A Meta-Analysis of Self-Regulated Learning Interventions and Learning Outcomes in Higher Education E-Learning Environments

ROWE, FRANCES,ANNE

A Meta-Analysis of Self-Regulated Learning Interventions and Learning Outcomes in Higher Education E-Learning Environments

Frances Rowe

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Abstract

Through a systematic review of the literature, 36 empirical studies regarding self-regulated learning (SRL) interventions and learning outcomes in higher education e-learning environments were identified and meta-analyzed using15 years of data. Frequently studied interventions included providing SRL scaffolding, SRL training, or SRL training and scaffolding either as a precursor or as part of the learning environment or both. Scaffolding interventions were embedded as part of the learning environment and designed to guide learners to perform cognitive and metacognitive strategies such as task analysis, goal setting, and reflection during a learning activity. Training interventions, by contrast, involved instruction in the use of SRL strategies prior to beginning a learning activity, course or program. In some studies, both training and scaffolding SRL interventions were implemented. Information about the types of SRL interventions including the means of measuring learning outcomes (more or less complex), instructional design characteristics and learning outcomes data for calculating effect sizes were extracted for the purposes of conducting this meta-analysis.

Declaration

I would like to declare that some of the sections on introducing self-regulated learning and models of self-regulated learning in this thesis have been developed from a prior publication in the Journal of Online Learning (JOLT). Papers in JOLT are published under a Creative Commons Attribution-Non-Commercial-Share-Alike License which permits me to use all or part of the prior work in future publications. It is not uncommon for graduate students to publish articles prior to incorporating such works in a thesis to constitute a completely new work. In certain disciplines, such as education, it is considered preferable to publish one's work when the research is complete rather than delay until a thesis is defended. Publication prior to defense is viewed as evidence that the research is original and significant. The citation for the publication is as follows:

Rowe, F. A., & Rafferty, J. A. (2013). Instructional design interventions for supporting self-regulated learning: Enhancing academic outcomes in postsecondary e-learning environments. Journal of Online Learning and Teaching, 9(4). Retrieved from http://jolt.merlot.org/vol9no4/rowe_1213.pdf

Permission from the co-author, Jennifer Rafferty, to incorporate this publication into my thesis was granted to me.

Statement of Copyright

Acknowledgements

My process for identifying a PhD program was to locate researchers with similar interests as my own. Steve Higgins, Professor of Education at Durham University, rose to the top of my search due to his research interests in areas such as evidence-based teaching practices, digital learning technologies and meta-analysis. Additionally, the University offered flexible learning paths. I made a good decision in applying to Durham and I am thankful for the support from various departments such as Information Services and the Library. Access to excellent student support helped mitigate concerns and allowed me to focus on writing the thesis and working with Steve, my thesis supervisor. I was very fortunate to work with Steve because of his expertise in meta-analysis, ability to recognize gaps in my methodology, knowledge of pertinent resources and capability to provide meaningful feedback. I am very grateful to Steve!

Preface

This study used a systematic search process and meta-analysis to examine data from 36 empirical studies and tried to understand the relationship between self-regulated learning (SRL) interventions and learning outcomes in higher education e-learning environments, particularly the characteristics of the more successful interventions. For this thesis, e-learning environments is used as an umbrella term encompassing a wide range of approaches to learning through electronic means such as in online and hybrid/Web-enhanced modalities. I examined two moderating effects: (a) how the interventions were implemented i.e. training, scaffolding or training and scaffolding; and (b) the means of measuring the learning outcomes i.e. more or less complex according to Bloom's cognitive domain taxonomy. For this thesis, scaffolding refers to instructional approaches such as embedded resources that support learners as they develop new skills and knowledge.

Thesis format and structure. The format and organization of this thesis is as follows. I begin with a literature review of prominent models and theories of SRL. I then provide a narrative review of empirical literature which examined SRL in e-learning environments. Following the review, I reveal the focus of the study, including my research objectives, research questions, hypotheses and rationale for the study. I then present a detailed account of my methodology for the purposes of guiding my own processes and also to serve as a reference for other researchers to consider when undertaking meta-analysis. In addition, I provide a statement on ethics as this relates to my study. For the findings, I document the systematic search process and provide data on effect sizes, heterogeneity and regression analysis. The discussion addresses my research questions and relates these to the wider literature and research in SRL. Of particular importance in the discussion are the characteristics of the more successful SRL interventions and their connections to SRL theories and models. Limitations are also described in the discussion section. Finally, the conclusion provides implications for practice, suggestions for further research and a reflection of what I learned through completing the study.

Researcher positionality. Being an instructional designer in higher education, I am frequently in a position of making pedagogical recommendations to faculty. My higher education experience spans over 25 years, mainly working with online program development. I also teach in both asynchronous and synchronous modalities. My disciplinary areas are instructional design and computer information systems. My interest in SRL sparked in about 2007 when I began hearing concerns from faculty about students' lack of self-discipline necessary for online learning. At that point, my colleagues and I created short, engaging videos on topics such as time management for which we received an award from the Online Learning Consortium. While investigating topics, I found that SRL is an umbrella term from educational research encompassing cognitive, metacognitive and motivational processes used to describe learners' intentional efforts towards the successful completion of academic goals (Zimmerman & Schunk, 2001). Further investigation into SRL models, theories and studies with interventions compelled me to conduct my own research. The literature review provided a collection of SRL models to draw from and I think certain ones will be more or less appealing to educators depending on factors such as complexity, discipline or educational need. As a result of the meta-analysis, I believe I am well positioned to make recommendations to my colleagues and the educational community at large with regard to SRL interventions, specifically concerning: (a) effectiveness; (b) design; (c) implementation; and (d) evaluation. Whilst these experiences and perspectives undoubtedly influenced my thinking about the study, I was also interested to find out how a more detailed understanding of the research might inform my understanding and my practice. I tried to ensure that this perspective did not affect the rigor of the methods or influence the findings and conclusions that I drew, but acknowledge that I may have been affected in ways that I was not aware.

Chapter 1 - Literature Review

Introduction to Self-Regulated Learning

Self-regulation is a skill that helps people focus on monitoring their task completion progress and assists with multiple areas of human functioning, such as management of a chronic illness, athletic training or learning in academic settings (Bandura, 1986). Zimmerman (2000) defined self-regulation as “self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal goals.” (p. 14). Educational psychology researchers in particular have found that students who self-regulate their learning perform better than students who do not self-regulate their learning irrespective of their course of study (Pintrich & Degroot, 1990; Pintrich, Wolters & Baxter, 2000; Zimmerman, Bandura & Martinez-Pons, 1992).

Self-regulated learning (SRL) is a process that involves learners’ intentional efforts to manage and direct complex learning activities towards the successful completion of academic goals (Zimmerman & Schunk, 2001). Zimmerman (2000) referred to SRL as the degree to which learners are able to become active participants in the process of monitoring their own studies. Pintrich (2000) referred to SRL as an active, constructive process whereby learners set goals for their studies and then attempt to monitor, regulate, and control their cognition, motivation and behavior in the services of those goals. Vygotsky (1934/1987b) described self-regulation as self-mastery of higher order levels of thinking through the process of constructing links and patterns among stimuli. Vygotsky also theorized that thinking improves when external guidance and resources in various forms such as scaffolds or joint participation are present. Self-regulatory processes include goal setting and time management, self-monitoring and reflection, modification of learning strategies, use of feedback, help seeking and resource-oriented learning (Bandura, 1986; Pintrich, 2000; Zimmerman, 2000; Zimmerman & Schunk, 2001).

Components of Self-Regulated Learning

Self-regulated learning's cognitive component refers to any learning strategies used to accomplish a given task and includes activities that support learners' active manipulation of academic content (Zimmerman & Schunk, 2001). Self-regulated learning's metacognitive component involves the knowledge and self-awareness learners have to self-monitor their understanding and cognitive processes (Zimmerman & Schunk, 2001). Metacognitive strategies refer to the skills that help learners control their cognitive processes such as recognizing gaps in one's knowledge. Almost all SRL models presume that motivation is a key factor of academic success (Bandura, 1986: Butler, 1997; Pintrich, 2000; Zimmerman, 2000; Zimmerman, Bandura & Martinez-Pons, 1992; Zimmerman & Schunk, 2001). Motivation or the will to learn involves learners' confidence in their abilities to organize tasks and make judgments in executing the necessary course of action to achieve explicit types of outcomes.

Models for classifying the different phases of SRL tend to vary according to the researcher's theoretical perspective; however, most models highlight the use of certain strategies and processes such as goal setting and self-monitoring (Bandura, 1986; Butler, 1997; Pintrich, 2000; Zimmerman & Schunk, 2001). Goal setting is a process whereby learners establish an objective to serve as the aim of their actions. Goals help learners focus on the task, select and apply strategies and self-monitor progress. Self-monitoring is a reflective process whereby learners evaluate their own progress and adjust strategies such as information processing, use of feedback, help seeking or time management toward attainment of learning goals.

Strengths and Weaknesses in the Field of Self-Regulated Learning

Given the field of SRL has provided a core, conceptual framework for describing cognitive, metacognitive and affective aspects of learning, it seems important to consider the overall strengths and weaknesses of the field. A main strength is that educators may choose to leverage information about SRL interventions from a long-term, comprehensive, research-based history that supports learners, particularly learners who are not as academically prepared. Another strength is the many SRL instruments that are available to institutions desiring to have a better grasp on learners' perceptions of and readiness to perform academic tasks. A weakness might be institutional and educator "know how" of implementing SRL interventions at the programmatic or task level of course activities. Additionally, learners who already possess strong study skills, may perceive SRL interventions as unnecessary. Although weaknesses, the core framework of SRL provides a foundation for positively influencing learning and is an important area of research within educational psychology to draw upon.

Emergence of Self-Regulated Learning Theories

Spanning approximately 25 years of research and development, SRL theory emerged in the 1980s in an effort to describe the attributes of academically successful students (Bandura, 1986). Zimmerman is one of the original authors on SRL theories, making major contributions to educational psychology from 1986 onward. The work by Boekaerts is also one of the earliest on SRL theories and research, dating back to the late 1980s; her work focused on explaining the role of goals (Boekaerts, 1988).

Boekarts, Pintrich and Zeidner (2000) published a collection of more prominent models and theoretical perspectives of SRL at the time including operant, information processing and social cognitive. All of these perspectives tend to agree that SRL has cognitive, metacognitive and motivational components, but they differ with regard to which components to emphasize and which are more likely to improve academic performance. While operant theorists emphasize the role of external reinforcement in the SRL process, information processing theorists stress the role of memory, tactics and knowledge (Winne & Hadwin, 1998; Zimmerman & Schunk, 2001). From the social cognitive perspective, SRL is a multidimensional construct that involves interactions between cognitive strategy use, metacognition and motivation (Bandura, 1986: Butler, 1997; Pintrich, 2000; Zimmerman, 2000; Zimmerman, Bandura & Martinez-Pons, 1992).

Since 2000, publications in the field of SRL have increased and expanded with regard to theoretical development and models; there are now further models of SRL in the field of educational psychology (Zimmerman &

Schunk, 2011). These newer models as well as the earliest models are described below.

Prominent Self-Regulated Learning Models

Introduction

Consistent with earlier reviews of the literature on SRL models, this review provides a detailed account of the prominent models including: (a) a description of the model; (b) a graphic of the model; and (c) a comparative analysis of the models' common and unique features.

To identify SRL models for this literature review, I took the following actions. The first action was to review handbooks of SRL, searching for chapters which contained a model that was presented in the form of a graphic. Second, I considered whether or not any widely used instruments had emerged from these models e.g. Pintrich's Motivated Strategies for Learning Questionnaire (MSLQ) and Boekaerts's Online Motivation Questionnaire (OMQ). Third, I retrieved existing scholarly articles on SRL models i.e. Pandero, E. (2017) and Urbina, S., Villatoro, S., & Salinas, J. (2021).

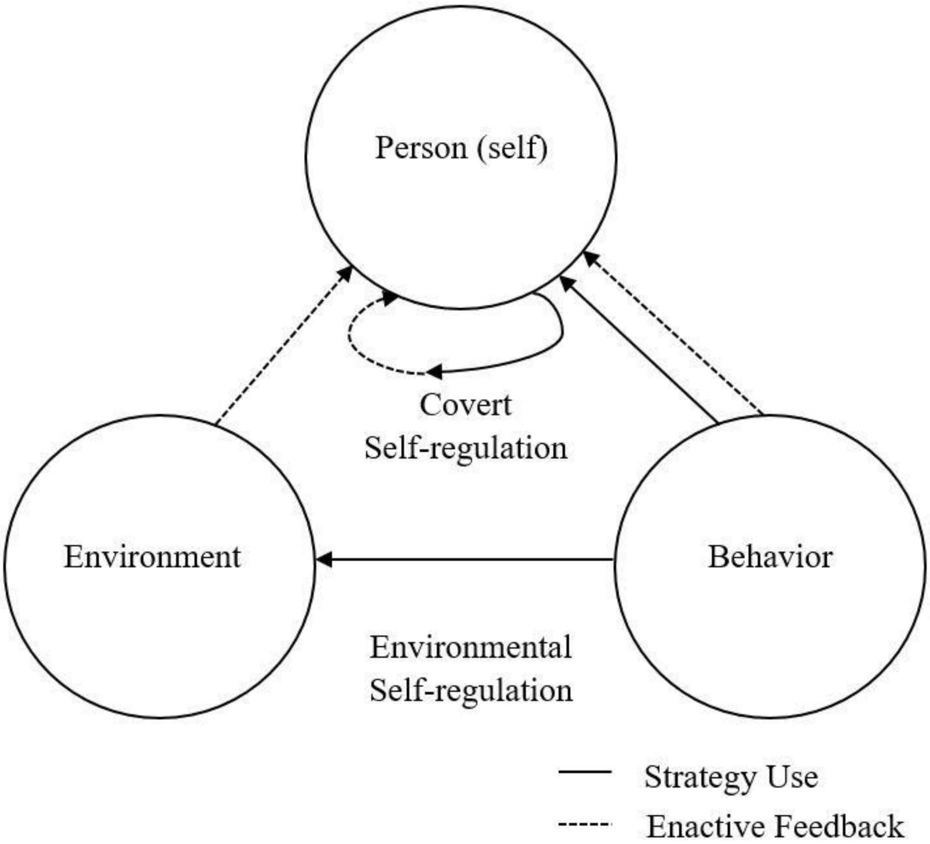
Based on my research, I provide a narrative of 11 prominent SRL models in chronological order from Zimmerman, B. J. (1989), Zimmerman, B. J. (2000), Boekaerts, M. (1992), Boekaerts, M. (1996), Boekaerts, M. (2011), Butler, D. L. and Winne, P. H. (1995), Butler, D. L. (1997), Winne, P. H. and Hadwin, A. F. (1998), Pintrich, P. R. (2000), Efklides, A. (2011), and Järvelä, S. and Hadwin, A. F. (2013).

Zimmerman. Zimmerman is one of the earliest to develop models representing SRL processes. Zimmerman's first model, known as the Triadic Analysis of SRL, is based on Bandura's theory of social cognition

(Zimmerman, 1989). The model, as shown in Figure 1, represents SRL as personal processes, environmental influences and behavioral events in a reciprocal pattern (Zimmerman, 1989). These three general areas of SRL may differ with regard to emphasis depending on the academic setting e.g. a highly structured curriculum vs. a self-directed curriculum (Zimmerman, 1989). The covert self-regulation represents metacognitive and affective states through a feedback loop whereby learners activate processes such as self-observation, self-judgement and/or self-reaction (Zimmerman, 1989).

