.
5	18	I judge the correctness of my work.
6	22	I correct my errors.
7	26	I check my accuracy as I progress through a test.
8	30	I ask myself, how well am I doing, as I proceed through tasks.

The scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.828 (see Table 8).

Table 8: Reliability of Sub-scales – Trait Self-Regulation Questionnaire

Scale	Pre-test	Post-test
Planning	**.835**	**.914**
Self-checking	**.828**	**.897**
Metacognition	**.891**	**.944**
Effort	**.831**	**.918**
Self-efficacy	**.927**	**.902**
Motivation	**.891**	**.927**

Self-monitoring skill was not measured in this study because the question was related to improvement in academic achievement based on levels of support offered in an online environment. However, data were collected to provide evidence of self-monitoring effort on the part of students within the minimum and maximum support groups. Students in both groups were required to answer a one-question multiple-choice quiz after the self-monitoring tutorial. The question was "Self-regulated learning has three phases. Which answer is incorrect?" and the correct answer was "Goal orientation" from a choice that also included "Forethought", "Performance", and "Self-reflection". Students were not required to pass the test before continuing. Answers to the self-monitoring questions administered during the three SRL phases of forethought, performance, and reflection, were also collected (see Table 9).

Table 9: Self-monitoring Questions and Answers of the Maximum Support Group

Phase	Question	Answer
Forethought Phase	What is the instructor's goal in having me do this task?	The instructor's goal is to help me learn problem-solving skills and to make a simulation based on international relations
	What are all the things I need to do to successfully accomplish this task?	I need to take the first three surveys, then I need to complete the different parts of the second section which will involve the actual simulation
	What resources do I need to complete the task?	I need a computer and this specific website
	How much time do I need to complete the task?	To complete the entire study, I will need about a week. To complete this specific section, about 1-2 hours
Performance Phase	What strategies am I using that are working well or not working well to help me learn?	Researching good, verified sources, and focusing completely on these different questions/tasks are helping me learn
	What other resources could I be using to complete this task?	I am mostly using internet sources, so some sort of newspaper or out publication would be good extra resources
	What is most challenging and/or confusing for me about this task?	The most challenging aspect of finding good information to help me answer these questions
Self-reflection phase	To what extent did I successfully accomplish the goals of the task?	I completed all of my goals
	To what extent did I use resources available to me?	I used all resources I thought would apply to this project
	If I were the instructor, what would I identify as strengths of my work and flaws in my work?	My work is done completely, but could possibly have more to it. It could be said that I gave the bare minimum
	When I do an assignment or task like this again, what do I want to remember to do differently?	Leave myself more time

Materials

Problem-Solving Activity Materials

The problem-solving assignment was designed by the professor of the three international studies courses that were used, and added to each Moodle course by the author. The assignment was entitled "Extra Credit Simulation Exercise: The Iranian Nuclear Negotiation" (See APPENDIX F). Students were tasked with creating a design document that consisted of four main sections: an objectives section, a summary section, a scenarios section and an analysis section. Their problem was to design a simulation of negotiations between the United States, China, and Iran about Iran's nuclear policy and its effects to peace within the Middle East and the world. They were tasked to research and describe the underlying issues in order to provide three possible negotiation scenarios: a scenario beneficial to the United States, a scenario beneficial to Iran, and a scenario beneficial to everyone.

Treatment Materials

The self-monitoring tutorial was devised by the researcher, drawing from SRL literature on self-monitoring (see APPENDIX C, Zimmerman & Paulsen, 1995; Zimmerman & Schunk, 2013). The self-monitoring questions used in the tutorial were modified from the planning, monitoring, and evaluating questions provided in Tanner (APPENDIX C, 2012). The same questions were used as the self-monitoring question prompts for the maximum support group during the forethought, performance, and reflection phases of SRL.

Treatment Procedure

First, the participants were clustered from three classes and then randomly assigned to the three experimental conditions (MAX, MIN, and C). Each of the participants were emailed a unique login and password with instructions for locating and signing into the Moodle problem-solving environment. The login gave each participant access only to the assigned group module. All participants read the informed consent, completed the demographic survey, Self-Regulation Questionnaire, and domain specific knowledge pre-test (see APPENDIX D).

Presentation of all materials and measures was online and self-paced, with an assignment duration of three days. The assignment website opened Wednesday morning, 6 AM, and closed Friday night, 12:00 AM. The procedure followed by each of the study groups is listed in Table 10. The maximum support (MAX) and minimum support (MIN) groups were required to read the self-monitoring tutorial before they could proceed to the next step. The MAX group answered a set of forethought questions (see APPENDIX C) before working on the first two steps of the problem-solving exercise. Both the MIN and control (C) groups proceeded through the problem-solving steps. The MAX group was prompted between Step 2 and Step 3 to reflect upon and answer performance-related questions, then once more were prompted to answer reflection questions after Step 4. After inputting their problem-solving assignments, all groups took the domain specific knowledge post-test.

Table 10: Problem-solving Exercise Procedure for Study Groups

Maximum Support (MAX)	Minimum Support (MIN)	Control (C)
Self-monitoring tutorial	Self-monitoring tutorial	
Forethought questions		
Problem-solving Step 1: Set Objectives	Problem-solving Step 1: Set Objectives	Problem-solving Step 1: Set Objectives
Problem-solving Step 2: Problem Summary	Problem-solving Step 2: Problem Summary	Problem-solving Step 2: Problem Summary
Performance questions		
Problem-solving Step 3: Develop Scenarios	Problem-solving Step 3: Develop Scenarios	Problem-solving Step 3: Develop Scenarios
Problem-solving Step 4: Analysis	Problem-solving Step 4: Analysis	Problem-solving Step 4: Analysis
Reflection questions		

Data Analysis

Data was entered into SPSS and statistical tests of analysis of covariance (ANCOVA) were used to test the study hypothesis. ANCOVA was chosen because it is used to test the differences of treatment effect between two or more groups controlling for covariates. ANCOVA controls threats to internal validity and is known to reduce error variance (Dimitrov & Rumrill, 2003). There were several possible threats to internal validity in the current study. First, students were volunteers and could drop out at any time. There was a possibility that the sample size would shrink below levels that would give the study sufficient power. Drop-outs could also cause uneven group size and compromise the randomness of the sample.

Also, it was chosen rather than a repeated measure ANOVA because the current research focus is on the treatment effects between groups using pretest as the baseline data.

Limitations

All studies have limitations to their internal validity, generalizability and applicability. There are several limitations noted here. First, power was reduced to 66% from the 80% a priori sample power estimate due to the reduction in sample size from 134 to 101 participants. In addition, the design is not a true experimental design because the sample is not randomly selected at the participant level due to the use of cluster samples, even though random assignment was used for the current study.

Second, although there was content validity due to the subject matter expertise of the test creator, the conceptual knowledge pre- and post-test was lacking in reliability, making it difficult to compare the effects of this research to other studies. The reliability and validity for the instructor created test could be a concern.

Third, this study focused on measures of academic performance within a limited time frame of three days. There are outcome variables arising from SRL supports that could not be tested in this study, including studying the effects of support over time. Finally, the study was limited by the static nature of the direct and indirect self-monitoring strategies. Some research has been done on adapting scaffolds by fading them as students become more self-regulated (Azevedo, 2014). Zheng (2016) notes that there are few adaptive scaffolds used to promote SRL in existing studies and they may lead to more significant gains in academic performance by adjusting to students' learning needs.