Figure 1

Triadic Analysis of Self-Regulated Learning

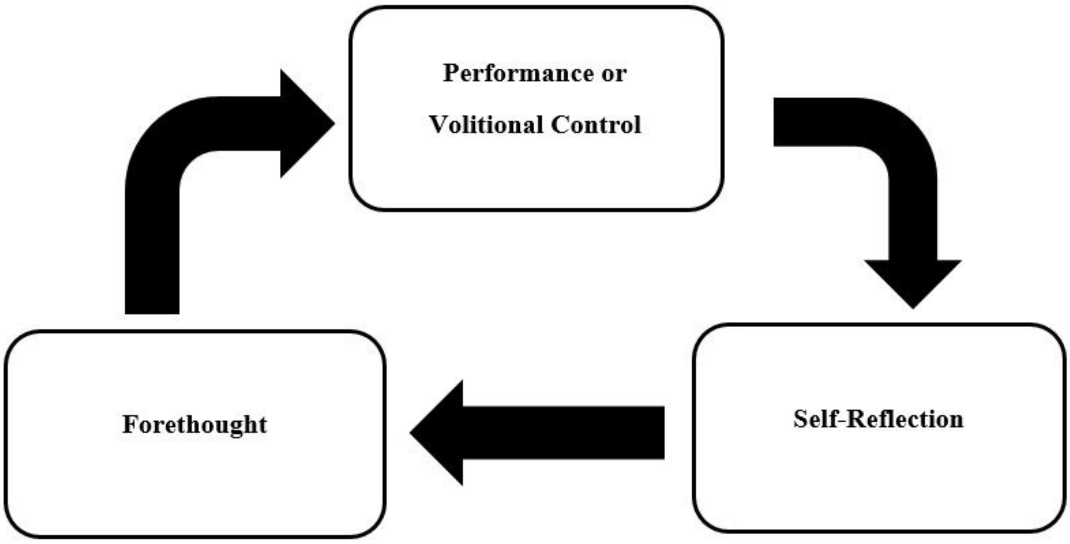


Note. From "A Social Cognitive View of Self-Regulated Academic Learning," by B. J. Zimmerman, 1989, *Journal of Educational Psychology*, 81(3), p. 330. (https://doi: 10.1037/0022-0663.81.3.329). Copyright 1989 by the American Psychological Association.

Zimmerman later developed a second model. In Zimmerman's Academic Learning Cycle Phases model for SRL, feedback from prior performance is used to make adjustments, increasing performance towards goals (Zimmerman, 1998). Figure 2 depicts the three cyclical phases: (a) forethought; (b) performance or volitional control; and (c) self-reflection. Forethought involves an analysis of the task along with motivation and confidence towards meeting a learning goal (Zimmerman, 1998). In the performance and control phase, learners work on a task, using self-monitoring strategies (Zimmerman, 1998). Then, in the reflection phase, students self-assess their own performance, making adjustments for future tasks (Zimmerman, 1998).

Figure 2

Academic Learning Cycle Phases

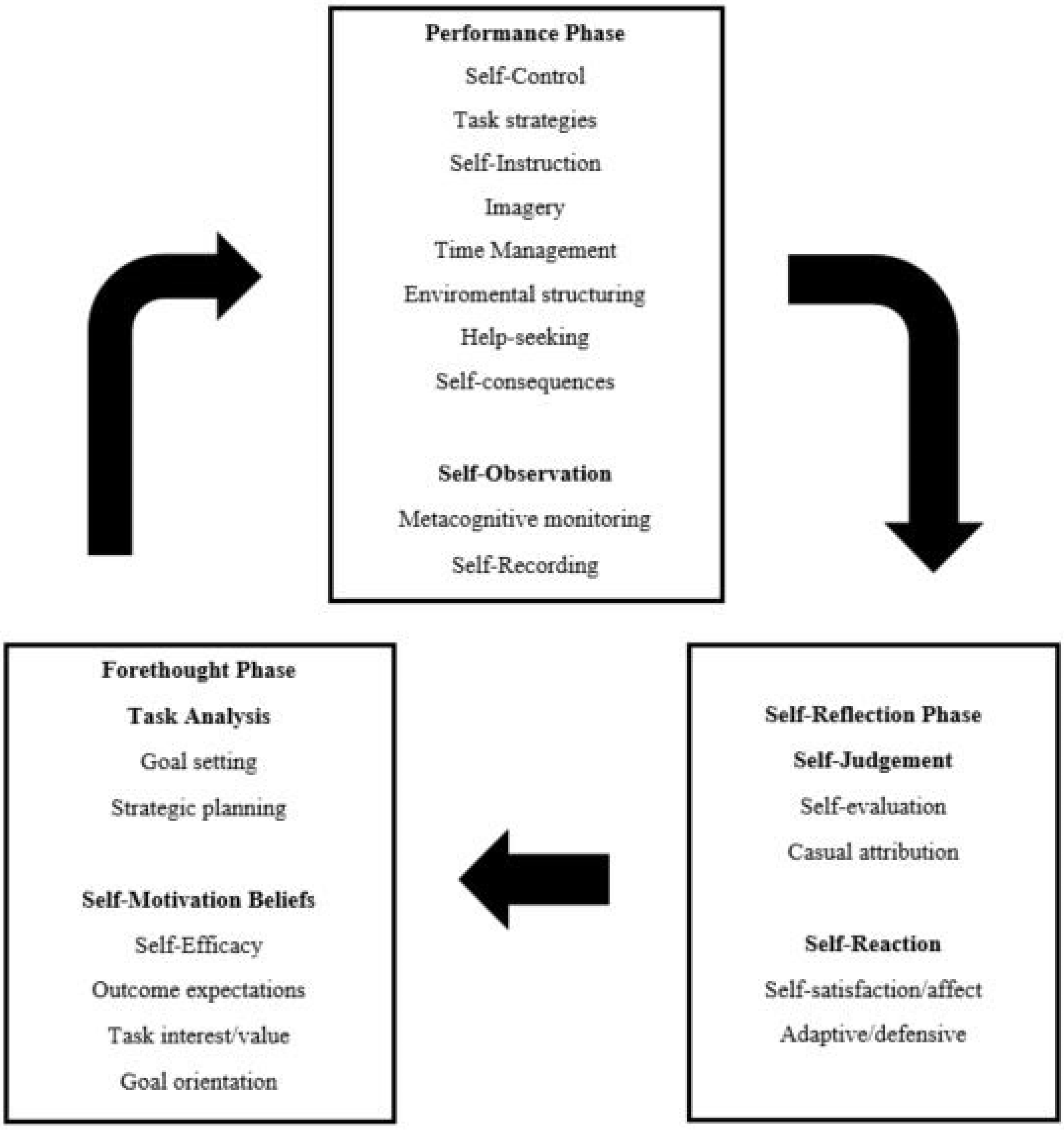


Note. From "Developing Self-Fulfilling Cycles of Academic Regulation: An Analysis of Exemplary Instructional Models," by B. J. Zimmerman, in D.H. Schunk & B. J. Zimmerman (Eds.), *Self-Regulated Learning: From Teaching to Self-Reflective Practice* (p. 3), 1998, Guilford Press. Copyright 1998 by Guilford Press.

Created by Zimmerman and Moylan (2009), Figure 3 depicts the most recent and detailed version of the Cyclical Phases of Self-Regulation model.

Figure 3

Cyclical Phases of Self-Regulation

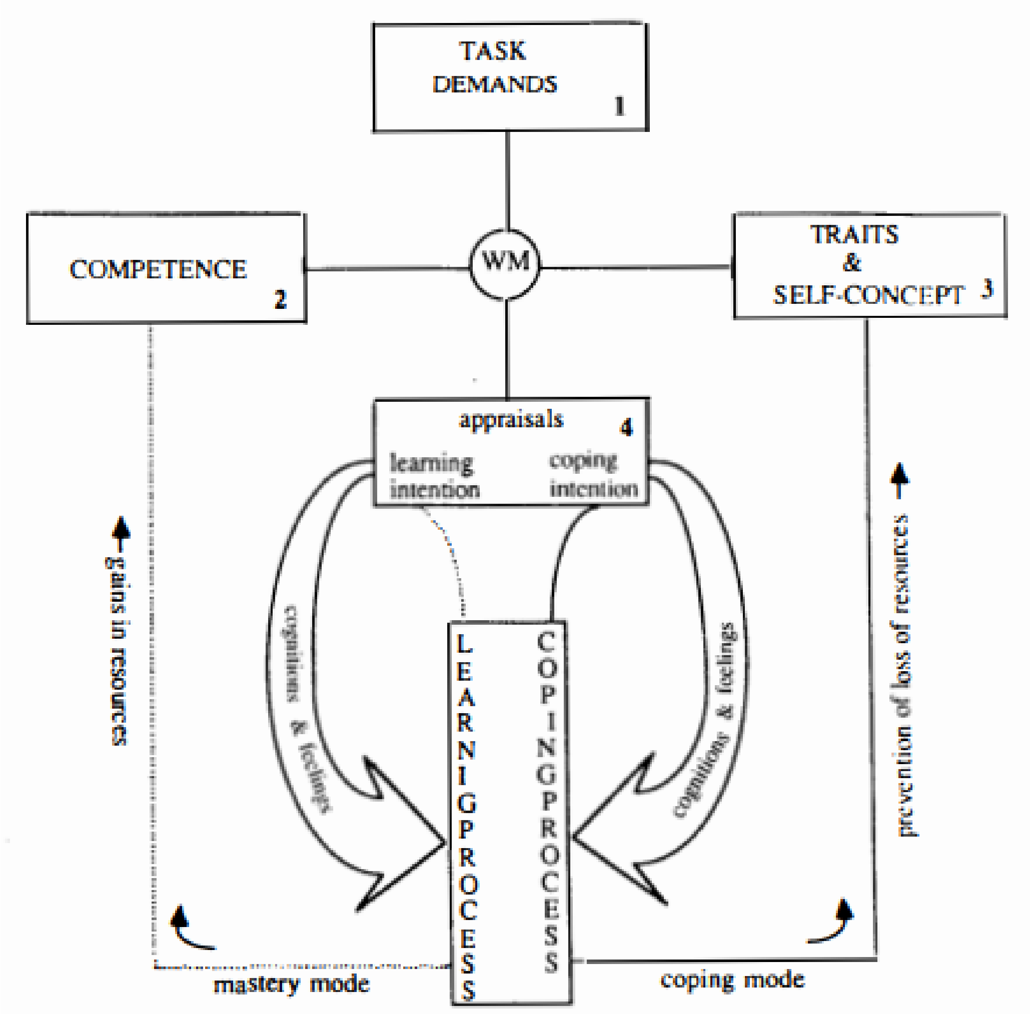


Note. From "Self-Regulation: Where Metacognition and Motivation Intersect," by B. J. Zimmerman, and A.R. Moylan, in D. J. Hacker, J. Dunlosky & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (p. 302), 2009, Routledge. Copyright 2009 by Routledge.

Boekaerts. One of Boekaerts's earliest SRL models addressed adaptable learning in an effort to represent various motivational and emotional constructs that link to the teaching and learning process (Boekearts, 1992). As shown in Figure 4, this model consists of four main areas. The first area is the learners' perception of the task (Boekaerts, 1992). The second area consists of domain related knowledge and skills that are relevant to the task (Boekaerts, 1992). The third area refers to personality traits such as self-concept, anxiety and goal-setting (Boekaerts, 1992). The fourth area depicts learners' appraisal of the situation e.g. threats, challenges, gains or losses (Boekaerts, 1992).

Figure 4

Heuristic Model of the Affective Learning Process

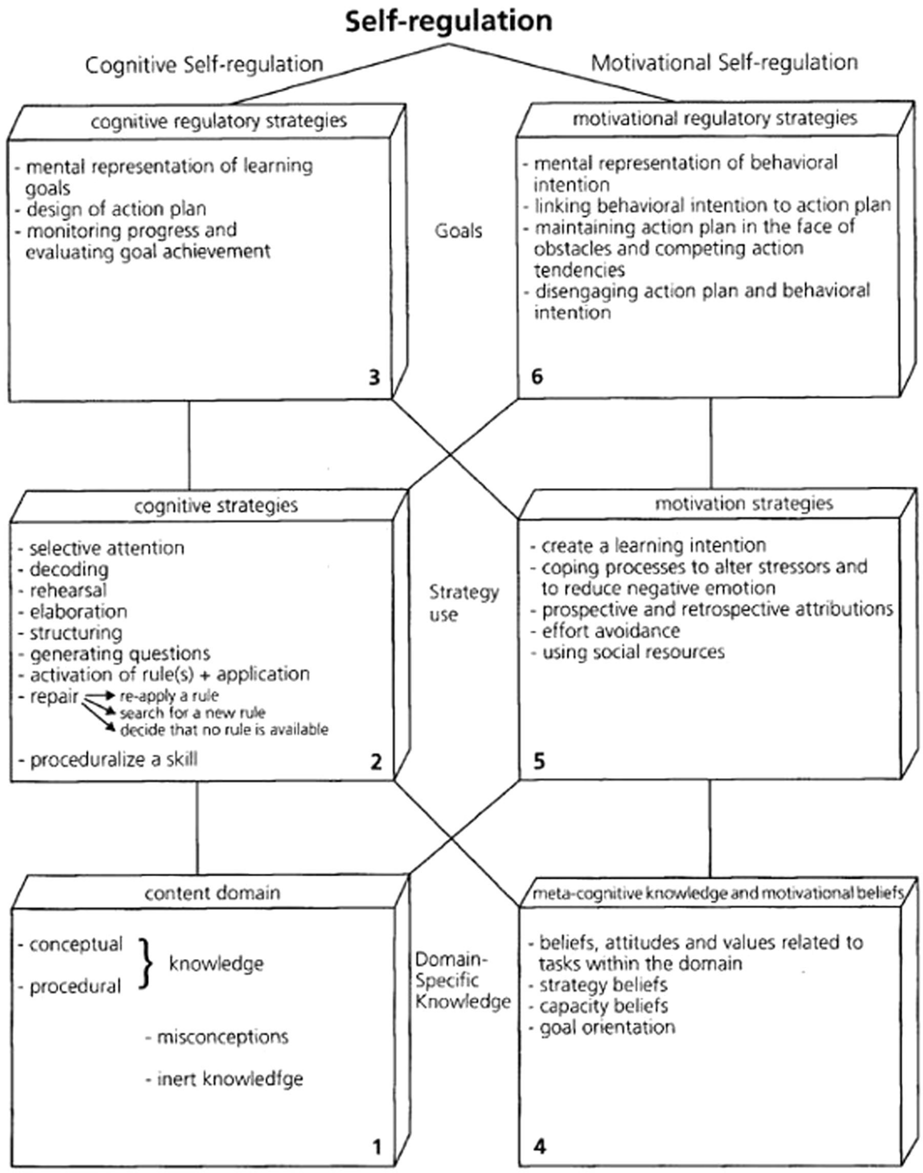


Note. From "The Adaptable Learning Process: Initiating and Maintaining Behavioral Change," by M. Boekaerts 1992, *Applied Psychology*, 41(4), p. 383. (https://doi: 10.1111/j.1464-0597.1992.tb00713.x). Copyright 1992 by Wiley-Blackwell.

Boekaerts created a second model which differs from prior conceptions of SRL by consisting of two parallel systems (Boekaerts, 1996). As shown in Figure 5, these two regulatory systems are pictured on the left and right sides. The left side of the model emphasizes cognitive components of SRL whereas the right side of the model emphasizes motivational components of SRL (Boekaerts, 1996). The different components of both sides are positioned at three levels according to goals, strategy use and domain-specific knowledge (Boekaerts, 1996).