CHAPTER 4: RESULTS

To test the research hypothesis, a one-way analysis of covariance (ANCOVA) was conducted to determine the effect of self-monitoring supports on the participants' concept knowledge achievement, controlling for prior knowledge through a pretest and self-efficacy. The one-way ANCOVA is a useful test to compare two or more groups when there are covariates and one independent variable. All tests for significance were set at the .05 level.

Before conducting ANCOVA, five tests were run to determine whether assumptions were met. First, a visual inspection of a matrix scatterplot revealed some issues with linearity. To research linearity further, quadratic and cubic trends were checked for each group and no significance was found. Therefore, it was decided to continue testing with ANCOVA. Second, homogeneity of variance was met, as assessed by Levene's test of homogeneity of variance (p=.225). Third, no outliers were found in the data, as assessed by a boxplot for each group. Fourth, the assumption was normality was assessed by Shapiro-Wilk's test and standardized residuals for the interventions and for the overall model were found to be normally distributed (p>.05). Finally, the assumption of homogeneity of regression slopes was met, as the interaction with group was not statistically significant for pretest ($F_{2, 96}$=.261, p>.05) and self-efficacy beliefs ($F_{2, 96}$=.270, p>.05). If the interaction is significant, the interpretation of main effect of an ANCOVA may not be helpful.

As seen in Table 11, ANCOVA results showed a significant difference on achievement across experimental and control groups after controlling for pretest and self-efficacy beliefs (p=.030). Additionally, pretest had a significant relationship to posttest (p<.001) while self-efficacy beliefs did not have a significant relationship with posttest (p=.481). Table 12 shows

how the covariates adjusted the original posttest means and shows slight differences due to both pretest and self-efficacy beliefs.

Table 11: ANCOVA Results

Source	Type III Sum of Squares	df	Mean Square	F	*p*	Partial eta squared
Corrected Model	490.284	4	122.571	12.181	.000	.337
Intercept	98.405	1	98.405	9.779	.002	.092
Pretest	445.127	1	445.127	44.236	.000	.315
Self-efficacy beliefs	5.032	1	5.032	.500	.481	.005
Group	73.394	2	36.697	3.647	.030	.071
Error	966.014	96	10.063			
Total	70986.000	101				
Corrected Total	1456.297	100				

Table 12: Adjusted and Unadjusted Means for Groups with Pretest and Self-Efficacy as Covariates

Group	Unadjusted			Adjusted	
	N	Mean	SD	Mean	SD
Maximum Support	39	25.821	4.10	25.323	3.21
Minimum Support	31	27.129	3.50	27.412	3.18
Control Group	31	25.871	3.73	26.214	3.19

Since there was a statistically significant difference between the adjusted means, a post-hoc analysis was performed with a Bonferroni adjustment. Table 13 shows that test scores were significantly higher in the minimum support group than in the maximum support group, a mean difference of 2.088 with a 95% Confidence Interval (.203, 3.974), $p<.025$.

Table 13: Group Comparisons as a Function of Instructional Condition, With Pretest Scores and Self-Efficacy as Covariates.

						95 % Confidence Interval for Difference	
Group Comparison	Mean Difference	Standard Error	*p*	*t*	*d*	Lower Bound	Upper Bound
Min - Max	2.088*	.774	.025	2.698	.649	.203	3.974
Min - C	1.198	.806	.421	1.486	.378	-.766	3.161
C - Max	.891	.776	.761	1.148	.276	-.999	2.781

Other than the significant difference between the minimum support and maximum support groups there were no other significant effects between groups. However, as seen in Table 9, the minimum support group also received higher scores than the control group. Although not significantly, the control group received higher scores than the maximum support group.

CHAPTER 5: DISCUSSION AND RECOMMENDATIONS FOR FUTURE STUDY

CHAPTER 5 discusses the research findings presented in CHAPTER 4. It is divided into two sections. The first section discusses effects of different levels of SRL support on student achievement, including effects specific to other factors such as self-efficacy and problem-solving environment and conclusions. The last section summarizes the conclusions and provides recommendations for future research.

Discussion

The null hypothesis of this study proposed that there was no significant difference in learners' concept knowledge achievement between the experimental and control groups after controlling for prior knowledge (as measured by a concept knowledge pretest) and students' individual self-efficacy beliefs. Results showed a significant difference between groups, and post-hoc tests revealed significantly higher concept knowledge achievement scores for the minimum support group over the maximum support group, suggesting that giving minimum external self-monitoring support in the form of direct instruction prior to learning can be effective in promoting higher concept knowledge achievement after learning in ill-structured problem-solving environments. Conversely, this study indicated that maximum self-monitoring support did not result in improved achievement scores above the control group. The findings support previous studies indicating that self-monitoring strategies benefit academic learning (Chang, 2007, 2010). Chang studied the effects of providing students learning English online with a self-monitoring form that allowed them to track their own progress, helping them to

monitor their own behavior. Both studies, using the same form on two different sets of participants, found that student English proficiency scores improved significantly.

The current study also contributed some evidence that training self-regulation alone may be sufficient to improve academic achievement. Bannert and Reimann (2012) conducted two studies, examining the effects of SRL prompts in one and the effects of training prior to learning plus, SRL prompts during learning. Results were inconclusive for both conditions, prompting the researchers to question whether training alone might have been sufficient. The current study examines this question by comparing students who only received self-monitoring instruction with a second group that received both training and question prompts. The results show that training alone could suffice for improving achievement scores in concept knowledge.

The current study's findings contradict the results of Rodicio et al.'s (2013) examination of minimum, intermediate, and maximum support. Rodicio et al.'s study found that only maximum support produced a significant positive effect on conceptual knowledge test scores after learning a complex topic (plate tectonics). In contrast, the current study found that only minimum support produced a significant positive effect on conceptual knowledge scores and that the maximum support group had a slightly lower mean score than the control group. This contradiction could be explained due to differences in domain knowledge levels of study participants: Rodicio et al.'s study used students with little to no prior knowledge of plate tectonics. The current study recruited students from courses within their own discipline, most of whom were juniors and seniors, suggesting that they are not novices in their field and may require less SRL support than novices.

Because only a few studies have previously examined SRL support within problem-solving environments, the current study adds findings that provide more information about designing SRL support in such environments. Only six studies examining external support of SRL during problem-solving activities were found in the literature review (Chen and Bradshaw, 2007, 2010; Crippen and Earl, 2007; Ifenthaler, 2012; Lehmann, Hähnlein, and Ifenthaler, 2014; Kim & Ryu, 2013). The current study's positive results of self-monitoring support on conceptual knowledge contradict earlier research results on promoting conceptual knowledge in problem-solving environments. Chen and Bradshaw (2007) found no significant effects of providing knowledge integration prompts to promote conceptual knowledge during problem-solving. Their negative findings might be explained by some research that suggests generic SRL support is more effective than domain specific support (e.g., Ifenthaler ,2012; Lehmann, Hähnlein, and Ifenthaler, 2014). Both studies indicated that domain-general rather than specific prompts produced significantly higher scores on knowledge tests given after an ill-structured problem-solving activity. The current study corroborated Ifenthaler et al.'s findings due to the use of domain-general self-monitoring questions in the treatment (see questions in APPENDIX C, Self-Monitoring Tutorial).

The present results also demonstrate that encouraging rather than requiring self-regulatory activities can benefit learning within a problem-solving environment. Providing instruction in strategy use and giving students control over their own use or non-use produced a significant benefit on academic achievement. These results corroborate previous results that indicate merely providing a list of strategies with no required participation was sufficient to enhance performance in near and far transfer tasks (Bednall & Kehoe, 2011, Experiment 1).