Figure 5

Six-Component Model of Self-Regulated Learning

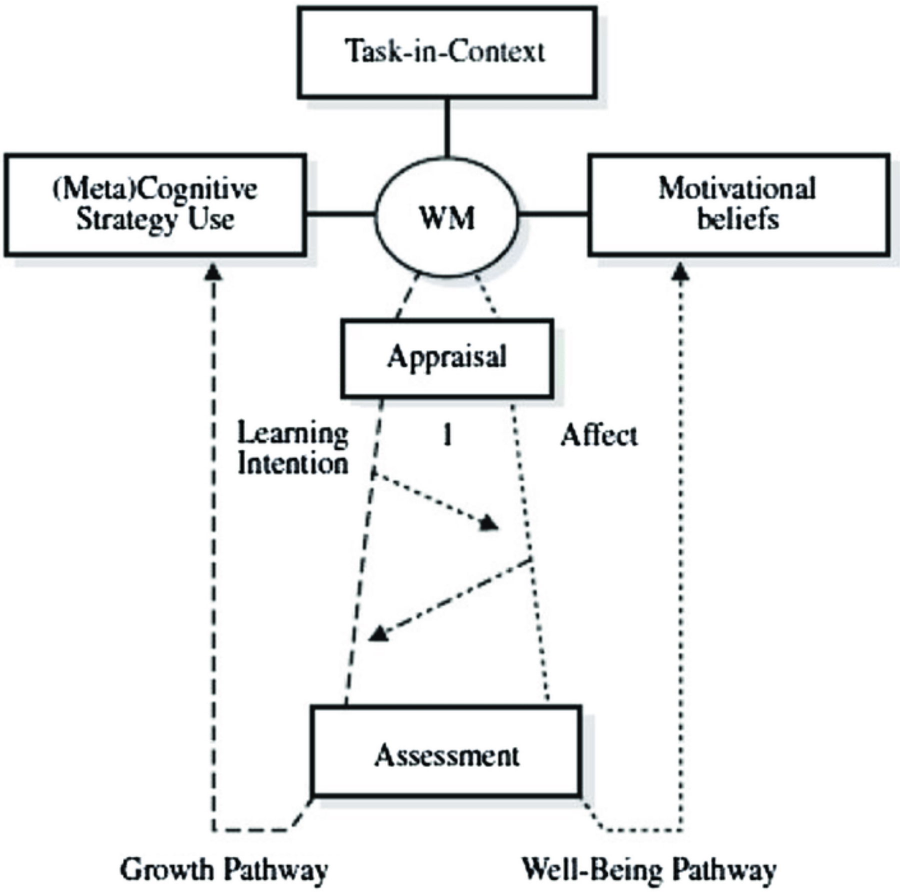


Note. From "Self-Regulated Learning at the Junction of Cognition and Motivation," by M. Boekaerts 1996, *European Psychologist*, 1(2), p. 103. (https://doi:10.1027/1016-9040.1.2.100). Copyright 1996 by Hogrefe & Huber Publishers.

As shown in Figure 6, Boekaerts's Dual Processing Model offers educators and researchers an updated version of when, why and how learners' self-regulation system works in certain content domains and when it tends to breakdown in others, including under social learning conditions (Boekaerts, 2011). Boekarts described this Dual Processing Model as having "top-down" and "bottom-up" phases (Boekaerts, 2011). The "top-down" consists of learners' tasks as driven by a mastery growth pathway (Boekaerts, 2011). The "bottom-up" consists of perceptions of the learners' well-being pathway (Boekaerts, 2011).

Figure 6

Dual Processing Model

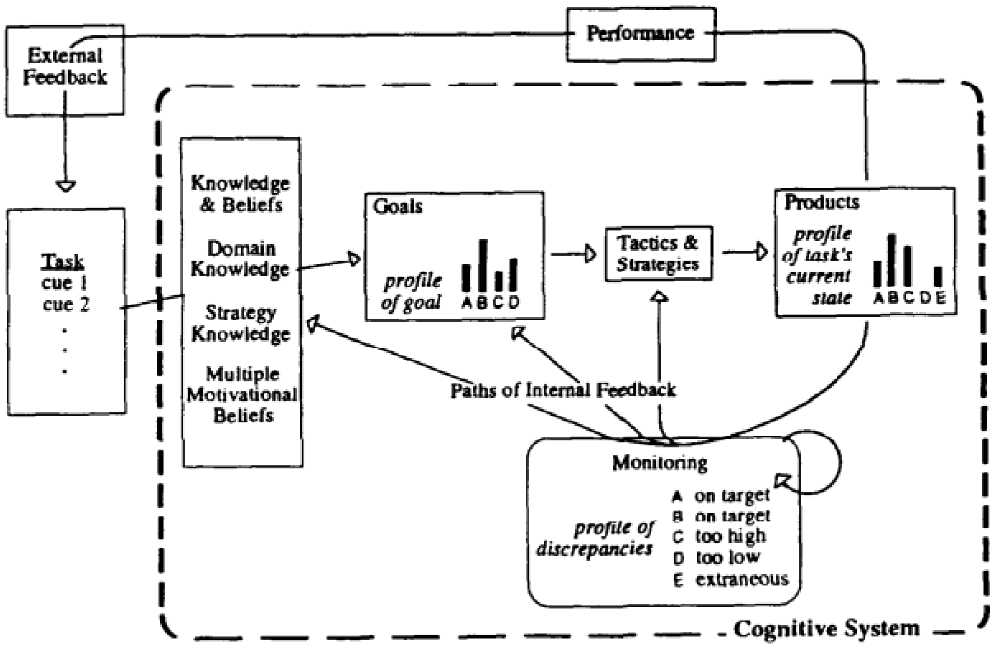


Note. From "Emotions, Emotion Regulation and Self-Regulation of Learning," by M. Boekaerts, in B. J. Zimmerman & D. H. Schunk (Eds.) *Handbook of Self-Regulation of Learning and Performance* (p. 410), 2011, Routledge. Copyright 2011 by Routledge.

Butler and Winne. As shown in Figure 7, SRL is represented as a recursive flow (Butler & Winne, 1995). In this model, learners clarify task requirements, set goals and create a plan for achieving goals, leading to the generation of products (Butler & Winne, 1995). The generation of products leads to internal feedback, directing subsequent engagement (Butler & Winne, 1995). If external feedback is introduced, learners may reexamine approaches to a task and make adjustments in their self-regulation (Butler & Winne, 1995).

Figure 7

A Model of Self-Regulated Learning

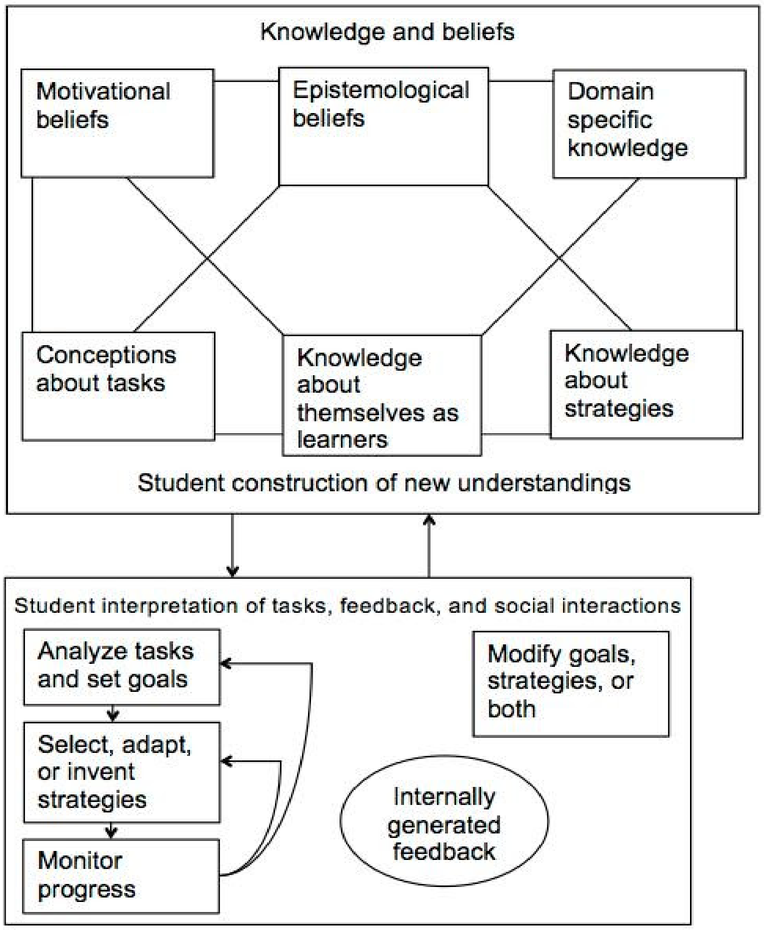


Note. From “Feedback and Self-Regulated Learning: A Theoretical Synthesis,” by D. L. Butler and P. H. Winne 1995, *Review of Educational Research*, 65(3), p. 248. (https://doi: 10.2307/1170684). Copyright 1995 by the American Educational Research Association.

Butler. In Butler’s simplified Self-Regulated Model, learners draw upon knowledge and beliefs to construct an interpretation of a task’s requirements and to set goals; goals are approached by applying strategies that generate products (Butler, 1997). Products have cognitive, motivational and behavioral components; monitoring of these components generates internal feedback that provides justification for reinterpreting a task (Butler, 1997). Learners may modify or set new goals, revisit strategies, select more productive approaches, adapt skills or generate new skills (Butler, 1997). As a result of monitoring, learners may alter knowledge and beliefs, thereby directing subsequent self-regulation (Butler, 1997). Butler's model is shown in Figure 8.

Figure 8

Model of Self-Regulated Learning



Note. From "The Roles of Goal Setting and Self-Monitoring in Students' Self-Regulated Engagement in Tasks," by D. L. Butler 1997, *Educational*

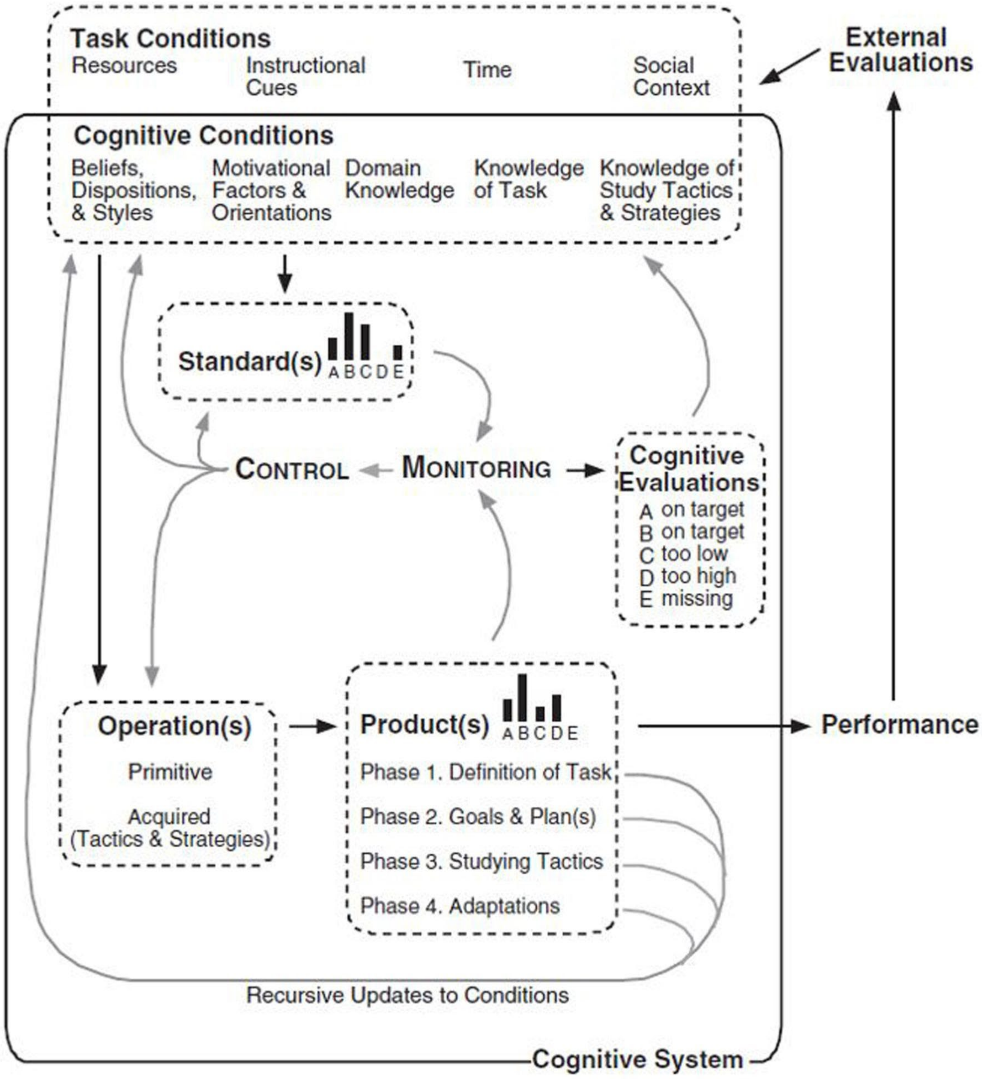
Resources Information Center, p. 3. (ED409323). Copyright 1997 by the U.S. Department of Education.

Winne and Hadwin. As shown in Figure 9, students are active with managing their own learning, using mainly cognitive and metacognitive strategies across four phases (Winne & Hadwin, 1998). These four phases are: (a) task definition; (b) goal setting and planning; (c) tactics; and (c) adaptions of metacognition (Winne & Hadwin, 1998). Using the acronym COPES, this model employs five angles which stresses the task-specific level (Winne & Hadwin, 1998). These five angles are: (a) conditions; (b) operations; (c) products; (d); evaluations and; (e) standards (Winne & Hadwin, 1998).

Greene and Azevedo (2007) reviewed the COPES model from a theoretical and procedural point of view, particularly the five angles. Conditions encompass the learner's available resources such knowledge of the domain, beliefs, time constraints and motivation towards the task (Greene & Azevedo, 2007). Operations are the processes used for creating a product during the learning and task completion process (Greene & Azevedo, 2007). A product, for example, might be where learners are asked to explain in their own words about the expectations for a given task. Evaluation is the process of monitoring whereby learners compare their own product to a set of expectations or standards (Greene & Azevedo, 2007). Standards, for example, could be in the form of rubrics and exemplary products.

Figure 9

Model of Self-Regulated Learning



Note. From "Studying as Self-Regulated learning," by P. H. Winne and A. F. Hadwin, in D. H. Hacker, J. Dunlosky & A. Graesser (Eds.) *Metacognition in Educational Theory and Practice* (p. 278), 1998, Lawrence Erlbaum Associates Incorporated. Copyright 1998 by Lawrence Erlbaum Associates Incorporated.

Pintrich. Pintrich's model, grounded in social cognitive theory and research, has contributed significantly to our understanding of how SRL, its components and its sub processes are developed. Table 1 from Pintrich (2000) displays an illustration of SRL. In this illustration, the regulatory processes are organized according to four stages: (a) planning and goal setting; (b) self-monitoring; (c) controlling; and (d) reflecting. Within each of these stages, self-regulation processes are structured into four areas: (a) cognition; (b) motivation; (c) behavior; and (d) context. Pintrich's illustration represents a holistic sequence which learners progress through as a task is being carried out. The stages produce various interactions among the different SRL processes as described below.

Planning and goal setting. The self-regulating processes begin in the planning stage with essential activities such as goal setting and activation of prior knowledge of the domain. The cognitive area recognizes the resources and strategies that are helpful in addressing the task. Metacognitive awareness recognizes the difficulty of the task and identifies the knowledge and skills needed for addressing the task. Motivational beliefs such as efficacy for completing the task or value given to the task, influence learner behavior toward the task such as planning time and effort and the activation of perceptions regarding the task and the contextual area.

Self-monitoring. Within the self-monitoring stage, learners become aware of their own state of cognition and motivation, use of time and effort, as well as conditions of the task and the context. Processes in this stage include self-observation of comprehension and competency, as well increased awareness of the goals that will subsequently direct behaviors and understanding of how performance will be evaluated.

Controlling. The activities in the controlling stage embody the selection and utilization of cognitive, metacognitive, and motivational strategies, as well as those strategies related to control of diverse academic tasks such as control of the atmosphere and structure of the task.

Reflecting. The final stage of reflecting includes evaluations that learners make regarding execution of the task. Processes in this stage include comparison of the executed task to previously established criterion that were determined by the learner and/or provided by the instructor, internal and external feedback about the results of the task, consequences for the results, and behavior to be followed, as well as overall assessments about the task.

Table 1

Phases and Areas for Self-Regulated Learning

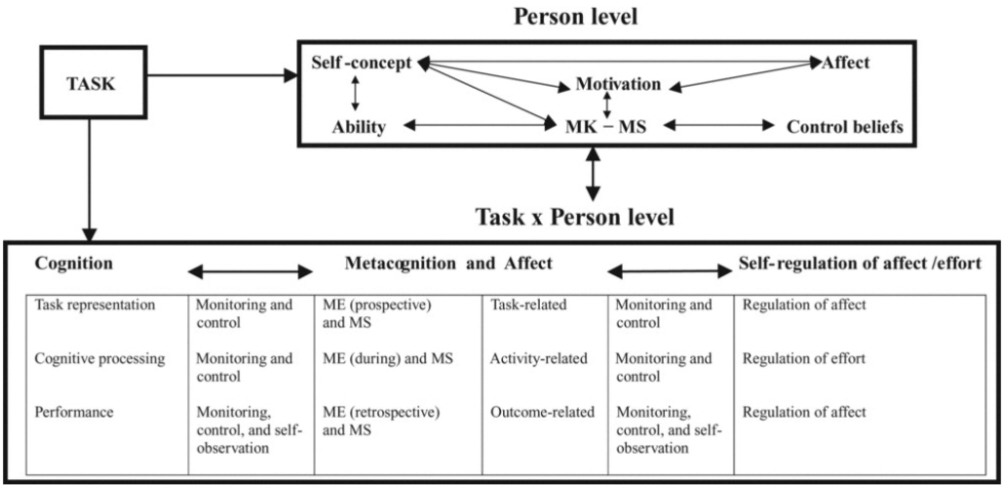
Stages	Cognition	Motivation/affect	Behavior	Context
Forethought, planning and activation	Target goal setting Prior content knowledge activation Metacognitive knowledge activation	Goal orientation adoption Efficacy judgements Perceptions of difficulty of the task Task value and interest activation	Time and effort planning Planning for self-observations of behavior	Perceptions of task Perceptions of context
Monitoring	Metacognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behavior	Monitoring changing task and context conditions
Control	Selection and adaption of cognitive strategies for learning, thinking	Selection and adaption of strategies for motivation and affect	Increase/decrease effort Persist, give up Help-seeking behavior	Restructuring the task Changing or leaving the context
Reaction and reflection	Cognitive judgements Attributions	Affective reactions Attributions	Choice behavior	Evaluation of task Evaluation of context

Note. From "The Role of Goal Orientation in Self-Regulated Learning," by P. R. Pintrich, in M. Boekaerts, P. R. Pintrich & M. Zeider (Eds.) *Handbook of Self-Regulation* (p. 454), 2000, Academic Press. Copyright 2000 by Academic Press.

Ekflides. Ekflides's approach is strongly based in metacognitive and motivational experiences whereby learners monitor their progress towards a goal, guiding the self-regulatory process in both cognitive and affective loops (Ekflides, 2006). As shown in Figure 10, the Metacognitive Affective Model of SRL (MASRL) represents task, person and person/task levels. The task level (top-down) includes defining characteristics such as learning goals and requirements, complexity, novelty, constraints and so on (Ekflides, 2006). The person level represents cognitive, metacognitive, affective and volitional components which can be intertwined, shaping how the person approaches an academic task (Ekflides, 2006). The person/task level (bottom-up) is where the learning event takes place or is processed (hands-on) and includes continuous SRL processing such as task monitoring (Ekflides, 2006).

Figure 10

The MASRL Model

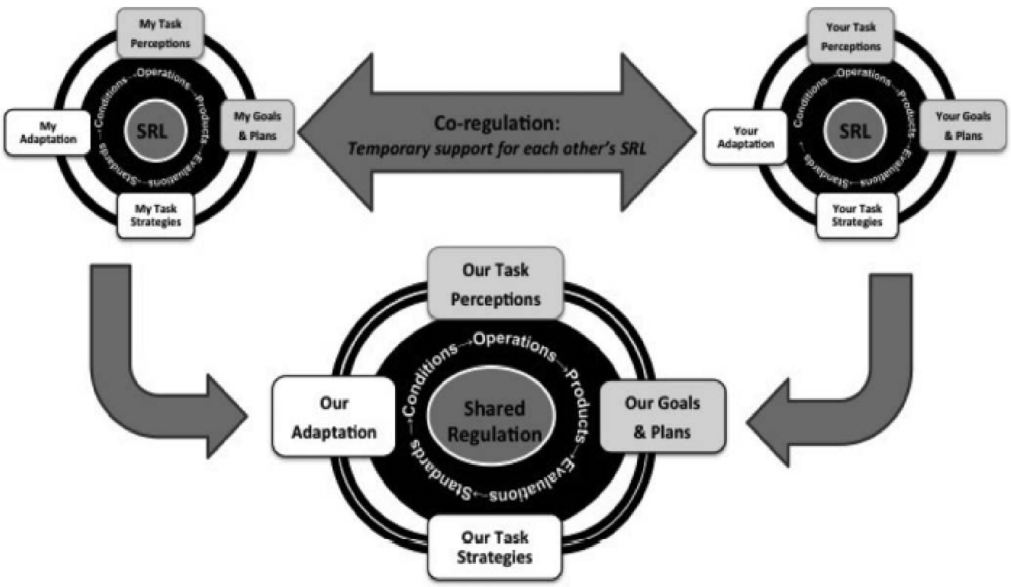


Note. From “Interactions of Metacognition with Motivation and Affect in Self-Regulated Learning: The MASRL Model,” by A. Efklides 2011, *Educational Psychologist*, 46(1), p. 7. (https://doi: 10.1080/00461520.2011.538645). Copyright 2011 by Routledge.

Järvelä and Hadwin. As shown in Figure 11, learners engage in activities where they work together towards individual mastery (Järvelä & Hadwin, 2013). The model uses the acronym computer supported collaborative learning (CSCL) in order to demonstrate ways in which CSCL can be used for group regulation of learning. In this model, three areas of SRL are represented: (a) individual SRL - taking responsibility for your own learning; (b) coregulated SRL - supporting group members; and (c) shared SRL - groups regulate as a collective, constructing shared perceptions of tasks and goals (Järvelä & Hadwin, 2013).

Figure 11

Three Forms of Regulated Learning in Successful Collaboration



Note. From “New Frontiers: Regulating Learning in CSCL,” by S. Järvelä and A. F. Hadwin 2013, *Educational Psychologist*, 48(1), 25–39, p. 29. (https://doi: 10.1080/00461520.2012.748006). Copyright 2013 by Routledge.

Comparison of Self-Regulated Learning Models

The forementioned models of SRL provide valuable frameworks for conceptualizing pathways to learning. All of the models propose that SRL is a cyclical or recursive process encompassing phases and subprocesses (components) that are used during learning including task analysis, planning and goal setting, cognition, metacognition, motivation, emotion, feedback and reflection. However, these SRL models differ with regard to which components are included and emphasized, and how they are positioned. Below is a comparative analysis offering strengths and weaknesses of the different models according to the most frequently discussed components in the field of SRL.

Task analysis, planning and goal setting. This is the preparatory component of SRL where learners identify expectations, establish objectives to serve as the aim of their actions and determine steps and resources necessary for the successful completion of any tasks. With the exception to the earliest model by Zimmerman (1989) which is more of a high-level definition of SRL, all of the forementioned SRL models include this phase. The positioning of this phase is typically found at the beginning of the learning pathway; however, there are some nuances in the positioning. For example, the model by Ekflides (2006) positions this phase as both top-down and bottom-up processes whereby students engage in continuous monitoring of the task. The model by Boekaerts (1996) positions this phase explicitly between two parallel constructs (cognition and motivation). Positioning aside, all of the available SRL models provided in this thesis are quite similar with regard to this phase.

Cognition and metacognition. The cognitive component involves the use of learning strategies to engage with concepts towards the goal of accomplishing a task whereas the metacognitive component involves the use of monitoring and regulation to control cognitive processes. All forementioned models have cognitive components either overtly (in diagram) or implicitly (in the explanatory text) whereas the use of metacognitive components is more or less challenging to discern. For example, the Dual Processing Model by Boekaerts (2011) has a prominent label in the model for metacognitive strategy although it doesn't show any sub processes. In Winne and Hadwin (1998), the model provides sub processes under the umbrella of "control and monitoring". Pintrich (2000) emphasizes monitoring skills such as self-observation and control skills such as selection of cognitive strategies. Given the differences in nuances between the models, it could be helpful to determine its applicability to a learning situation based on need i.e. more or less emphasis on cognitive and/or metacognitive components depending on the context of the desired outcomes.

Motivation. Motivation or the will to learn involves learners' confidence in their abilities to organize tasks and make judgments about the necessary course of action towards achieving desired outcomes. The use of this component is more or less apparent in the models either overtly (in diagram) or implicitly (in the explanatory text). For example, the model by Zimmerman (1998) places emphasis on motivation within all three phases of the model although the sub processes are not shown. In Zimmerman and Moylan (2009), the model provides sub processes under the umbrella of "self-motivation and beliefs". Boekaerts (2011) includes motivation as a main component whereby students activate learning paths leading to control of regulatory skills. Efklides (2011) includes motivation in her model, but it is not the main focus. In Järvelä and Hadwin (2013), motivation is not apparent in the model, however the text discusses its role in the context of collaborative learning situations.

Emotion. Emotions or feelings can play a part in SRL by either facilitating or hindering the learner's ability to engage in the effective use of learning strategies. The use of this component is generally as an intertwined component when it is present. For example, the models by Boekaerts (1992) and (1996) highlight the importance of emotion in relation to the use of coping strategies during the learning process. Efklides (2011) does not explicitly show emotion as a component, but it includes regulation of affect and self-concept in the model. The model by Pintrich (2000) includes affective reactions as a component of reflection. In Järvelä and Hadwin (2013), the model's emphasis on coregulation could be associated with the emotional challenges that learners encounter in collaborative learning situations.

Feedback. Feedback is the information or input provided to learners about their performance or progress towards achieving a learning goal. The use of this component when it is shown in a model is generally as an intrinsic component that can be inferred; however, certain models place emphasis on feedback directly in the model. For example, Butler and Winne (1995) position paths of internal feedback at the center of the model. In the model by Winne and Hadwin (1998), external evaluations are shown as part of a feedback loop. Zimmerman (1989) includes feedback as a main component of the model.

Reflection. The reflection component involves learners' self-awareness and evaluation of their progress towards the completion of goals. This component is also more or less prominent in the models. For example, Pintrich (2000), Zimmerman (2000) and Zimmerman and Molan (2009) include reflection as a main component in their models. Boekaerts (1996) includes evaluation of goal achievement as a subprocess in the model. In Boekaerts (2011), the model's connection to reflection can be captured from the emphasis on appraisal e.g. a reflective analysis of an event for the purposes of making judgements or modifications.

Provided below in Table 2 is an overview of common and unique components of the SRL models reviewed in this thesis.

Table 2

Analysis of Self-Regulated Learning Models

Authors	Model	Common Components	Unique Components
Zimmerman (1989)	Triadic Analysis of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Three areas, emphasis on feedback loops, Self-Regulated Learning Interview Schedule (SRLIS) instrument
Boekaerts (1992)	Heuristic Model of the Affective Learning Process	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Four areas, emphasis on feelings, coping, cognition and mastery
Boekaerts (1996)	Six-component Model of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Two parallel systems with six areas, emphasis on domain specific knowledge and social resources
Butler and Winne (1995)	A Model of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Eight areas, emphasis on external feedback
Butler (1997)	Model of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Intuitive, simplified model, emphasis on feedback
Winne and Hadwin (1998)	Model of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Four phases with five angles, performance standards, operations, instructional cues, social context, domain knowledge
Zimmerman (1998)	Cyclical Phases of Self-regulation	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Three areas, less detailed phases, emphasis on motivation
Zimmerman and Moylan (2009)	Cyclical Phases of Self-regulation	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Three areas, more detailed phases, emphasis on motivation

Authors	Model	Common Components	Unique Components
Pintrich (2000)	Stages and Components of Self-regulated Learning	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Four stages, detailed sub processes, emphasis on reflection, cognition, metacognition and motivation, MSLQ instrument
Boekaerts (2011)	Dual Processing Model	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Five areas, emphasis on well-being, growth and motivation, OMQ instrument
Ekflides (2011)	The MASRL Model	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Three levels, task (top-down SRL), person, task/person (bottom-up SRL), emphasis on intrinsic motivation
Järvelä and Hadwin (2013)	Three Forms of Regulated Learning in Successful Collaboration	Cyclical - task analysis, planning, goal setting, cognition and metacognition	Three areas, emphasis on collaborative and technology assisted learning

Note. Analysis of Self-Regulated Learning Models.

In summary, the above SRL models are described in the literature as a cyclical, multifaceted process whereby learners iteratively engage in analyzing tasks, setting goals, choosing learning strategies, executing tasks and monitoring progress. These SRL models also include learners' construction of a range of knowledge and beliefs such as conceptions about tasks, awareness of motivation and familiarity with the discipline. These models differ by way of presentation and emphasis, but they share common attributes of SRL such as task analysis, goal setting, and use of cognitive and metacognitive strategies that are entwined and iteratively engaged with during the learners' process of completing an academic task. As educators, we might think about our learning objectives, disciplines, audiences and research goals in determining a model or combination of these that fit our needs.

Self-Regulated Learning in Higher Education E-Learning Environments

The following is a narrative review in chronological order from 1999 to 2022 of selected studies about SRL in higher education e-learning environments. Although not all of these studies met the inclusion criteria for this meta-analysis, they make important contributions to the literature and are described for this reason.

Chung, Chung and Severance (1999) examined how online prompts designed to elicit self-monitoring strategies affected learner engagement and knowledge building, as measured by students' ability to incorporate concepts into writing assignments. The participants in this study were engineering students taking an online course in Internet literacy. Students were assigned to two different groups: (a) an intervention group with support tools; or (b) a control group without support tools. The support tools prompted students to summarize, explain and reflect on course concepts. These three activities were chosen in an attempt to help students with activation of prior knowledge, knowledge construction and comprehension checks. The findings of this study indicated that the students who used the support tools incorporated a significantly higher number of concepts into their writing than students who did not use the support tools.

Park (2000) studied the use of SRL instruction in a computer-based environment. The participants were undergraduates taking a technology course for teachers. In this study there were four groups. The first group did not have SRL instruction. The second group received detached SRL instruction. In the third group, the SRL instruction was embedded into the computer-based environment. The fourth group received detached and embedded SRL instruction. The embedded instruction prompted students to set goals and identify strategies for achieving those goals. Students were also instructed to explain the material to a peer. The findings of this study revealed significant differences in achievement of test scores between the control group and the embedded group only.