Bednall and Kehoe conducted three other experiments that included more targeted interventions. Although they all produced positive effects, effect sizes were less than for Experiment 1, the least controlled intervention. The authors suggested that from a cognitive load perspective, Experiments 2, 3, and 4 might have induced more load on students' cognitive resources, lessening the impact of the interventions.

Limitations

A limitation of the current study was that time constraints within the larger course did not permit testing possible long-term effects of external support of self-monitoring and their effects on academic achievement. Further research is necessary to determine the long-term effects self-monitoring has on improving conceptual knowledge after ill-structured problem-solving.

The study was also limited by the static nature of the direct and indirect self-monitoring interventions. Some research is beginning to examine adaptive scaffolds that fade over time as students become better self-regulators (Azevedo, 2014). Zheng (2016) notes that there are still few studies investigating adaptive scaffolds to promote SRL and encouraging results may lead to more significant gains in academic performance by adjusting to students' learning needs.

Finally, the current study was limited due to small sample size and therefore a decrease in statistical power. The small sample size increases the likelihood of a Type II error skewing the results of the study. Further research is necessary to corroborate the results of this study using a larger sample, increasing power and lessening the chances for Type II errors.

Conclusion and Recommendations for Future Research

Based on the current study findings, there are more questions with both theoretical and practical implications. First, given that the participants in this study were almost all junior and senior students majoring in political science, their general domain knowledge would be higher than for students at the beginning of the political science program. It is unclear whether minimum support would be as effective for novice students less familiar with the political science domain. Thus, a promising avenue of research might be to examine the effects of different levels of support on students with different levels of general domain knowledge.

Second, as noted by Bednall and Kehoe (2011), the positive effects of minimum over maximum support might be explained by students in the maximum condition experiencing cognitive overload, hindering their performance on the conceptual knowledge test (Sweller, 2004; Sweller et al., 1998). Cognitive load theory posits a "split-attention" effect of the maximum support intervention on the primary problem-solving learning activity (Chandler & Sweller, 1991). Future studies may be strengthened by measuring and controlling for cognitive load.

Finally, the study's review of literature showed a growth in the number of SRL studies done in problem-solving environments. Given the breadth of existing studies done in hypermedia environments, it is possible compare the effectiveness of SRL interventions within the different environments and consider whether there are differences between SRL support needs between hypermedia and problem-solving environment

APPENDIX A: IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Naomi Malone**

Date: **February 19, 2014**

Dear Researcher:

On 2/19/2014, the IRB approved the following human participant research until 2/18/2015 inclusive:

Type of Review:	UCF Initial Review Submission Form
Project Title:	• The effects of metacognitive monitoring on problem solving in an ill-structured problem solving environment.
Investigator:	Naomi Malone
IRB Number:	SBE-14-10081
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

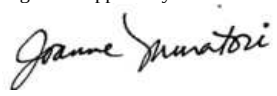
If continuing review approval is not granted before the expiration date of 2/18/2015, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 02/19/2014 09:55:33 AM EST



IRB Coordinator

APPENDIX B: INFORMED CONSENT FORM

Effects of metacognitive monitoring on problem-solving in an ill-structured problem-solving environment

Informed Consent

Principal Investigators: Naomi Malone, Doctoral Candidate.

Faculty Supervisor: Atsusi Hirumi, PhD

Investigational Site(s): University of Central Florida

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include about 200 people UCF. You have been asked to take part in this research study because you are a student attending a Political Science course at a university. You must be 18 years of age or older to be included in the research study.

The person doing this research is Naomi Malone, a doctoral student at the University of Central Florida's Department of Educational and Human Sciences. Because the researcher is a doctoral student, she is being guided by Dr. Atsusi Hirumi, a UCF faculty supervisor in the Department of Educational and Human Sciences. UCF Political Science professor Dr. Houman Sadri is conducting the research and providing opportunities for his students to take part in this research.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study: The purpose of this study is to study the effects of explicit self-monitoring instruction coupled with question prompts on students' problem-solving during an ill-structured problem-solving activity – specifically, you are tasked with designing a role-play simulation. Undergraduate students are increasingly learning in learner-centered online learning environments that provide little guidance during their instructional activities that frequently require them to solve ill-structured problems. Many studies indicate that students with better self-regulation skills do better academically. Self-monitoring in particular is an overarching self-regulation process that helps students regulate their learning. This study seeks to learn whether learning about and practicing self-monitoring during online problem-solving is beneficial to their learning and problem-solving performance.

What you will be asked to do in the study:

- February 20: You will be randomly assigned to one of three courses that have been set up for the study. After you sign in, you will be asked to fill out a Demographic survey, take a 32-item Self-Regulation Questionnaire and a pre-test that tests your knowledge of political science concepts relevant to the design of role-play simulation.
- All your interactions with the study will occur on a specially designed website: http://simport.org.
- Your participation in the study will last from February 20 to February 27. During that time, you will be asked to design a role-play simulation in four steps. You will be guided through these steps on the website when you sign in.
- All of you will receive a short tutorial in problem-solving. Some of you will receive extra guidance as you go through the role-play building exercise. Specifically, some of you will receive another short tutorial about self-monitoring during learning and will be prompted to use self-monitoring as a strategy during your task. Some of you will only be prompted to self-monitor. This guidance is geared to help you monitor your activities in order to perform them within the criteria requested and the one week time-frame.
- All study participants will read a short tutorial about problem-solving, which will take 10 minutes. Depending on the course you are randomly assigned to, you may be asked to read a one short tutorial on self-monitoring, receive prompts to remind you to self-monitor, or both. The tutorial should take up to 10 minutes.

- You must finish all four steps of the problem-solving activity that your professor assigned as your problem-solving activity in order to receive the full extra credit points for your course.

Location: The study will be conducted on a website created specifically for administering the study and collecting the data. The website is located at: http://simport.org.

Time required: We expect that you will spend up to (2) hours per day to complete all of the requirements for the research, beginning Thursday, February 20 and ending Thursday, February 27 for a total of 10 hours.

Risks:

There are no reasonably foreseeable risks or discomforts involved in taking part in this study.

Benefits:

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include learning about and improving strategies that may help you in your academic career, as well as problem-solving skills.

Alternatives:

If you choose not to participate, you may notify your instructor and ask for an alternative assignment of equal effort for equal credit. There will be no penalty.

Compensation or payment:

There is no direct compensation for taking part in this study. You will receive extra credit for your participation, but this benefit is at the discretion of your instructor.

If you choose not to participate, you may notify your instructor and ask for an alternative assignment of equal effort for equal credit. There will be no penalty.

Anonymous research: This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you. In order to receive credit, please follow your professor's instructions by submitting your work to the drop box set up in your course.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, talk to Naomi Malone, Graduate Student, Instructional Design & Technology, College of Education, (727) 480-0092 or by email at Naomi@knights.ucf.edu; Dr. Atsusi Hirumi, Faculty Supervisor, Department of Educational and Human Sciences at (407) 823-1760 or by email at atsusi.hirumi@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study:

If you decide to leave the research, you will not receive the extra credit points for the course. If you decide to leave the study, contact the investigator so that the investigator can omit any anonymous contributions to the study you have submitted before leaving. The person in charge of the research study or the sponsor can remove you from the research study without your approval. Possible reasons for removal include not participating in all the requirements of the extra credit that have been explained to you by your professor. We will tell you about any new information that may affect your health, welfare or choice to stay in the research.

APPENDIX C: TREATMENTS

SELF-MONITORING INSTRUCTION/SELF-MONITORING QUESTIONS

The treatments groups received self-monitoring instruction prior to beginning their problem-solving activity. The instruction included the set of questions that were embedded into each of the three SRL phases during the exercise.