Cennamo, Ross and Rogers (2002) implemented a scaffolding structure designed to support students' development of self-regulatory skills in a Web-enhanced university level course in human development. This structure consisted of several SRL support tools. First, students were assigned to take the MSLQ and as they completed the questionnaire, students received individualized feedback as to their strengths and weaknesses for SRL. Students were also referred to additional information on improving their skills in needed areas. Secondly, students were provided with an acronym that served as a reminder of the steps to follow for SRL: Goal, Action, Monitor and Evaluate (GAME). All of the course materials and activities associated were organized in the GAME plan using a table format. Thirdly, students were provided with study guides to help structure their note taking and they took quizzes to monitor their understanding as often as they liked. Fourthly, students used a Web-based goals checklist to set and keep track of their completion process. Overall, the course evaluations showed that students believed that the course design and support tools improved their learning.

Azevedo and Cromley (2004) studied the effectiveness of SRL training to facilitate undergraduate, college students' learning with interactive, digital content for a unit on the human circulatory system. Students in the treatment group attended a 30-minute, face-to-face training on the use of SRL strategies designed to facilitate their conceptual understanding of complex topics while students in the control group did not attend any SRL training. In the SRL training, students were provided with descriptions and examples of the phases of SRL from Pintrich (2000), including planning (prior activation of knowledge, goals, and sub goals), monitoring (feeling of knowing, judgment of learning and identifying adequacy of information), strategy use (note taking, mnemonics, and help seeking), task demands (time and effort planning) and interest (curiosity towards the domain of the content). In addition, a visual of the model from Butler (1997) was provided. The training session lasted 30 minutes and was held in a face-to-face setting. During interacting with the content on the human circulatory system, students were reminded to reference the SRL material from the training session. Learning was measured by means of a declarative test on the components of the human circulatory system. The results of this study indicated that students in the treatment group gained a deeper understanding of the circulatory system than students in the control group.

Dabbagh and Kitsantas (2004) examined SRL in Web-based environments; specifically, whether SRL strategies could be supported in a similar fashion to those that are implemented in a face-to-face environment. The authors of this article provided insightful guidance on how SRL might be applied in Web-based environments based on seven instructor competencies. The first competency, interpersonal communication, includes being able to communicate with students individually, in small and/or large forums and being able to provide timely feedback such as praise or feedback to scaffold the learner experience. The second competency, promoting interaction, involves using Web-based tools to foster communication and collaboration by planning discussions and other activities that that promote interaction. Additionally, the second competency includes setting expectations for interaction and modeling for students how to apply strategies for making meaning from the key points of the discussion. Administrative and service skills, the third competency, are necessary to assist students with administrative functions such as clear expectations of what is required of the students in terms of learning outcomes, assignments and activities, assessment and evaluation, response time frames and any prerequisite skills. The instructor should also have teamwork skills, the fourth competency, to successfully interface with the technical and instructional design support staff and to promote collegiality among students. The fifth competency, instructional design, enables Web-based instructors to develop and produce online courses that are accessible to diverse audiences. Further, instructors need to possess knowledge and skills with using Web-based technologies, the sixth competency, to design, produce and facilitate effective Web-based learning environments. Finally, by developing an overarching strategy for planning and envisioning the design of a Web-based course, the seventh instructor competency is to ensure that all necessary elements have been incorporated, including any pedagogical, technological, organizational and logistical implications of Web-based course delivery.

Kauffman (2004) examined the learning outcomes of undergraduate students in an educational psychology course who either received or did not receive Web-based, instructional tools designed to facilitate cognitive strategy use, metacognitive processing and motivational beliefs. These three components were defined relative to note taking methods (cognitive component), self-monitoring prompts (metacognitive component) and self-efficacy building feedback (motivational component). Students took notes in a matrix or free form method from a Web site and either received or did not receive self-reflection prompts and self-efficacy feedback. Three quizzes were used to assess declarative, procedural and application knowledge. The results of this study indicated that the matrix note taking intervention had a significant effect on learning outcomes. The self-monitoring prompts had modest effects and the self-efficacy prompts revealed small effects.

Whipp and Chiarelli (2004) conducted a case study and found that students in online learning environments draw upon many of the same learning strategies as students in face-to-face environments such as calendars and organizers, self-imposed deadlines, reducing distractions, print outs, note taking and annotation, records of completed assignments, assignment criteria, checklists or rubrics, instructor feedback and grades.

Moreover, the authors of this study discovered that online students take face-to-face learning strategies a step further by devising unique ways to systematically manage their environment in order to improve their performance including:

1. Logging into to the course on a daily basis and making weekly plans for coordinating online and offline work
2. Checking the electronic grade book
3. Backing up assignments via email attachments and/or external storage devices

4. Composing posts offline and then copying and pasting the text to the online forum
5. Tracking comments from others to help with judging the quality of their own posts
6. Drawing upon other students' posts as models for improving their own work
7. Creating a psychological space similarly to being in class on a consistent schedule
8. Calling upon classmates, tutors or instructors via phone or Web-based tool

Williams and Hellman (2004) sought to confirm previous research findings, namely that first-generation college students possess lower levels of self-regulation than second-generation college students. The participants in this study were college students enrolled in courses delivered online across a range of subject areas. For this study, the researchers' dependent variable was self-regulatory behaviors for online learning. A subscale of four items based on the Multi-Dimensional Self-efficacy Scales of Bandura (1998) was used to measure students' self-regulatory behaviors for online learning including student perceptions on how well they overcome technology problems, use electronic library resources, remember information read online or in textbooks for exams and projects, and participate in online discussions. The independent variable, parent education level, was measured with two items asking the participants the highest education level attained for both their mother and father. The results of this study indicated that first-generation students lack the self-regulation skills needed to be successful online learners.

Anderton (2005) studied the use of weekly forms designed to facilitate strategies that promote self-regulated learning in an online course in educational testing and measurement. Participants in the treatment completed a daily progress chart that they submitted at the end of each week. The progress chart asked questions about time spent on studying, number of pages read, completion of assignments and assignments worked ahead on. Academic achievement between the treatment and control groups was measured by two quizzes. Although the treatment group average score on the quizzes was higher, it was not significant.

Dabbagh and Kitsantas (2005) sought to confirm previous research findings, namely student perceptions of the usefulness of Web-based pedagogical tools (WBPT) in supporting different SRL processes including, goal setting, help seeking, self-evaluation, and task strategies. The participants in this study were enrolled in three sections of a Web-enhanced, college course in advanced instructional design. The results of this study confirmed that different categories of WBPT tools supported different SRL processes. In terms of which WBPT tools were the most useful in supporting students' learning in the courses, discussion area and resources, were reported as most useful, followed by sample projects, rubrics, an area to post work and compare to others, announcements and email. Check grades and calendar tools were reported as least useful in supporting student learning overall.

Bates (2006) examined the effects of an online orientation tutorial designed to teach self-regulated learning strategies to community college students enrolled in an introductory computer class. The tutorial instructed students to establish goals for the course and develop steps that they would follow to accomplish their goals. In this study, students' performance did not improve as a result of the online orientation tutorial.

Bell and Akroyd (2006) conducted a cross-sectional study in order to examine the effect of SRL on learning outcomes in online courses while holding constant the effect of computer self-efficacy, reason for taking an online course and prior college academic achievement. Data was collected using a Web-based instrument that consisted of 24 questions taken from the MSLQ. The MSLQ questions are designed to assess participant ratings on SRL attributes, including: (a) being intrinsically motivated to reach goals; (b) expecting that one's effort to learn will result in positive outcomes; (c) being confident in one's ability to complete an academic task; (d) monitoring one's progress toward goal completion; (e) controlling effort; and (f) managing resources for studying (Butler, 1997; Pintrich, 2000; Zimmerman & Schunk, 2001). In this study, the best predictors of academic achievement were prior grade point average (GPA) and the expectation that one will experience positive outcomes in one's learning.

Lewis (2006) investigated students' use of an SRL Webquest in an undergraduate, educational technology course. The Webquest was designed to increase SRL skills through exploration of characteristics and activities of self-regulated learners. The SRL activities were built into the context of the assignments i.e. case studies of educational technology development in school systems. Although the findings of this study were not significant, students in the Webquest outperformed students in the control group.

Moos and Azevedo (2006) studied undergraduates' use of SRL processes during a hypermedia-based learning unit on the circulatory system. The researchers also manipulated the goal structure of the hypermedia environment to explore whether the goal structure of the learning task was related to the use of SRL processes. Participants were assigned to one of three conditions: (a) mastery goal structure; (b) performance approach goal structure or (c) performance avoidance goal structure. Each condition received directions with a different goal structure. The directions for the performance-approach and the performance-avoidance goal structure were designed to promote potential achievement outcomes and provide a normative reference for performance evaluation, while the mastery goal structure was designed to downplay a normative reference for performance. The researchers then captured the SRL behaviors of the participants from five SRL categories: (a) planning; (b) monitoring; (c) strategy use; (d) task value; and (e) motivation. The findings from this study suggested that undergraduates use more SRL processes from the strategy category than from either the planning or monitoring category irrespective of the condition that they were assigned to. Thus, it may be important for designers of hypermedia environments to provide scaffolding that prompts for planning processes such as activation of prior knowledge and monitoring strategies such as feeling of knowing and recycling of goals in working memory. Lastly, the findings of this study suggested that the different goal structures of the hypermedia learning tasks were not significantly related to task value or motivation.

Boom, Paas, and Merrienboër (2007) investigated the effects of reflective dialogues on the learning outcomes of university students in an undergraduate, online course in introductory work psychology. Students were randomly assigned to one of three conditions: (a) reflection prompts with tutor feedback; (b) reflection prompts with peer feedback or (c) no reflection prompts and no feedback. Learning outcomes were measured by means of a multiple-choice test. In this experiment, the students in the reflection and tutor feedback condition outperformed the students in the other two conditions.

Chang (2007) examined the effects of self-monitoring on the learning outcomes of college students in a freshman level, Web-based, English language course. Students in the treatment group were provided with a Web-based, self-monitoring tool while students in the control group were not. The purpose of this self-monitoring intervention was to help students better manage their time, evaluate their own learning and make adaptions as needed in order to improve academic performance. Upon logging into the online course, students in the treatment group were provided with an interface that asked them to record the starting time, the place they studied and the person(s) with whom they studied. In addition, students were asked to predict their score for the post-lesson. Each time students logged into the course a history of time spent on task was shown to them. Students' scores, which included grades from comprehension, discussion and assignments, were used as the index for academic performance. Chang found that the Web-based, self-monitoring tool had a significant effect on learning outcomes.

Goh, Seet and Chen (2012) studied the use of persuasive text messaging in a Web-enhanced, first year, undergraduate information systems course to foster SRL in lower performing students. In tandem with the course modules, one to two text messages were sent each week and served as reminders to students about completing course assignments and making effective use of resources. In addition, the messages were designed to motivate students by providing positive reinforcement and familiar abbreviated language commonly found in texting such as "ur" for your or "4get" for forget. In this study, the persuasive messaging intervention had a significant effect on grade performance.

Hu (2007) compared the performance of students who did and did not receive online training about SRL strategies as part of their course of study. The participants in this study were undergraduate students in a Web-enhanced, college success course. Prior to learning students, received a Web-based tutorial on basic concepts of SRL along with practice activities. During learning, students received staged emails asking them to complete an online study plan including goal setting and planning strategies. Students were also asked to complete self-evaluation forms at the end of each period of study. In this study, Hu found that the students who received the SRL interventions performed significantly higher on the tests and assignments than the students who did not receive the interventions.

Saito and Miwa (2007) examined the effects of a self-reflection prompts on learning outcomes of university students in a freshman level, Web-enhanced course in information fluency. Students in the intervention group were prompted to complete reflective exercises as part of their Internet searching process while students in the control group were not. The design of the intervention included a search-process feedback system with two types of reflection: (a) a schematic visualization of the search process; and (b) question prompts designed to help students reflect on their own search processes presented by the system. For example, students were asked what kinds of keywords were used and how these keywords were combined, how many results of search pages were browsed per search and how many links per page were clicked. The results of this study indicated that the students who used the reflective exercises as part of their Internet searching process were more engaged than the students who did not.

Shen, Lee and Tsai (2007) randomly assigned college freshmen in a Web-enabled computer software applications course to one of four groups: (a) SRL with problem-based learning; (b) SRL only; (c) problem-based learning only: or (d) no SRL or problem-based learning. The SRL groups received a two-hour lecture on how to manage study time and self-regulate learning. Content of the SRL lecture was on the following four processes:
(a) self-evaluation and monitoring; (b) goal setting and strategy planning; (c) strategy implementation and (d) monitoring the outcome of the strategy. Students were taught how to apply these four processes to become more regulated learners. Additionally, students were required to record their learning behavior on a weekly basis. The problem-based learning (PBL) group received an authentic problem situation along with a Web-based multimedia application that helped students construct their own models for problem solving. Student learning outcomes were measured by their skills in using the application software to create graphs and tables with accuracy and artistry. Overall, Shen et al. found that the students who received the SRL intervention performed significantly better than students who did not. Likewise, students who received the PBL intervention were also better performers, especially when they received it in combination with the SRL intervention.

Bannert, Hildebrand and Mengelkamp (2008) analyzed the learning outcomes of university students in an educational media course who either did or did not receive computer-assisted training on why metacognitive activities are useful and when to apply them. After the training, students completed a learning task that required them to study theories of using multimedia in learning environments and be able to teach these concepts to other students. During the learning task, students in the intervention group were given a diagram visualizing all of the metacognitive activities from the training to serve as a prompt. Immediately after learning, students' academic performance was measured on three different levels by means of recall, comprehension and transfer to tasks. Students in the intervention outperformed students in the control group on all three levels, especially transfer to tasks.

Bixler (2007) investigated the effects of reflective question prompts on students' problem solving processes in a college level, online course in information technology. The online learning environment was provided through the learning management system (LMS). The assigned problem was to create a Website for a group of band members. Instead of providing students with instructions on how to go about the problem, the online screens in the LMS consisted of several questions that prompted students to think about the problem and write down their thoughts in a Web-based note taking tool. A typical screen in the LMS displayed the following question prompts:

1. How do I define the problem?
2. What are the parts of the problem?
3. Am I on the right track and how do I know?
4. What information is already provided?
5. What information do I need to generate?
6. This is an example of…?
7. This is similar to…?
8. What would be a new example of…?

9. What did the other members of your group think about…?

Academic achievement was measured on four different levels of problem solving by means of: (a) representing the problem; (b) developing solutions; (c) making justifications and (d) monitoring and evaluation. The results of the experimental study showed that students who worked with reflective question prompts significantly outperformed students who did not work with reflective question prompts in all four levels of problem solving.

Kauffman et al. (2008) randomly assigned students in an undergraduate case-based psychology course to one of four conditions in a Web-based module: (a) an intervention group that received a metacognitive prompt designed to focus learner attention on problem identification and a reflection prompt designed to elicit learner confidence in their identification of the problem along with an opportunity to make revisions to their answer; (b) an intervention group with metacognitive prompts only; (c) an intervention group with reflection prompts only; or (d) a control group that did not receive any metacognitive or reflection prompts. Overall, this study found that students who received metacognitive prompts were better problem solvers and wrote higher quality responses than students who did not. Likewise, students who received reflection prompts were also better performers, but only when they received metacognitive prompts.

Martel (2008) recruited undergraduate and graduate volunteers for a study in the use of metacognitive prompts in a Web-based learning environment on the human auditory system. All participants were subjected to one of three levels of metacognitive treatments to aid in comprehension. Prior to beginning the learning material, participants in the first treatment group received an instructional package on how cognitive and metacognitive strategies could be applied during learning. Participants in the second group received the same material as the participants in the first group, but they were embedded into the We-based learning environment and students were informed that the material was optional. The third group received that same treatment as the second group; however, participation in the metacognitive activities was mandatory. The findings from this study revealed that participants in the third group significantly outperformed the other two groups.