DIRECTING YOUR OWN LEARNING

Importance of Self-Monitoring

Self-monitoring is an important skill for achieving success in academics (Zimmerman, 2000). Developing this skill helps people self-regulate and promotes reflective thinking in all aspects of their lives and in all forms of academic study and activity. This is especially true when you are taking an online course where you do not have as much access to the instructor as in face-to-face situations.

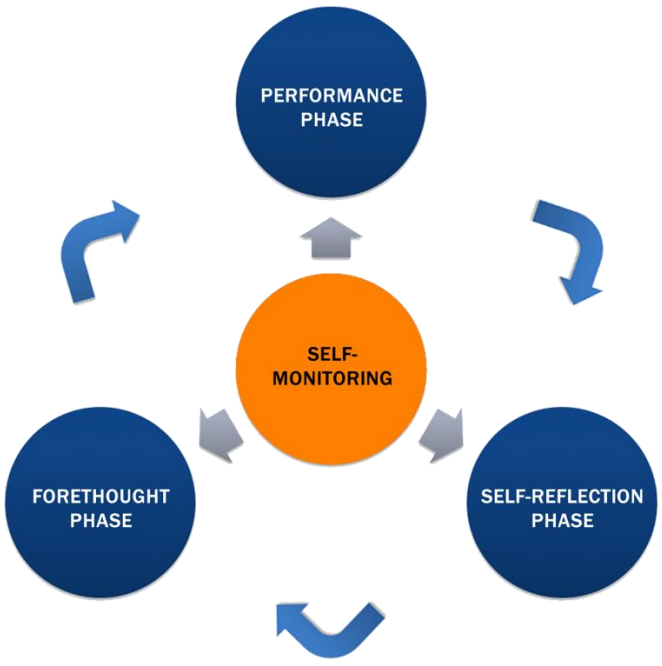


Figure 7: SRL Self-Monitoring Model for Study

When you regulate your own learning, it is vital that you are accurate in your self-monitoring by honestly assessing each individual component of the tasks and activities you are performing. Self-regulation consists of three main processes: Forethought, Performance, and Self-Reflection (see Figure 1). You should monitor yourself during all three of these steps by asking yourself questions appropriate to each phase.

HOW TO SELF MONITOR

As you go through this role-play design exercise, you will answer these questions to help you monitor your activities (Tanner, 2012):

FORETHOUGHT PHASE QUESTIONS:

Before you begin the exercise, ask yourself these questions:

- What is the instructor's goal in having me do this task?
- What are all the things I need to do to successfully accomplish this task?
- What resources do I need to complete the task?
- How much time do I need to complete the task?

PERFORMANCE PHASE:

During the exercise, ask yourself these questions:

- What strategies am I using that are working well or not working well to help me learn?
- What other resources could I be using to complete this task?
- What is most challenging and/or confusing for me about this task?

SELF-REFLECTION PHASE QUESTIONS

- To what extent did I successfully accomplish the goals of the task?
- To what extent did I use resources available to me?

- If I were the instructor, what would I identify as strengths of my work and flaws in my work?
- When I do an assignment or task like this again, what do I want to remember to do differently?

References

Tanner, K. D. (2012). Promoting student metacognition. CBE-Life Sciences Education, 11(2), 113-120.

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. *New directions for teaching and learning, 1995*(63), 13-27.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (2013). Self-regulated learning and academic achievement: Theoretical perspectives. Routledge.

APPENDIX D: INSTRUMENTS

This APPENDIX includes the following sections:

- Demographic Survey (Administered in the pre-tests)
- Self-Regulation Trait Questionnaire (Administered in the pre-tests)
- Achievement Test (Administered in both pre- and post tests)

Demographics Survey

1. **Age**: a, 18-29; b. 30-44; c. 45-59; d. 60+
2. **Gender** (please circle one): a. female b. male
3. **Race/Ethnicity** (please circle only 1): a. Caucasian; b. African-American; c. Asian-American; d. Hispanic; e. Other
4. Are you in an International Studies, Political Science other, or no degree program? a. IS; b. PS, c. other, d. none
5. If you are in a program, which year? a. Freshman; b. Sophomore; c. Junior; d. Senior; e. Graduate level
6. **What is the highest degree you have obtained?** (choose one only) a. Some high school; b. High school diploma; c. Some college; d. Bachelor's degree; e. Some Graduate experience; f. Completed Graduate degree
7. **What is your primary language**? (choose one) a. English; b. Spanish; c. Other
8. **How often are you on the Internet?** _____ hours/week
9. **How often do you play video games (computer or console)?** _____ hours/week
10. **How often are you on the computer?** _____ hours/week
11. **How would you rate your degree-of-comfort with computers?** (Choose one) a. Poor; b. Fair; c. Average; d. Above average; e. Proficient
12. **How would you rate your degree of familiarity with elements of simulation design?** (Choose one) a. Poor; b. Fair; c. Average; d. Above average; e. Proficient

Self-Regulation Trait Questionnaire

		Almost never	Sometimes	Often	Almost always
1.	I determine how to solve a task before I begin.	1	2	3	4
2.	I check how well I am doing when I solve a task.	1	2	3	4
3.	I work hard to do well even if I don't like a task.	1	2	3	4
4.	I believe I will receive an excellent grade in this course..	1	2	3	4
5.	I carefully plan my course of action.	1	2	3	4
6.	I ask myself questions to stay on track as I do a task.	1	2	3	4
7.	I put forth my best efforts on tasks.	1	2	3	4
8.	I'm certain I can understand the most difficult material presented in the reading of this course.	1	2	3	4
9.	I try to understand the task before I attempt to solve them.	1	2	3	4
10.	I check my work while I am doing it.	1	2	3	4
11.	I work as hard as possible on tasks.	1	2	3	4
12.	I'm confident I can understand the basic concepts taught in this course.	1	2	3	4
13.	I try to understand the goal of a task before I attempt to answer.	1	2	3	4
14.	I almost always know how much of a task I have to complete.	1	2	3	4
15.	I am willing to do extra work on tasks to improve my knowledge.	1	2	3	4
16.	I'm confident I can understand the most complex material presented by the teacher in this course.	1	2	3	4
17.	I figure out my goals and what I need to do to accomplish them.	1	2	3	4
18.	I judge the correctness of my work.	1	2	3	4
19.	I concentrate as hard as I can when doing a task.	1	2	3	4
20.	I'm confident I can do an excellent job on the assignments and tests in this course.	1	2	3	4
21.	I imagine the parts of the task that I have to complete.	1	2	3	4

22. I correct my errors.	1	2	3	4
23. I work hard on a task even if it does not count.	1	2	3	4
24. I expect to do well in this course.	1	2	3	4
25. I make sure I understand just what has to be done and how to do it.	1	2	3	4
26. I check my accuracy as I progress through a task.	1	2	3	4
27. A task is useful to check my knowledge.	1	2	3	4
28. I'm certain I can master the skills being taught in this course.	1	2	3	4
29. I try to determine what the task requires.	1	2	3	4
30. I ask myself, how well am I doing, as I proceed through tasks.	1	2	3	4
31. Practice makes perfect.	1	2	3	4
32. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course.	1	2	3	4

Achievement Test

(Extra Credit Simulation Exercise: The Iranian Nuclear Negotiation)

1. The main goal of political research is: to find the truth?

   A. True

   B. False X

2. The sole aim of research in political science is: to describe any phenomenon.

   A. True

   B. False X

3. The only goal of political scientists is: to explain a phenomenon.

   A. True

   B. False X

4. Political research is solely interested in predicting a particular phenomenon.

   A. True

   B. False X

5. Research in politics is all about a problem-solving activity.

   A. True

   B. False X

6. "Political Science Research" is the same as "Normative Analysis."