Puzziferro (2008) studied undergraduates in a cluster of online liberal arts courses. Two surveys were administered: (a) the MSLQ and (b) the Online Technologies Self-Efficacy Scale (OTES). Additionally, this study included a student satisfaction poll at the end of the online course that they were taking. The OTES scores yielded no effect on performance or satisfaction in online courses. For the MSLQ scores, time management, study environment and effort regulation were positively related to grade performance and satisfaction.

Santhanam, Sasidharan and Webster (2008) examined the effects of SRL training in an undergraduate, Web-enhanced business course in Web design. In this study, students were assigned to one of four conditions during an online training module: (a) an intervention group that received pre-training and midpoint scripts designed to encourage students to follow SRL strategies; (b) an intervention group with SRL pre-training scripts only; (c) an intervention group with SRL midpoint scripts only; or (d) a control group that did not receive any SRL interventions. The pre-training script was designed to focus learner attention on learning goals and task analysis whereas the midpoint script prompted students to reflect on their progress. This study found a significant difference in learning achievement for the group that received pre-training and midpoint scripts.

Schober, Wagner and Reimann (2008) evaluated the effects of online modules designed to instruct university students in a psychology course to learn more effectively by completing different tasks. The modules were based in SRL principles and structured according to the phases of activation, action and reflection from Zimmerman (2000). Upon logging into a module, students in the intervention group were provided with a description of the module and a question that activated prior knowledge of the subject. Students in the control group did not receive the online modules. Goals specifying the learning objectives of the module were provided followed by any projects that needed to be accomplished. A project deliverable checklist was provided for the group project. The instructor, group members and peer groups gave group-specific feedback about the project deliverables. Self-tests allowed students to individually monitor their understanding of the concepts during the module. The module culminated with students reflecting on their ability to plan, organize and complete projects individually and in groups. Academic achievement was measured on three different levels by means of recall, comprehension and production. Students in the intervention group achieved better results in completing more complex “comprehension” and “production” items.

Artino and Stephens (2009) explored SRL from a social cognitive perspective in a self-paced, online course. The participants in this study were Naval Academy undergraduates in a flight physiology and aviation survival course. The instrument used in this study was composed of 50 items designed to assess students' motivational beliefs, negative achievement emotions, use of cognitive and metacognitive learning strategies and overall course satisfaction. In particular, the researchers found that students with high motivational beliefs and low negative emotions experienced much greater academic success than students with low motivational beliefs and high negative emotions, as measured by students' reported use of SRL strategies, course satisfaction, continuing motivation and final course evaluation.

Chen, Wei, Wu and Uden (2009) explored how prompts, peer observation and peer feedback affect students' reflection levels in an online learning context. The participants in this experiment were college students from different major disciplines. The learning material used in this experiment was a biology article about the human ear. After reading the article, students in the prompt group were asked to carry out reflection and to post their reflection responses in the online course system by clicking on pre-designed anchor points that were embedded in the article. Students in the prompt and observation group were able to view the reflections of other students in addition to receiving the prompts. Students in the feedback group received comments from their peers about the quality of their reflection. This study found that prompts with observation had the most significant effect on student reflection levels, as students in this group would revise their reflection contents to a higher quality in order to avoid an unbalancing effect if they could review other students' high quality reflection contents. The results of this study also showed that peer feedback did not positively or negatively affect students' reflection levels. Although peer feedback had no significant effect on students' reflection levels, peer feedback may have provided an opportunity for students to improve their own critical thinking abilities through having to provide comments to their peers.

Crippen, Biesinger, Muis, and Orgill (2009) explored the roles of goal orientation and self-efficacy on learning outcomes when learning from worked examples in a Web-based environment. The use of worked examples was defined as a SRL strategy and represented the number of times that a student elected to view a worked example. The participants in this study were university students in an undergraduate chemistry course. At the beginning of the course, three different surveys were used to assess students' individual goal orientation, self-efficacy and perception of the learning environment: (a) the Achievement Goals Questionnaire (AGQ); (b) a self-efficacy assessment designed to measure students' level of confidence with the course subject matter: and (c) the Patterns of Adaptive Learning Survey (PALS), which is designed to measure students' preference for a mastery learning approach or a performance approach. All of the participants had access to the Web-based worked examples and multiple-choice quizzes for one week. During this period, students could modify their quiz responses at any time as their skills and understanding of the material changed. The results of this study showed that a mastery goal orientation towards learning was the strongest predictor of learning outcomes and that for students with performance goal orientations, the use of worked examples enhanced self-efficacy. In this study, the performance-oriented students perceived the worked examples as helpful and made use of them to develop confidence. These results suggest that the availability of worked examples afforded students with a performance goal orientation a strategy for improving achievement and increasing self-efficacy.

Lee, Lim and Grabowski (2009) studied computer generated metacognitive feedback in an undergraduate science course. The embedded generative learning strategies asked students to highlight important sentences and construct personal meaning in a note taking field. The metacognitive feedback instructed students to revisit certain material when they received a low learning estimate. The findings of this study revealed that the generative strategy with metacognitive feedback significantly improved learning outcomes.

Ge, Planas and Er (2010) developed a Web-based cognitive support system to assist students' problem solving performance in a college pharmacy course. The purpose of the system was to provide modeling and scaffolding for students' problem-solving steps and self-regulatory abilities. Based around a case study and characterized by mentorship and social interactions, the system consisted of five problem solving steps, question prompts, peer review, expert modeling and self-reflection. For example, Step 4 "Choose, justify and implement a plan" would present the following questions:

1. Which option would you implement as a plan?
2. Why is this plan the best choice?
3. How will you implement the plan?

Student's responses were stored in a database where they could be commented on by peers and revised according to the feedback that they received. Learning outcomes were measured by a written report. In this study, the treatment group was more likely to have better problem representation and respond in more detail.

Hodges and Kim (2010) examined the effects of email messages that were designed to promote self-regulatory skills in an online, college-level mathematics course. Learners in the first treatment group received a weekly email. The email messages, for example, reminded learners to make sure to allocate enough time for studying or track their progress in the electronic course grade center. Learners in the second treatment group also received the same weekly emails, but these emails were personalized e.g. used the learner's name. Findings from this study indicated that the emails did not significantly improve achievement.

Kauffman, Zhao and Yang (2011) investigated conditions under which note taking methods and self-monitoring prompts were most effective for facilitating information collection and achievement in an undergraduate level, Web-enhanced course in educational psychology. Students took notes using matrix, outline or conventional methods in a Web-based form. The main page provided a brief introduction to the topic and instructed students to take notes from the linked Web-based tutorials in preparation for a series of tests on statistical procedures. In each of the three note taking methods, there was a self-monitoring group and a no self-monitoring group. The self-monitoring groups received prompts that encouraged them to monitor their progress. The prompts were inserted at the end of the Web-based tutorial and just prior to the test questions. In the prompts, students were provided with a sample test question and asked if they wanted to move forward to the test or return to the Web-based tutorials. Students could also review their notes. The results of this study revealed five main effects: (a) matrix note takers collected more notes than outline note takers who collected more notes than conventional note takers; (b) students who received self-monitoring prompts collected more notes than students who did not receive self-monitoring prompts; (c) the presence of self-monitoring prompts increased note taking in conventional note takers more than it did in matrix note takers; (d) students who used the matrix note taking tool scored significantly higher on the tests than students who used the outline or conventional note taking tools and; (e) students who received the self-monitoring prompts outperformed students who did not receive the self-monitoring prompts.

Tsai, C., Shen and Tsai, M. (2011) explored the effects of providing students with training in SRL strategies and Web-enabled prompts for recording their learning behaviors and submitting assignments in a database management course for college level, vocational students in a blended learning course. Delivered in the classroom, the SRL instruction discussed how students could manage study time and regulate their learning by implementing four SRL processes: (a) self-evaluation and monitoring; (b) goal setting and strategy planning; (c) strategy implementation and monitoring; and (d) monitoring of the outcome strategy. Students recorded the data of their learning behaviors in the course Website. In the assignment section of the course Website, the assignment link prompts instructed students to submit by certain due dates and then became unavailable when the time was up. To measure the learning outcomes, students were required to solve simulated problems by designing and building a database for a customer. The results of this study revealed that students' skills in using database management software were significantly higher when they received SRL instruction and SRL Web-enabled prompts.

Bannert and Reimann (2012) investigated SRL prompting support in a Web-based learning environment. The participants were undergraduates in an educational psychology course. During the learning session, the experimental group was prompted for the following activities:

1. What is the task and what resources are available?
2. What do I want to learn and understand?
3. How do I proceed? How long and in which sequence am I going to study the topics? How will I check my understanding?
4. Did I approach my goals? Did I understand the content so far? Do I need to alter my course of action?
5. Where can I find the information?
6. Did I reach my goals? Can I remember, explain and apply what I learned?

Learning performance was measured on three levels: (a) knowledge; (b) comprehension; and (c) transfer. This study found that learners achieved better performance for transfer only when they complied with the support in the intended way.

Tsai, Hsu and Tseng (2013) explored the effects of game-based learning (GBL), Web-mediated GBL and SRL on student learning in an undergraduate level marketing course. For the SRL intervention, students received training on how to manage study time and SRL processes such as goal setting and they also kept a weekly journal of SRL activities. Students were randomly assigned to one of three conditions: (a) Web-mediated GBL and SRL; (b) Web-mediated GBL; and (c) GBL only. Learning outcomes were measured by means of students' scores on the midterm and final exams. In this study, students who received GBL and SRL simultaneously outperformed students in the Web-mediated GBL and GBL only groups.

Tsai, Lee and Shen (2013) studied the effects of SRL and problem-based learning (PBL) with first year college students who were learning Microsoft Office productivity tools in a hybrid course setting. There were three groups in this study. The first group received PBL and SRL prior to as well as during learning. The second group received PBL only and the third group received nether PBL or SRL. Students in the PBL and SRL group significantly outperformed students in the control group. The PBL only group performed better than the control group, but not significantly.

Delen, Liew and Willson (2014) examined the effectiveness of interactive video-based content on learners' self-regulation skills. Participants were graduates and undergraduates from various disciplines who were unfamiliar with the topic of the video content. In the treatment group, students were provided with a tool for generating notes, supplemental resources and practice questions. The control group had only the regular video functions such as play, pause and rewind. In this study, leaners who received the interactive tools scored significantly higher on the recall test that was administered after the interactive video.

Ko (2013) investigated the effectiveness of structured, reflective online discussions in an undergraduate computer course. In this study, self-monitoring and self-reflective components were provided to learners as scaffolding. There were two experimental groups. The first group received the structured, reflective online discussions and teacher feedback whereas the second group received only the structured, reflective online discussions. Prior to the discussions, the learners in the experimental group were asked to self-judge their level of understanding for various concepts on a scale of 0 (completely unclear) to 10 (completely clear) and then reflect on their judgement in the class discussion board. The control group did not receive a self- judgment prompt prior to participating in the discussion forum. Findings indicated that students in both experimental groups performed better academically than the control group, particularly for the group that also received teacher feedback.

Lehmann, Hahnlein and Ifenthaler (2014) investigated the use of SRL prompts for pre-reflection and post-reflection thinking activities in a graduate, research methods course. Students in the control group received generic prompts whereas students in the treatment group were asked to complete sentences in order to induce the specific processes of SRL. Findings from this study indicated that the directed, reflective prompts worked best for novice learners.

Duffy and Azevedo (2015) studied the effectiveness of an intelligent tutoring system on SRL and achievement in an undergraduate biology course. Embedded within the learning environment were places to write content summaries, make metacognitive judgments, take notes, evaluate content and activate prior knowledge. Learners were grouped according to their responses to the Achievement Goal Questionnaire (AGQ) i.e. mastery approach to learning or performance approach to learning. Learner achievement was measured by an overall post-test score. In this study, students with a performance approach to studying benefitted from the tutoring system.

Michalsky and Kramarski (2015) investigated Web-based question prompts in an undergraduate teacher preparation course. The prompts represented an acronym for a teaching model and consisted of introducing new concepts, metacognitive questioning, practicing, reviewing and reducing difficulties, obtaining mastery, verification and enrichment (IMPROVE). The IMPROVE model guided the development of the question prompts for two reflection types: (a) judgment; and (b) modification. Learners responded to the questions in the online forum where they would receive peer feedback and discuss. The task was to analyze a lesson plan. The questions, for example, consisted of:

1. What is the lesson about? Explain.
2. What is the lesson design? Explain.
3. What was done? Why? Explain.
4. What could be done differently? Explain.
5. What was the best/worst solution? Explain.
6. How can I modify the solution? Explain.

The findings of this study revealed that students who received the Web-based question prompts significantly outperformed students who did not.

Bellhäuser, Lösch, Winter and Schmitz (2016) studied the effects of a Web-based training (WBT) in SRL versus a learning diary in an online undergraduate mathematics major preparation course. The WBT consisted of weekly SRL lessons over a four-week span; the online diary consisted of daily entries such as goal-setting. Results of this study showed significant effects for WBT to foster students' SRL knowledge.

Zheng, Li and Chen (2018) examined the effectiveness of a mobile SRL system in an undergraduate English course. The system helped learners set goals, make plans, monitor learning processes, reflect and evaluate. After setting goals, learners could browse materials and complete tasks. The system provided analytics to both students and instructors on learning processes such as time on task and achievement. If learners did not achieve their goals, they could reset and try again. This study found that the SRL mobile system significantly improved learning achievement and SRL skills.

Chen and Su (2019) studied an electronic book system in an undergraduate course in information systems basics. The system promoted SRL strategies such as marking of reading passages where students believed further help would be needed. Analytic dashboards on the students' footprints were recorded for the purposes of understanding the student situation and performing instructor outreach such as offering appropriate learning activities. The results of this study indicated that students using the electronic book system demonstrated better academic achievement and were better able to apply SRL strategies.

Broadbent, Panadero and Fuller-Tyszkiewicz (2020) studied the effects of an SRL mobile diary application versus online SRL training on undergraduate students from a range of majors. This study was designed to extend the findings of Bellhäuser et al. (2016) and had four conditions: (a) SRL mobile application diary; (b) online SRL training; (c) SRL diary and SRL training; and (d) no intervention. The diary consisted of daily before and after study questions. The SRL training consisted of three sessions: (a) forethought; (b) performance; and (c) reflection. Overall, the findings revealed that a combined condition of SRL diary and SRL training led to greater student SRL intention.

Song, Hong and Oh (2021) analyzed students' computer programming processes in relation to SRL, computational thinking and learning performance in an undergraduate course for education majors. To measure students' SRL awareness, the MSLQ instrument was administered to all participants. Participants also received online, self-paced modules which instructed on software coding processes. Overall, the analysis showed an association between students' SRL awareness and their performance, specifically with regards to time spent on a coding task as measured by length of coding. Suggestions for further research in this study included systems that scaffold SRL within a learning task.

Khiat (2022) investigated the use of an automated time management system in an online, healthcare research certificate designed for post baccalaureate students. The time management intervention was deployed in the LMS and consisted of four components: (a) a visual representation of the study plan, timelines and due dates; (b) the use of adaptive release to break up content into manageable chunks of time; (c) a weekly email reminder regarding leaning goals to meet for that week; and (d) a weekly email acknowledging progress and any gaps in meeting learning goals. This study found that students in the intervention group, completed the content in a significantly shorter amount of time and had a higher probability of completing the course.

In summary, this systematic review of the literature yielded a total of 49 relevant studies about SRL in e-learning environments, providing educators with a rich and diverse research history to draw upon. Recurring themes and mechanisms in these studies include a number of connections to SRL models and theory, examples of SRL instruments as part of the study, a range of learning outcomes in conjunction with SRL interventions, examples of SRL scaffolding, details of SRL training, note taking tools, question prompts and information about technology use such as LMS. Major differences between these studies include the researchers' questions and focus for the studies and aspects of study design. In some studies, the researcher was interested in possible connections between learner awareness of SRL and successful learners whereas other studies examined SRL interventions. In addition, the studies vary according to the learning environment i.e. online or hybrid/Web-enhanced. Table 3 provides a summary breakdown of the studies.

Table 3

Summary of SRL Studies

Total	Online	Hybrid/Web-enhanced	SRL intervention
49	14	35	36

Note. Summary of SRL studies.

Chapter 2 - Study Focus

Research Objectives

There are two main objectives for this meta-analysis: (a) locate and synthesize empirical evidence from studies about SRL interventions in higher education for consideration by individuals who are engaged in designing, developing and delivering e-learning environments such as academic coaches, instructors, instructional designers, curriculum developers, instructional technologists, training specialists, retention counselors and learning support specialists: and (b) identify and describe the characteristics of the more successful SRL interventions to make it clear to educators as to which ones result in better learning outcomes for their students. I chose e-learning and higher education because this is the area I work in.

Research Questions and Hypotheses

Prior to embarking on this study, I published a journal article on SRL interventions with regard to higher education e-learning environments. This publication was mainly a review of the literature and I did not employ a systematic search nor did I analyze the effects. My work seemed incomplete and I was curious about what the defining features of the more effective SRL interventions might be. Having reviewed multiple studies during my literature review, I was able to formulate two hypotheses.

First, I hypothesize that the more effective SRL interventions will be associated with specific features such as the method of implementation. Second, I hypothesize that the effectiveness of the SRL interventions will be greater when more complex tasks compared to less complex tasks are used as the means of measuring the learning outcomes. Representation of a problem, for example, requires greater or more complex thinking skills than reading comprehension.

The research questions connected with these two hypotheses are as follows:

1. How are SRL interventions more or less connected to learning outcomes in higher education e-learning environments?
2. What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when these interventions are implemented as training, scaffolding or training with scaffolding?
3. What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when more complex means of measuring learning outcomes are used compared to when less complex means of measuring learning outcomes are used?
4. What are the defining characteristics of the more effective SRL interventions with regards to higher education e-learning environments?

Rationale

Theories and models about SRL are important to educators attempting to understand why some learners succeed and others have difficulty in a range of academic settings. Understanding SRL in e-learning environments is particularly important because there is much agreement in the literature that e-learning requires a higher degree of self-regulatory control than face-to-face learning (Biesinger & Crippen, 2010; Cennamo, Ross & Rogers, 2002; Dabbagh & Kitsantas, 2005; Moos & Azevedo, 2006; Puzziferro, 2008; Whipp & Chiarelli, 2004). For example, some learners may find the self-directed nature of e-learning difficult to manage. When learners fail to manage their studies, the consequences may include anxiety, underachievement, withdrawal or even academic failure. Furthermore, the literature indicates that the defining features of the interventions foster SRL to different degrees (Chang, 2007; Kauffman, 2004; Kauffman, Ge, Xie & Chen, 2008; Kauffman, Zhao & Yang, 2011; Santhanam, Sasidharan & Webster, 2008; Shen, Lee & Tsai, 2007). Therefore, it is also important for educators to understand the effect of the different types of SRL interventions that have been studied. Moreover, there is strong evidence that support for SRL in e-learning environments results in significantly higher learning outcomes (Bixler, 2007; Ge, Planas & Er, 2010; Kauffman, 2004; Kauffman et al., 2008; Kauffman et al., 2011; Lee, Lim & Grabowski, 2009; Michalsky & Kramarski, 2015; Rowe & Rafferty, 2013).

As educators strive to design better e-learning environments and improve learning outcomes, it seems relevant to garner a more comprehensive understanding of the effectiveness of the different types of SRL interventions that have been studied. There are prior meta-analyses that examined the effectiveness of SRL interventions on academic performance in e-learning environments. For example, Broadbent and Poon (2015) identified 12 studies from online, higher education and found time management, metacognition, effort regulation and critical thinking to be positively correlated with academic performance. Xu et al. (2022) identified 50 studies from online and blended environments in K-12 and higher education. The findings of this meta-analysis showed a moderate effect size (ES) of 0.630 on academic performance when SRL interventions were used. While these prior meta-analyses are excellent additions to the field, this present meta-analysis aims to make a unique contribution. A key difference with this meta-analysis is the comparison of academic performance by means of measuring learning outcomes i.e. more or less complex. Additionally, this meta-analysis reveals in detail the characteristics of the SRL interventions i.e. training, scaffolding or both. The above distinctive features of this meta-analysis are aimed at providing educators with: (a) rigorous evidence about which SRL interventions lead to the best outcome for the learner and; (b) options for how these interventions might be implemented.

Chapter 3 - Methodology

Why Meta-Analysis?

Meta-analysis goes beyond the question of statistical significance by providing a mechanism for calculating the effect size for each study and these effects sizes become the heart of the analysis when they are combined into a report and can be examined for patterns in the data. This is important because researchers sometimes misinterpret terms such as “not statistically significant” for a single study to mean that there is no effect and they have not come to this conclusion based on patterns in the data as none exist. In contrast, meta-analysis reveals the magnitude of each study in the context of a report by the means of pooling their effect sizes. By working with the effect size, researchers can identify patterns in the data such as variation across studies and the dispersion of the effects (Borenstein, Hedges, Higgins & Rothstein, 2009). This approach is especially helpful for determining which interventions were the most meaningful or important.

Educators have tremendous discretion on how to address SRL interventions in e-learning environments. Although some literature is available to assist in the selection of effective SRL interventions, limited information is available regarding which ones can be viewed as more effective. Furthermore, studies about SRL interventions are published in a wide array of journals, making the job of identifying and critically evaluating effective interventions difficult for most educators. With strong evidence that certain SRL interventions positively affect learning outcomes, it seems important that I investigate the relevant literature by means of a systematic search. Then, using meta-analysis, my aim is to pool the studies and address the below research questions.

1. How are SRL interventions more or less connected to learning outcomes in higher education e-learning environments?
2. What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when these interventions are implemented as training, scaffolding or training with scaffolding?
3. What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when more complex means of measuring learning outcomes are used compared to when less complex means of measuring learning outcomes are used?
4. What are the defining characteristics of the more effective SRL interventions with regards to higher education e-learning environments?

Overall, meta-analysis is a powerful technique for synthesizing evidence from multiple studies that is capable of providing insights into my research questions i.e. the effectiveness of SRL interventions. By using meta-analysis, I will have the ability to pool data from multiple studies, making it more efficient to formulate estimates and detect significant effects. Additionally, I should be able to identify sources of variability across studies such as characteristics of SRL interventions. This may help me understand why different studies produce different results and lead to the discovery of more effective SRL interventions.

Meta-Analysis Structure, Process and Procedures

This meta-analysis is structured in accordance with the recommended reporting standards set forth by the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (2009). Considered to be one of the most widely used and recognized standards for systematic reviews in healthcare, the PRISMA statement is also relevant to other discipline areas such as education and the social sciences. The PRISMA statement, which consists of a 27-item checklist and a four-phase flow diagram, focuses on how to ensure the complete reporting of systematic reviews and meta-analysis.

To understand the procedural aspects of meta-analysis in detail, I leveraged other sources such as Cochrane and the Campbell Collaboration. The Campbell Collaboration guidelines (2015) provide a range of resources and strategies for conducting a meta-analysis in regards to inclusion and exclusion criteria, data extraction and coding procedures, risk of bias and statistical procedures. In the "*Cochrane Handbook for Systematic Reviews*", Higgins et al. (2022) discuss eight steps for conducting a systematic review. These eight steps are: (a) define the review question and develop criteria for including studies; (b) search for studies; (c) select studies and collect data; (d) assess risk of bias in included studies; (e) analyze data and undertake meta-analyses; (f) address reporting biases; (g) present results and summary of findings; and (h) interpret results and draw conclusions.

To deeply understand the complexities of meta-analysis, the textbook by Borenstein et al. (2009) "*Introduction to Meta-Analysis*" provided an excellent resource for both basic and advanced topics such as addressing bias and heterogeneity, synthesizing data, avoiding common mistakes, addressing dependencies, using subgroups, interpreting variation in effect sizes across studies and conducting regression analysis.

The methodology that follows adheres to processes and procedures from Borenstein, Campbell, the Cochrane Collaboration and PRISMA as well as some additional prominent authors on systematic reviews.

Systematic Review of the Literature

A comprehensive literature search was conducted. Every reasonable effort was made to identify a robust sample of published and unpublished studies from 1998 (the approximate year of the inception of e-learning) onward that explicitly examined SRL interventions in higher education e-learning environments. According to Lipsey and Wilson (2000), the best literature search is one that includes every study that has a reasonable prospect of being eligible, but exercises restraint in adding low probability studies.

Search strategies recommended by Cooper (2016) and Lipsey and Wilson (2000) were used to inform the methods of the search process. According to Lipsey and Wilson (2000), the search process consists of two main parts. These parts are: (a) finding references to potentially eligible studies; and (b) obtaining full-text copies of those studies to screen and, if eligible, code for inclusion in the meta-analysis. Cooper (2016) offers updated strategies for Internet searching and networking through the use of social media channels that have emerged due to changes in the World Wide Web and human communication. Described below are the search strategies and sources that I used.

Electronic databases. Electronic databases searched included Academic Search Complete, Educational Resources Information Center

(ERIC), Journal Storage (JSTOR), ProQuest, ProQuest Conference Proceedings, ProQuest Dissertations and Theses Global and Psychological Abstracts (PsycInfo). These electronic databases were searched using the following key words: “self-regulated learning” OR “self-regulation” AND “higher education” OR “post-secondary education” AND “adaptive” OR “blended” OR “computer” OR “digital” OR “distance” OR “distributed” OR “e-learning” OR “hybrid” OR “hypermedia” OR “interactive” OR “intelligent” OR “multimedia” OR “online” OR “technology” OR “web”. Key words were entered as could be located in the title or the body of the text.

Professional networking. Cooper (2016) recommends that professional associations and professionals in the field of study be contacted as potential sources of relevant data. In accordance with these recommendations, Western Interstate Commission for Higher Education (WCET) and the Online Learning Consortium (OLC) were contacted for information pertaining to conference presentations as well as other leads for published and unpublished studies and for assistance in locating research conducted internationally. LinkedIn, a leading professional network on the Web, was used to locate relevant groups and individuals who may have information to share.

Hand searching. *American Journal of Distance Education, Australasian Journal of Educational Technology, Canadian Journal of Learning and Technology, European Journal of Open, Distance and E-Learning, International Journal of E-Learning and Distance Education, International Review of Research in Open and Distance Learning, Journal for Asynchronous Learning Networks, Journal of Educational Multimedia and*

Hypermedia, Journal of Learning Design, Journal of Online Learning Research, Journal of Online Learning and Teaching, International Journal of Instructional Technology, Online Learning Journal, Turkish Online Journal of Educational Technology and United Distance Education for Eastern Europe, Western Asia and Northern Africa were hand searched, as they were likely to contain relevant studies and were not indexed by databases.

Internet searching. Key word searches as stated earlier were conducted through Google Scholar. This method of searching was used to locate grey literature such as conference reports or dissertations that may not have been located in any of the electronic databases or found by hand searching.

Reference lists. Examination of the reference lists of relevant studies was performed continuously during all of the above search phases.

Inclusion and Exclusion Process

Criteria for inclusion of studies in the review. For this meta-analysis, an SRL intervention refers to a treatment that is designed to positively influence learning outcomes in higher education e-learning environments. Frequently studied interventions include providing training and/or scaffolding activities into the learning environment that prompt learners to follow SRL strategies and processes. Scaffolding is an instructional method for guiding and supporting learners to perform a specific activity as part of a learning situation. In general, SRL scaffolds prompt learners to become aware of and monitor their learning strategies. Training, by contrast, provides explicit instruction in the use of cognitive, metacognitive and motivational components of SRL.

A checklist to evaluate each study concerning SRL interventions in e-learning environments was used. To be included in this review, the study must have met the following criteria:

1. Explicitly employed an SRL intervention in an e-learning environment.
2. Subjects were higher education learners.
3. Used a randomized, controlled or balanced research design.
4. Reported a measure of learning outcomes for the experimental and control conditions.
5. Provided sufficient quantitative data to allow for the calculation of an effect size or could be requested from the author.
6. Available in English.

Screening and data reduction. The screening process consisted of reviewing the abstract of each study, applying the inclusion criteria and determining if the study should be excluded or included for further examination. A full text version of the studies to be included for further examination was retrieved and stored. When the same study was identified, duplicates were flagged and removed in the screening process by maintaining the record of the study that included the most relevant information. In compliance with the PRISMA rubric (2009), records were kept for the total number of studies screened, studies excluded, studies included and the number of studies that were located through databases vs. other sources. All citations for references identified in the literature search process were compiled in Microsoft Excel for ease of record keeping.

Coding Process

Coding was done independently by me and two associates; disagreements were discussed and resolved through consensus with a goal of 100% agreement. The coding instrument used was developed according to Lipsey and Wilson (2000) and used in an earlier meta-analysis by Bernard et al. (2009). Permission to use and modify the coding instrument was granted to me by Bernard. I developed the coding instrument to guide the process of recording information from each study. In Appendix A, the instrument is shown. Data was coded according to: (a) researcher; (b) type of publication; (c) learner characteristics; (d) country; (e) subject; (f) e-learning mode; (g) study design; and (h) SRL intervention characteristics.

Study design. Information about the methodological aspects of the studies was extracted. The quality rating system from the Scottish Intercollegiate Guidelines Network (SIGN) checklist (2015) was used to appraise study methods and design characteristics, such as randomization, similarity of the treatment and control groups at the start of the experiment and minimization of bias. In the SIGN system, studies are rated as to how well the methods are fulfilled using a coding system of “++” indicating that all or most of the criteria have been fulfilled, “+” indicating that some of the criteria have been fulfilled and “-” indicating that few or none of the criteria have been fulfilled.

Descriptive information about the treatment and control conditions was captured, including the types of SRL interventions and the means of measuring the learning outcomes. The control condition was generally without any treatment, but if any treatment was administered it was captured in the coding process. The treatment condition usually represented one or a combination of these three interventions: (a) SRL training; (b) SRL scaffolding; or (c) SRL training and scaffolding. Any interventions that were combined were categorized as such. For the means of measuring the learning outcomes, there were four main categories of assessments: (a) exams; (b) projects; (c) problem solving; and (d) written assignments. These assessments were then categorized into higher (more complex) or lower (less complex) order thinking skills based on the Anderson and Krathwohl revision (2001) of Bloom’s cognitive domain taxonomy (1956). The revised framework offers six cognitive processes in order of their complexity from less to more complex thinking skills. These processes are: (a) remember; (b) understand; (c) apply; (d) analyze; (e) evaluate; and (f) create. My thinking was that categorizing the interventions would allow me to combine effect sizes within groups of constructs that were similar.

Addressing bias. Higgins et al. (2022) discuss two key areas for which bias should be considered: (a) the actions of the primary study investigators; and; (b) the actions of the author(s) of the systematic review. For these two distinctions, judgements are necessary making it important to have mechanisms in place for deciding which studies to include and which to exclude (Borenstein et al., 2009). Prior to beginning my search for studies, I created explicit criteria for inclusion so that the studies would be similar enough to yield results that could be understood. I worked with two other associates during the coding and inclusion decision making phases. In the search phase, one associate assisted me, especially with locating grey literature (unpublished or missing studies). In Borenstein et al. (2009) "*Introduction to Meta-Analysis*", the issue of missing studies is covered at length. The specific issue is that the studies that report insignificant results are less likely to be published making them difficult to locate. For example, conference papers and dissertations are more difficult to locate as are journal articles that are not indexed by electronic databases. In order to address the issue of publication bias, I did not rely on locating literature from solely electronic databases and I made every reasonable effort to locate unpublished studies as described in the section of this thesis about searching strategies.