   A. True

   B. False X

7. Scientific Research and Normative Analysis are synonymous.

   A. True

   B. False X

8. Political Research is all about the right/wrong moral issues.

   A. True

   B. False X

9. Research for political scientists is about facing challenging ethical issues.

   A. True

B. False X

10. All scientists must eventually solve moral or ethical issues that face the society.

    A. True

    B. False X

11. Problem-solving activity often deals with policy issues.

    A. True X

    B. False

12. Problem-solving activity must rely on the assumption that individuals act rationally.

    A. True X

    B. False

13. Political Research is possible, because all individuals act rationally and logically.

    A. True

    B. False X

14. Rational Individual is based on the "Rational Choice" theory or perspective.

    A. True X

    B. False

15. A Rational Individual maximizes his/her benefits and minimizes his/her cost.

    A. True X

    B. False

16. Like individuals, countries try to maximize their benefits by protecting their National Interests.

    A. True X

    B. False

17. Like individuals, countries try to minimize their cost by decreasing the concessions that they make to other countries.

    A. True X

    B. False

18. Like individuals, countries negotiate to maximize their benefits or interests.

A. True X

B. False

19. Like individuals, countries do not use “war” or “conflict” as their first policy choice.

A. True X

B. False

20. Like individuals, most countries try to maximize their benefit(s) by negotiating and cooperative behavior.

A. True X

B. False

21. The “Cause” is the main focus of any political research?

A. True

B. False X

22. The “Effect” is the major focus of a political research?

A. True X

B. False

23. Political research is always interested in the “fairness” of the policy?

A. True

B. False X

24. Political research tends to identify any problems followed by suggesting solution(s).

A. True

B. False X

25. Some political research tends to “identify political challenges” followed by presenting “appropriate policy (s).”

A. True X

B. False

26. In any domestic or international political research there is always only one main independent factor (variable) that influences the focus of the research.

A. True

B. False X

27. In any domestic or international political research there is always a series of independent factors (variables) that influence the focus of the research.

A. True X

B. False

28. In any domestic or international political research the independent factors (variables) almost equally influence the focus of the research.

A. True

B. False X

29. In domestic political research the independent factors (variables) almost equally influence the focus of the research.

A. True

B. False X

30. In international political research the independent factors (variables) almost equally influence the focus of the research.

A. True

B. False

31. Based to the Golden Rules, there are significant similarities between the general behaviors of biological and political units.

A. True X

B. False

32. Unlike biological units, political units (countries or politicians) do not aim to survive at any cost.

A. True

B. False X

33. Unlike biological units, political units (countries or politicians) do not aim to grow, even if their environment allows that.

A. True

B. False X

34. Like biological units, political units (countries or politicians) plan to reproduce. Political reproduction, however, is inform of exporting one's ideas, values, and culture to others to creating similar units.

A. True X

B. False

35. Unlike biological units, political units (countries or politicians) do not fail in achieving the Golden Rules.

A. True

B. False X

APPENDIX E: SELF-REPORT TRAIT SELF-REGULATION QUESTIONNAIRE SCORING KEY

Scoring Key: Self-Report Trait Self-Regulation Questionnaire

Scales	Items
Planning	1, 5, 9, 13, 17, 21, 25, 29
Self-Checking	2, 6, 10, 14, 18, 22, 26, 30
Effort	3, 7, 11, 15, 19, 23, 27, 31
Self-Efficacy	4, 8, 12, 16, 20, 24, 28, 32

Planning

1. I determine how to solve a task before I begin.
5. I carefully plan my course of action.
9. I try to understand tasks before I attempt to solve them.
13. I try to understand the goal of a task before I attempt to answer.
17. I figure out my goals and what I need to do to accomplish them.
21. I imagine the parts of a task I have to complete.
23. I make sure I understand just what has to be done and how to do it.
29. I try to determine what the task requires.

Self-Checking

2. I check how well I am doing when I solve a task.
6. I ask myself questions to stay on track as I do a task.
10. I check my work while I am doing it.
14. I almost always know how much of a task I have to complete.
18. I judge the correctness of my work.

22. I correct my errors.

26. I check my accuracy as I progress through a task.

30. I ask myself, how well am I doing, as I proceed through tasks.

Effort

3. I work hard to do well even if I don't like a task.

7. I put forth my best effort on tasks.

11. I work as hard as possible on tasks.

15. I am willing to do extra work on tasks to improve my knowledge.

19. I concentrate as hard as I can when doing a task.

23. I work hard on a task even if it does not count.

27. A task is useful to check my knowledge.

31. Practice makes perfect.

Self-Efficacy

4. I believe I will receive an excellent grade in this course.

8. I'm certain I can understand the most difficult material presented in the readings for this course.

12. I'm confident I can understand the basic concepts taught in this course.

16. I'm confident I can understand the most complex material presented by the teacher in this course.

20. I'm confident I can do an excellent job on the assignments and tests in this course.

24. I expect to do well in this course.

28. I'm certain I can master the skills being taught in this course.

32. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course.

Herl, H. E., O'Neil Jr, H. F., Chung, G. K. W. K., Bianchi, C., Wang, S. L., Mayer, R., ... & Tu, A. (1999). Final report for validation of problem-solving measures. *Gefunden am, 2*, 2012. Retrieved from http://cresst.org/wp-content/uploads/TECH501.pdf

APPENDIX F: EXTRA CREDIT ASSIGNMENT INSTRUCTIONS

Students were given instructions to read about the assignment requirements before they could start working on it on the website. The text is provided here:

This Extra Credit optional assignment is worth 10 points replacing the 5-points Extra Credit assignment in Module 12. The assignment is due on Friday, February 28, at 11:55 PM. There is a final post-test that is due Sunday, March 2 at 11:55 PM. Please read below for detailed instructions:

INFORMATION ABOUT THE DISSERTATION STUDY

This extra credit assignment is part of a research study conducted by Naomi Malone, a doctoral candidate in the Department of Instructional Design and Technology.

If you are interested in participating in the research, please email Naomi@knightsemail.com to receive instructions for accessing the study website. The website is http://simport.org.

You will be assigned to one of three separate courses, Simulation Design Group 1, Simulation Design Group 2, or Simulation Design Group 3.

- You will be asked to fill out a demographic survey.
- You will be asked to answer questions regarding your thoughts on self-regulation and self-monitoring. There are no right or wrong answers.
- As part of the study, you will be asked to read a 10 minute tutorial on problem-solving that is pertinent to the political science domain.
- Depending on which course you are assigned to you will be asked to take part in activities that are part of the dissertation study on self-monitoring. These include:
    - A short, 10 minute tutorial on problem-solving
    - A short, 10 minute tutorial on self-monitoring
    - Answer three to four questions during the four assignment sections.

We would like to thank all students who choose to participate in this research. Please read the Informed Consent form, which provides more detailed information about the study. Your participation is strictly voluntary. If you choose not to participate, you may notify your instructor and ask for an alternative assignment of equal effort for equal credit. There will be no penalty.

THE ASSIGNMENT

This assignment has different dimensions, such as learning about:

1. the process of diplomatic communication & negotiation,
2. geopolitics & political geography,
3. international political & economic relations, and
4. the nature & scope of research in Political Science.

This is a **problem-solving activity that involves using the concepts and knowledge that you have learned in your class to create material for a role-play simulation on a relevant international studies issue.**

If you are registered in more than 1 course with Dr. Sadri, you may use this assignment for only one Sadri's classes. Please indicate for which class you want to use it.

ASSIGNMENT TIMELINE

Research Stages:

This project has three major parts, all of which are required to earn the 10 Extra Credit points.

The points are based on a pass-fail basis. The assignment begins with a Pre-Test (on Thursday February 21st), then you conduct your own research, complete the writing of your project, and taking part in activities associated with the dissertation study; You will put the four sections into a Word document and submit it into the Drop Box. Finally, you will take the Post-Test, which will be due on Sunday, March 2.

STAGE 1: THURSDAY FEBRUARY 21- SUNDAY FEBRUARY 23

Get your username and password from Naomi by emailing her at naomi@knights.ucf.edu. After signing into the Extra Credit Assignment website, please click on and follow the instructions to finish the three activities listed below:

1. Read the Extra Credit Assignment instructions

2. Read the Informed Consent - Please read the Informed Consent Form for further information about the study you are participating in.

3. Take the Demographic Survey

4. Take the Self-Regulation Survey

5. Take the Pre-Test

The website is http://simport.org

ALL OF THESE ITEMS MUST BE FINISHED BY SUNDAY, FEBRUARY 23 AT 11:55 PM.

PART 2: ASSIGNMENT

Click on the course that was assigned to you in the email and follow the steps outlined below to work on your assignment. Depending on the group that you have been assigned to, there will also be some extra steps that you will be asked to do for the dissertation study, which will involve reading and answering surveys.

The simulation assignment steps are:

I. **Objectives:** **Minimum of 50 Words**

II. Summary: **Minimum of 150 Words**

III. Scenarios: **Minimum of 150 Words**

IV. Analysis: **Minimum of 150 Words**

TOTAL **Minimum of 500 Words = 10 Extra Credit Points**

YOU HAVE FROM MONDAY, FEBRUARY 24 UNTIL FRIDAY, FEBRUARY 28, 11:55 PM TO COMPLETE ALL FOUR SECTIONS. PLEASE FOLLOW THE DIRECTIONS ON THE WEBSITE TO TURN IN ALL OF THE SECTIONS.

PART 3: SUNDAY MARCH 2

Post-Test

THE POST TEST WILL OPEN SATURDAY, MARCH 1, 6:00 AM UNTIL SUNDAY, MARCH 2, 11:55 PM.

If you have any problems, please contact Naomi.

APPENDIX G: PRE- AND POST-TEST RESULTS

Group	Pre-Test	Post-Test
1	28	22
1	30	31
1	22	21
1	27	31
1	29	28
1	21	23
1	28	34
1	25	24
1	29	22
1	21	25
1	22	19
1	23	23
1	21	23
1	18	18
1	23	27
1	22	27
1	32	31
1	24	24
1	25	24
1	25	28
1	22	24
1	23	30
1	30	30
1	30	27
1	25	30
1	25	27
1	24	19
1	22	19
1	29	29
1	30	29
1	28	27
1	29	30
1	24	28
1	30	31
1	27	23
1	24	28
1	25	27
1	23	19

Group	Pre-Test	Post-Test
1	23	25
2	21	23
2	17	23
2	27	32
2	22	25
2	25	29
2	26	26
2	30	30
2	25	30
2	21	30
2	20	28
2	24	31
2	25	27
2	23	25
2	27	29
2	27	28
2	23	31
2	20	24
2	23	31
2	28	25
2	26	27
2	20	23
2	28	33
2	30	31
2	19	19
2	26	27
2	28	27
2	28	27
2	24	28
2	16	19
2	22	25
2	27	28
3	24	23
3	24	29
3	26	23
3	20	23
3	27	30
3	26	30

Group	Pre-Test	Post-Test
3	23	21
3	25	27
3	26	28
3	20	17
3	24	26
3	27	32
3	25	23
3	23	31
3	23	28
3	27	34
3	22	27
3	23	27
3	25	25
3	20	27
3	27	24
3	23	22
3	19	28
3	28	30
3	24	22
3	23	24
3	24	27
3	21	25
3	26	25
3	25	23
3	25	21

LIST OF REFERENCES

Alias, N. A. (2012). Design of a Motivational Scaffold for the Malaysian e-Learning Environment. *Educational Technology & Society, 15*(1), 137-151.

Allen, I. E., & Seaman, J. (2013). Changing Course: Ten Years of Tracking Online Education in the United States. Sloan Consortium. PO Box 1238, Newburyport, MA 01950.

Allen, I. E., & Seaman, J. (2014). Grade change. Tracking online education in the United States. Babson Survey Research Group and Quahog Research Group, LLC. Retrieved from http://www.utc.edu/learn/pdfs/online/sloanc-report-2014.pdf

Azevedo, R. (2014). Issues in dealing with sequential and temporal characteristics of self- and socially-regulated learning. *Metacognition Learning, 9*, 217-228. doi 10.1007/s1140901491231.

Azevedo, R., & Aleven, V. (2013). Metacognition and learning technologies: An overview of the current interdisciplinary research. In R. Azevedo & V. Aleven (Eds.), *International handbook of metacognition and learning technologies* (pp. 1–16). Amsterdam, The Netherlands: Springer.

Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia?. *Journal of educational psychology, 96*(3), 523.

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia. *Contemporary Educational Psychology, 29*, 344–370.

Azevedo, R., Greene, J. A., & Moos, D. C. (2007). The effect of a human agent's external regulation upon college students' hypermedia learning. *Metacognition and learning*, *2*(2-3), 67-87.

Azevedo, R., Witherspoon, A. M., Chauncey, A., Burkett, C., & Fike, A. (2009, October). MetaTutor: A metacognitive tool for enhancing self-regulated Learning. In *Proceedings of the AAAI Fall Symposium on Cognitive and Metacognitive Educational Systems*. (pp. 14–19). Menlo Park, CA: Association for the Advancement of Artificial Intelligence (AAAI) Press.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, *50*, 248-287.

Bannert, M., Hildebrand, M., & Mengelkamp, C. (2009). Effects of a metacognitive support device in learning environments. *Computers in Human Behavior*, *25*(4), 829-835.

Bannert, M., & Mengelkamp, C. (2008). Assessment of metacognitive skills by means of instruction to think aloud and reflect when prompted. Does the verbalisation method affect learning?. *Metacognition and Learning*, *3*(1), 39-58.

Bannert, M., Sonnenberg, C., Mengelkamp, C., & Pieger, E. (2015). Short-and long-term effects of students' self-directed metacognitive prompts on navigation behavior and learning performance. *Computers in Human Behavior*, *52*, 293-306.

Bannert, M., & Reimann, P. (2012). Supporting self-regulated hypermedia learning through prompts. *Instructional Science*, *40*(1), 193-211.

Bell, B. S., Kanar, A., Liu, X., Forman, J., & Singh, M. (2006). Adaptive guidance: Effects on self-regulated learning in technology-based training. *Personnel Psychology*, 55, 267–306.

Bednall, T. C., & Kehoe, E. J. (2011). Effects of self-regulatory instructional aids on self-directed study. *Instructional Science*, *39*(2), 205-226.

Bergin, D. A., Ford, M. E., & Hess, R. D. (1993). Patterns of motivation and social behavior associated with microcomputer use of young children. *Journal of Educational Psychology*, *84*(3), 272–281.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and instruction*, *7*(2), 161-186.

Boekaerts, M. (2002). Bringing about change in the classroom: Strengths and weaknesses of the self-regulated learning approach—EARLI Presidential Address, 2001. *Learning and instruction*, *12*(6), 589-604.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. *The Internet and Higher Education*, *27*, 1-13.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognitive Instruction*, *8*, 293–332.

Chang, M. M. (2007). Enhancing web-based language learning through self-monitoring. *Journal of Computer Assisted Learning*, *23*(3), 187-196.

Chang, M. (2010). Effects of self-monitoring on web-based language learner's performance and motivation. CALICO Journal, 27(2), 298-310.

Chen, C. H., & Bradshaw, A. C. (2007). The effect of web-based question prompts on scaffolding knowledge integration and ill-structured problem-solving. *Journal of research on Technology in Education*, *39*(4), 359-375.

Clarebout, G., & Elen, J. (2006). Tool use in computer-based learning environments: Towards a research framework. *Computers in Human Behavior, 22*, 389–411.

Crippen, K. J., & Earl, B. L. (2007). The impact of web-based worked examples and self-explanation on performance, problem-solving, and self-efficacy. *Computers & Education*, *49*(3), 809-821.

Crowley, R. S., Legowski, E., Medvedeva, O., Tseytlin, E., Roh, E., & Jukic, D. (2007). Evaluation of an intelligent tutoring system in pathology: Effects of external representation on performance gains, metacognition, and acceptance. Journal of the American Medical Informatics Association, 14(2), 182–190. doi:10.1197/jamia.M2241.

Croxton, R. A. (2014). The role of interactivity in student satisfaction and persistence in online learning. *Journal of Online Learning and Teaching*, *10*(2), 314.

de Bruijn-Smolders, M., Timmers, C. F., Gawke, J. C., Schoonman, W., & Born, M. P. (2016). Effective self-regulatory processes in higher education: Research findings and future directions. A systematic review. *Studies in Higher Education, 41*(1), 139-158.

Devolder, A., van Braak, J., & Tondeur, J. (2012). Supporting self-regulated learning in computer-based learning environments: systematic review of effects of scaffolding in the domain of science education. *Journal of Computer Assisted Learning*, *28*(6), 557-573.

Dimitrov, D. M., & Rumrill Jr, P. D. (2003). Pretest-posttest designs and measurement of change. *Work*, *20*(2), 159-165.

Duffy, M. C., & Azevedo, R. (2015). Motivation matters: Interactions between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system. *Computers in Human Behavior, 52*, 338-348.

Efklides, A. (2011). Interactions of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational psychologist*, *46*(1), 6-25.

El Saadawi, G. M., Tseytlin, E., Legowski, E., Jukic, D., Castine, M., Fine, J., ... & Crowley, R. S. (2008). A natural language intelligent tutoring system for training pathologists: implementation and evaluation. *Advances in health sciences education, 13*(5), 709-722.

El Saadawi, G. M., Azevedo, R., Castine, M., Payne, V., Medvedeva, O., Tseytlin, E., ... & Crowley, R. S. (2010). Factors affecting feeling-of-knowing in a medical intelligent tutoring system: the role of immediate feedback as a metacognitive scaffold. *Advances in Health Sciences Education*, *15*(1), 9-30.

Entwistle, N. J. (2000). Approaches to studying and levels of understanding: The influences of teaching and assessment. In J. C. Smart (Ed.), Higher education: Handbook of theory and research (Vol. 15, pp. 156–218). New York: Agathon Press.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project-based learning. *Interdisciplinary Journal of Problem-based Learning*, *7*(2), 6.

Fern, E. F., & Monroe, K. B. (1996). Effect-size estimates: Issues and problems in interpretation. Journal of Consumer Research, 23(2), 89-105.

Ge, X., & Land, S. M. (2004). A conceptual framework for scaffolding iii-structured problem-solving processes using question prompts and peer interactions. *Educational Technology Research and Development, 52*(2), 5-22. doi:10.1007/BF02504836

Gerjets, P., Scheiter, K., & Schuh, J. (2008). Information comparisons in example-based hypermedia environments: Supporting learners with processing prompts and an interactive comparison tool. *Educational Technology Research and Development*, *56*(1), 73-92.

Graesser, A. C., Wiley, J., Goldman, S. R., O'Reilly, T., Jeon, M., & McDaniel, B. (2007). SEEK Web tutor: Fostering a critical stance while exploring the causes of volcanic eruption. *Metacognition and Learning*, *2*(2-3), 89-105.

Greenland, S. J., & Moore, C. (2014). Patterns of online student enrolment and attrition in Australian open access online education: a preliminary case study. *Open Praxis*, *6*(1), 45-54.

Grosse, M. E., & Wright, B. D. (1985). Validity and reliability of true-false tests. *Educational and Psychological Measurement*, *45*(1), 1-13.

Hadwin, A., & Winne, P. (2001). CoNoteS2: a software tool for promoting self-regulation educational research and evaluation. *Educational Research and Evaluation, 7,* 313–334

Hannafin, M., Hannafin, K., & Gabbitas, B. (2009). Re-examining cognition during student-centered, Web-based learning. *Educational Technology Research and Development*, *57*(6), 767-785.

Hathorn, L. G., & Rawson, K. A. (2012). The roles of embedded monitoring requests and questions in improving mental models of computer-based scientific text. Computers & Education, 59(3), 1021-1031.

Herl, H. E., O'Neil Jr, H. F., Chung, G. K. W. K., Bianchi, C., Wang, S. L., Mayer, R., ... & Tu, A. (1999). Final report for validation of problem-solving measures. *Gefunden am*, *2*, 2012. Retrieved from http://cresst.org/wp-content/uploads/TECH501.pdf

Hodges, C. B. (2008). Self-efficacy, motivational email, and achievement in an asynchronous math course. *The Journal of Computers in Mathematics and Science Teaching*, *27*(3), 265-285.

Hong, E., & O'Neil Jr, H. F. (2001). Construct validation of a trait self-regulation model. *International Journal of Psychology*, *36*(3), 186-194.

Hu, H., & Driscoll, M. P. (2013). Self-regulation in e-learning environments: a remedy for community college?. *Educational Technology & Society*, *16*(4), 171-184.

Huck, S. W., & McLean, R. A. (1975). Using a repeated measures ANOVA to analyze the data from a pretest-posttest design: A potentially confusing task. *Psychological Bulletin*, *82*(4), 511.

Ifenthaler, D. (2012). Determining the effectiveness of prompts for self-regulated learning in problem-solving scenarios. *Educational Technology & Society*, *15*(1), 38-52.

Jacobson, M., & Archodidou, A. (2000). The design of hypermedia tools for learning: Fostering conceptual change and transfer of complex scientific knowledge. *Journal of the Learning Sciences, 9*, 149–199.

Jacobson, M. J., & Azevedo, R. (2008). Advances in scaffolding learning with hypertext and hypermedia: Theoretical, empirical, and design issues. *Educational Technology Research and Development, 56*, 1-3.

Jonassen, D. (1996). Computers as mind tools for schools. Columbus, OH: Merrill.

Kauffman, D. F., Zhao, R., & Yang, Y. S. (2011). Effects of online note taking formats and self-monitoring prompts on learning from online text: Using technology to enhance self-regulated learning. *Contemporary Educational Psychology*, *36*(4), 313-322.

Kim, K. J., & Bonk, C. J. (2006). The future of online teaching and learning in higher education. *Educause quarterly*, *29*(4), 22-30.

Kim, M., & Ryu, J. (2013). The development and implementation of a web-based formative peer assessment system for enhancing students' metacognitive awareness and performance in ill-structured tasks. *Educational Technology Research and Development*, *61*(4), 549-561.

Klingsieck, K. B., Fries, S., Horz, C., & Hofer, M. (2012). Procrastination in a distance university setting. *Distance Education*, *33*(3), 295-310.

Kondo, M., Ishikawa, Y., Smith, C., Sakamoto, K., Shimomura, H., & Wada, N. (2012). Mobile assisted language learning in university EFL courses in Japan: Developing attitudes and skills for self-regulated learning. *ReCALL*, *24*(02), 169-187.

Kramarski, B., & Michalsky, T. (2009). Investigating preservice teachers' professional growth in self-regulated learning environments. *Journal of educational psychology*, *101*(1), 161-175.

Ku, D. T., & Chang, C. S. (2011). The effect of academic discipline and gender difference on Taiwanese college students' learning styles and strategies in web-based learning environments. *TOJET: The Turkish Online Journal of Educational Technology*, *10*(3).

Lajoie, S. P. (2008). Metacognition, self regulation, and self-regulated learning: A rose by any other name?. *Educational Psychology Review*, *20*(4), 469-475.

Lan, Y. C., Lo, Y. L., & Hsu, Y. S. (2014). The effects of meta-cognitive instruction on students' reading comprehension in computerized reading contexts: A quantitative meta-analysis. *Educational Technology & Society*, *17*(4), 186-202.

Lehmann, T., Hähnlein, I., & Ifenthaler, D. (2014). Cognitive, metacognitive and motivational perspectives on preflection in self-regulated online learning. Computers in Human Behavior, 32, 313-323.

Lin, X., & Lehman, J. D. (1999). Supporting learning of variable control in a computer-based biology environment: Effects of prompting college students to reflect on their own thinking. *Journal of research in science teaching*, *36*(7), 837-858.

Moore, M. G. (Ed.). (2013). *Handbook of distance education*. Routledge.

Moos, D. C., & Azevedo, R. (2008). Exploring the fluctuation of motivation and use of self-regulatory processes during learning with hypermedia. *Instructional Science*, *36*(3), 203-231.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. Journal of Counseling Psychology, 38,1, 30-38.Murphy, K. P., & Alexander, P. A. (2000). A motivated exploration of motivation terminology. *Contemporary Educational Psychology*, *25*, 3–53.

Narciss, S., Proske, A., & Körndle, H. (2007). Promoting self-regulated learning in web-based learning environments. *Computers in Human Behavior*, *23*, 1126–1144.

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory, Vol. 26. (pp. 125–141)New York, NY: Academic Press.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33.

Pintrich, P. R. (1995). Understanding self-regulated learning. *New Directions for Teaching and Learning*, *63*, 3-12.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.) *Handbook of self-regulation* (pp. 452–502). New York: Academic.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of educational psychology*, *82*(1), 33.

Puustinen, M., & Pulkkinen, L. (2001). Models of self-regulated learning: A review. *Scandinavian Journal of Educational Research*, *45*(3), 269-286.

Ranellucci, J., Muis, K. R., Wang, X., Duffy, M., & Franco, G. M. (2012). To master or perform? Exploring relations between achievement goals and conceptual change learning. *British Journal of Educational Psychology*, *83*, 431–451.

Reid, A. J., Morrison, G. R., & Bol, L. (2016). Knowing what you know: improving metacomprehension and calibration accuracy in digital text. *Educational Tech Research Dev*, 1-17.

Rodicio, H. G., Sánchez, E., & Acuña, S. R. (2013). Support for self-regulation in learning complex topics from multimedia explanations: do learners need extensive or minimal support?. *Instructional Science*, *41*(3), 539-553.

Schmitz, B., & Perels, F. (2011). Self-monitoring of self-regulation during math homework behaviour using standardized diaries. *Metacognition and Learning*, *6*(3), 255-273.

Shiu, L. P., & Chen, Q. (2013). Self and external monitoring of reading comprehension. *Journal of Educational Psychology*, *105*(1), 78.

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The journal of educational research*, *99*(5), 307-320.

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science, 32*, 9–31.

Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251–296.

Tanner, K. D. (2012). Promoting student metacognition. CBE-Life Sciences Education, 11(2), 113-120.

Thalheimer, W., & Cook, S. (2002). How to calculate effect sizes from published research: A simplified Method. Retrieved from http://work-learning.com/effect_sizes.htm.

Trevors, G., Duffy, M., & Azevedo, R. (2014). Note-taking within MetaTutor: interactions between an intelligent tutoring system and prior knowledge on note-taking and learning. *Educational Technology Research and Development*, *62*(5), 507-528.

Tsai, C. W., Shen, P. D., & Fan, Y. T. (2013). Research trends in self-regulated learning research in online learning environments: A review of studies published in selected journals from 2003 to 2012. British Journal of Educational Technology, 44(5), E107-E110.

Van den Boom, G., Paas, F., & van Merriënboer, J. J. (2007). Effects of elicited reflections combined with tutor or peer feedback on self-regulated learning and learning outcomes. *Learning and Instruction*, *17*(5), 532-548.

Van Dijk, T. A., Kintsch, W., & Van Dijk, T. A. (1983). *Strategies of discourse comprehension* (pp. 11-12). New York: Academic Press.

Van Gog, T., Kester, L., & Paas, F. (2011). Effects of concurrent monitoring on cognitive load and performance as a function of task complexity. *Applied Cognitive Psychology*, *25*(4), 584-587.

Waschull, S. B. (2001). The online delivery of psychology courses: Attrition, performance, and evaluation. *Teaching of Psychology*, *28*(2), 143-147.

Winne, P. H. (2001). Self-regulated learning viewed from models of information processing. *Self-regulated learning and academic achievement: Theoretical perspectives*, *2*, 153-189.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.). *Metacognition in educational theory and practice* (pp. 277-304). Hillsdale, NJ: Lawrence Erlbaum Associates.

Winne, P. H., & Hadwin, A. F. (2008). The weave of motivation and self-regulated learning. In D. Schunk & B. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 297–314). NY:Taylor & Francis.

Winters, F. I., Greene, J. A., & Costich, C. M. (2008). Self-regulation of learning within computer-based learning environments: A critical analysis. *Educational Psychology Review*, *20*(4), 429-444.

Zhang, D., & Nunamaker, J. F. (2003). Powering e-learning in the new millennium: an overview of e-learning and enabling technology. *Information Systems Frontiers*, *5*(2), 207-218.

Zheng, L. (2016). The effectiveness of self-regulated learning scaffolds on academic performance in computer-based learning environments: a meta-analysis. *Asia Pacific Education Review*, *17*(2), 187.

Zimmerman, B. J. (2000a). Attaining self-regulation: A social-cognitive perspective. In M. Boekaerts & P. R. Pintrich (Eds.), *Handbook of self-regulation* (pp. 13–39). New York, NY: Academic Press. doi:10.1016/B978-012109890-2/50031-7

Zimmerman, B. J. (2000b). Self-efficacy: An essential motive to learn. *Contemporary educational psychology*, *25*(1), 82-91.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, *41*(2), 64-70.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Journal of International Research*, *45*, 166–183. http://dx.doi.org/10.3102/0002831207312909.

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. *New Directions for Teaching and Learning*, *1995*(63), 13-27.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (1998). *Self-regulated learning and academic achievement: Theory, research, and practice*. New York: Springer-Verlag.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (2013). Self-regulated learning and academic achievement: Theoretical perspectives. Routledge.

Zumbach, J., & Bannert, M. (2006). Editorial introduction: Analyzing (self-)monitoring in computer assisted learning. *Journal of Educational Computing Research, 35*(4), 315–317.