Finally, I used the functions in Comprehensive Meta-Analysis software (CMA) [version 3.0] to address the possibility that the results might be affected by publication bias. There are a range of methods to test for bias in CMA such as Duval and Tweedie's Trim and Fill, Begg and Mazumdar's Rank Correlation, Egger's Linear Regression, Rosenthal's Fail-safe N and Orwin's Fail-safe N. The funnel plot by precision is the traditional form that is used in conjunction with all of these methods (Borenstein et al., 2009). For example, Trim and Fill builds on the concept behind the funnel plot; this procedure imputes the missing studies and re-computes the overall effect size. In a traditional funnel plot, large studies appear toward the top of the graph and tend to group around the mean effect size whereas smaller studies appear towards the bottom of the graph (Borenstein et al., 2009). In the presence of bias, the bottom of the graph would show a higher concentration of studies on one side of the mean and would not be distributed symmetrically about the combined effect size (Borenstein et al., 2009). When asymmetry is present in the funnel plot, researchers may consider reasons beyond missing studies such as heterogeneity (Higgins et al., 2022)

Statistical Procedures

Effect size calculation. To evaluate the effectiveness of an intervention, individual effect sizes were calculated using Hedges's g by dividing the difference between the learning outcomes mean scores between the experimental group and the control group by the pooled standard deviation and then multiplying the result by a correction factor. This correction factor removes a small positive bias affecting the calculation of the effect size (Borenstein et al., 2009).

In the numerator, $M_{EG\ and}\ M_{CG}$ are the sample means of the two groups. In the denominator, the within-group standard deviation is pooled across groups. The terms in the below calculation are represented by the following: M= mean; EG=experimental group; CG=control group; n =number of study subjects; and s = standard deviation and df =degrees of freedom.

$$g = \frac{M_{EG} - M_{CG}}{\sqrt{\frac{(n_{EG}-1){s^2}_{EG} + (n_{EG}-1){s^2}_{CG}}{n_{EG}+n_{CG}-2}}} 1 - \frac{3}{4df-1}$$

When studies did not report means and standard deviations, effect sizes can be calculated from other indicators of treatment effects using appropriate transformations such as t-values, F-ratios and *p*-values (Borenstein et al., 2009).

If studies included more than one intervention, every comparison of an intervention group with a control group was treated as a separate study as shown by example in Figure 12 (Borenstein et al., 2009).

Figure 12

Example Studies with One or More Interventions

Study name	Title
Anderton (2005)	An evaluation of strategies to promote self-regulated learning in pre-service teachers in an online class
Azevedo & Cromley (2004) a	Does training on self-regulated learning facilitate students' learning with hypermedia?
Azevedo & Cromley (2004) b	Does training on self-regulated learning facilitate students' learning with hypermedia?
Azevedo & Cromley (2004) c	Does training on self-regulated learning facilitate students' learning with hypermedia?
Bannert & Reimann (2012) a	Supporting self-regulated hypermedia learning through prompts
Bannert & Reimann (2012) b	Supporting self-regulated hypermedia learning through prompts

Note. Example of studies with one or more interventions.

Statistical analyses. According to Borenstein et al. (2009), most meta-analyses use one of two statistical models, the fixed effect model or the random effects model. In the fixed effect model, it is assumed that there is one true effect size and that all of the comparisons included in the analysis are identical (Borenstein et al., 2009). In contrast, the random effects model controls for variation from study to study e.g. sample size (Borenstein et al., 2009). That is, the weights under the random effects model are more balanced i.e. small studies are less likely to be marginalized and large studies are less likely to be given more weight (Borenstein et al., 2009). Because there were differences between the studies, the method of statistical analysis I used for this meta-analysis is the random effects model.

Addressing heterogeneity. Under the random effects model, it is still best practice to investigate and describe heterogeneity if it is present (Borenstein et al., 2009). According to Borenstein et al. (2009), there are five main ways of measuring heterogeneity, Q, p, T^2, T and I^2. All of these measures of heterogeneity build on Q; however, each measure is useful for a specific purpose. For example, I^2 has the advantage of not being directly affected by the number of studies and allows us to view the variance on a relative scale (Borenstein et al., 2009). Higgins et al. (2022) provide some guidelines for benchmarking I^2, proposing that values of 25%, 50% and 75% might be considered as low, moderate and high heterogeneity, respectively. When heterogeneity is substantial, it is important to check for outliers amongst the studies. Outliers could simply be a data entry mistake or calculation error. In some cases, effect sizes may need to be examined for pre-test differences if significant differences exist between the groups before the start of the intervention (Borenstein et al., 2009). These types of outliers may hint at bias or lead to investigation of subgroups which could be used to describe the variation (Borenstein et al., 2009). For this thesis, I ran heterogeneity tests for the total of the studies and for subgroups. I examined outliers and the possible causes.

Addressing dependencies. Another important factor in performing meta-analysis is to account for dependencies in studies with multiple outcomes (Borenstein et al., 2009). Studies with multiple outcomes and dependencies (the same participants) cannot be treated as independent samples as this could inflate the variance of the effect size giving studies more weight (Borenstein et al., 2009). For the studies with dependencies, I configured CMA to assume dependence.

Ethics

This meta-analysis used precautions and procedures in order to mitigate ethical issues and uphold my responsibilities to stake holders, potential beneficiaries and the community of educational researchers. First, meta-analysis is a form of secondary data analysis and normally does not involve contributing participants. According to the British Educational Research Association (BERA, 2018), researchers must ensure that participant data is anonymized. None of the studies in this meta-analysis revealed the identity of the participants. Second, I followed a widely accepted and rigorous protocol for conducting meta-analyses from the "*Cochrane Handbook for Systematic Reviews*". In this handbook, Higgins et al. (2022) provide best practices and procedures including: (a) addressing a need that will provide decision makers with relevant information; (b) using pre-specified research questions and methods; (c) working with a team; (d) using good data management, project management and quality assurance mechanisms; and (e) making every reasonable effort to ensure completeness of reporting. With regard to working with a team, the role of the two associates was to assist me with the systematic search and participate in the inclusion/exclusion process. Associates were graduate students working with me on a number of projects related to online courses. For this arrangement, I guided students to make decisions based on objectivity, particularly for the inclusion/exclusion stage. That is, I do not believe students' decisions for inclusion/exclusion were affected by my working relationship with them.

Note. Formal ethical approval for this research was not required by Durham University as it did not involve contributing participants.

Approach

Meta-analysis, the methodology selected for this thesis, is a good fit for educational psychology research because it offers an approach for making assumptions about the effectiveness of interventions from both quantitative and qualitative information across a pool of studies. From the quantitative data, I was able to calculate an overall effect size. The overall effect was a helpful starting point, but the most insightful information was revealed through further investigation through the use of subgroups for the purpose of identifying which SRL interventions were more or less effective. The data set naturally lent itself to subgroups i.e. SRL training, scaffolding or both and more or less complex means of measuring the learning outcomes. From the subgroup quantitative data, I was able to see patterns by comparing the SRL interventions' effect sizes across the groupings. This stage of the meta-analysis prompted me to think about implications. Which types of SRL interventions lead to the best outcomes for the learners? At this point, I could generally determine which types of SRL interventions were more effective by looking at the subgroup data. However, I wasn't able to make further assumptions until taking a closer look at the design characteristics of the SRL interventions, the qualitative information. Through investigation of the design features from the more effective studies, I began to conceptualize how educators might implement SRL interventions. Which interventions are worth implementing and what design recommendations would I make?

Chapter 4 - Findings

Here I present the findings from the 36 studies that addressed the effectiveness of SRL interventions on learning outcomes in higher education e-learning environments. I begin with a descriptive overview of my systematic search process because it is important to document this in regard to compliance with recommended reporting standards. I then provide information on my data entry and checking process. Although time-intensive, keeping excellent records is a critical component of meta-analysis. Finally, I provide the overall effect size and effect sizes for the subgroups: (a) scaffolding; (b) training; (c) training and scaffolding; (d) more complex means of measuring the learning outcomes; and (e) less complex means of measuring the learning outcomes. For each effect size, I provide tests of heterogeneity. Additionally, I provide tests for regression and bias.

Systematic Search

This meta-analysis is structured in accordance with the recommended reporting standards set forth by PRISMA. The phases of this process are described below.

In the Identification phase, my two main databases were ProQuest Dissertations and Academic Search Complete. In the beginning of the systematic search, I contacted Academic Search Complete to obtain a list of their data partners and found that their database indexed most of the sources I planned to use except for dissertations. I made certain that this was the case by searching within JSTOR and ERIC, for example, and then searching for the same studies in Academic Search Complete. Consolidating searches to a few key databases is a helpful strategy for meta-analysis and I was fortunate to avail myself of this technology. Still there were some journals that were not indexed, so I hand searched these journals. I also hand searched reference lists within studies and I used Google Scholar because it is more likely to index grey literature such as unpublished presentations and dissertations.

Google Scholar is a search engine with limited filtering capability, so I made a decision in the screening phase to read the abstracts of the first 350 of the thousands of records returned by Google. Beyond 350, the studies seemed to stray from my subject of interest. I used the same approach for dissertations because the ProQuest database filters were also not that robust. With Academic Search Complete, I screened all of the abstracts because I was able to leverage filters in the database such as “age group” or “quantitative study” to hone my search. I found that even the studies at the end of the list in Academic Search Complete appeared relevant. I also screened all of studies located by hand searching because they were high contenders for inclusion. Of the 1215 studies from the screening phase, 1112 were excluded, leaving 101 to be accessed via full-text and examined for eligibility. I stored the 101 studies along with my other thesis files so that all could be backed up and secured. I also entered each of these studies in Excel.

In the eligibility phase, 65 studies were excluded for one of the following reasons: (a) not e-learning; (b) not higher education with credit bearing; (c) no measure of learning outcomes; (d) no treatment and control groups (e) no SRL intervention; or (f) duplicate study. Figure 13 shows an example of how I documented the reasons for exclusion for each of the 65 studies. When a study did not meet an inclusion criterion “no”, it was not eligible. As shown in Figure 14, the final number of studies in this meta-analysis is 36. I stored these 36 studies separately from the 65 studies that I had accessed so that I could refer back to these final studies throughout my analysis. I also entered these studies in Excel.

Figure 13

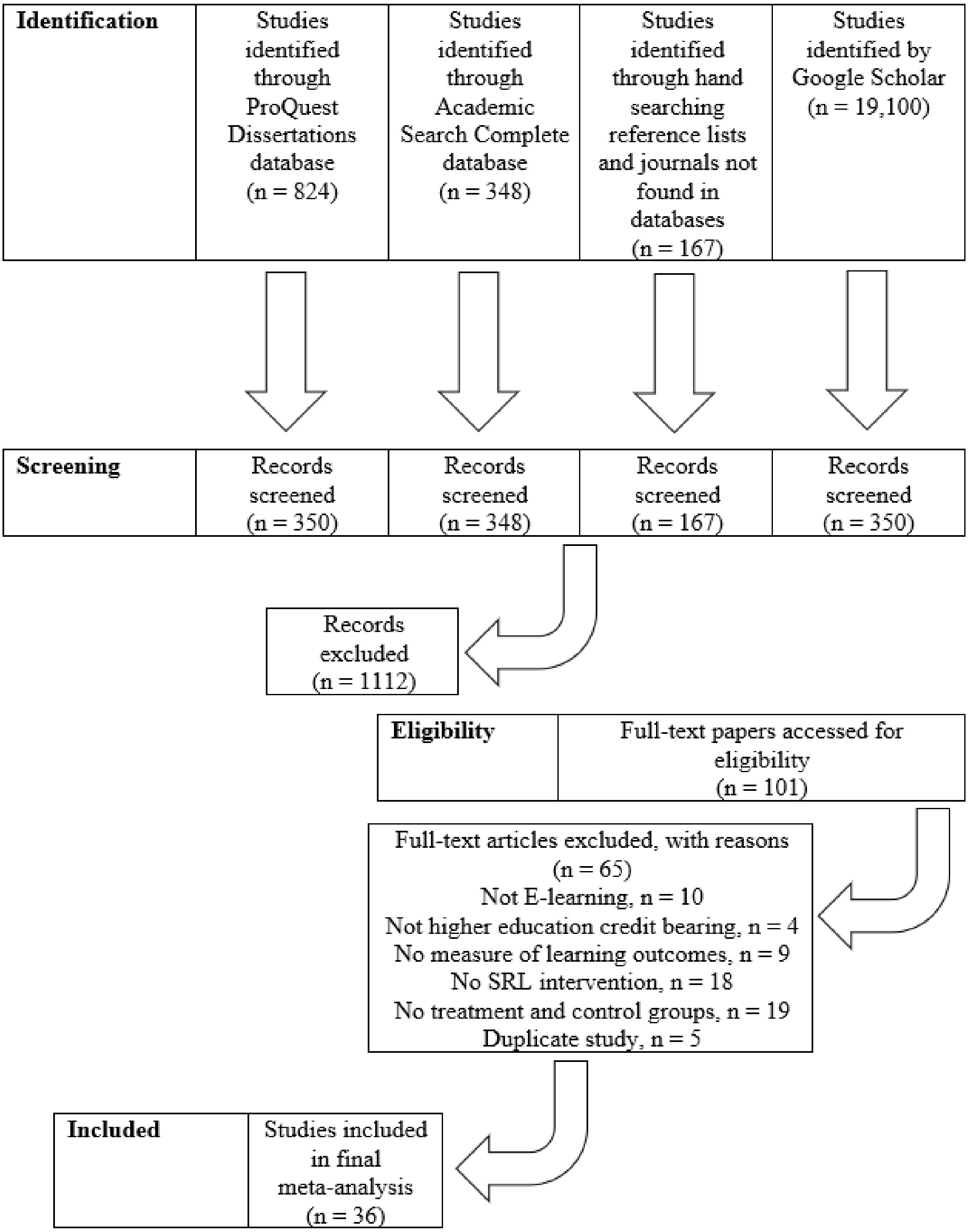
Eligibility Phase

Author(s)	Year	Title	E-learning	Postsecondary	Measures outcomes	Treatment and control group	Self-regulated learning intervention	Duplicate	Include
Williams & Hellman	2004	Difference in self-regulation for online learning between first- and second-generation college students					No		No
Yang	2006	Effects of embedded strategies on promoting the use of self-regulated learning strategies in an online learning environment			No				No
Anderton	2005	An evaluation of strategies to promote self-regulated learning in pre-service teachers in an online class							Yes
Azevedo & Cromley	2004	Does training on self-regulated learning facilitate students' learning with hypermedia?							Yes

Note. Example of documenting eligibility phase.

Figure 14

PRISMA Diagram



Note. Flow chart of the systematic search process.

Data Entry and Checking

Following the eligibility phase, studies identified for inclusion were then examined to extract quantitative data for the learning outcomes. Although the coding sheets captured the quantitative data, I returned to each of the 36 studies to check for accuracy. I also made sure to retrieve the data for any studies that had more than one intervention. For each intervention, I coded the type of SRL intervention and the means of measuring the learning outcomes. This data was then entered into Excel for ease of checking prior to importing into CMA. Once the data from the 36 studies was entered in Excel, I checked the data against the studies one more time. During testing, I found two data entry errors and corrected these. I then brought the data into CMA and ran some preliminary tests to detect outliers.

Meta-Analysis Findings

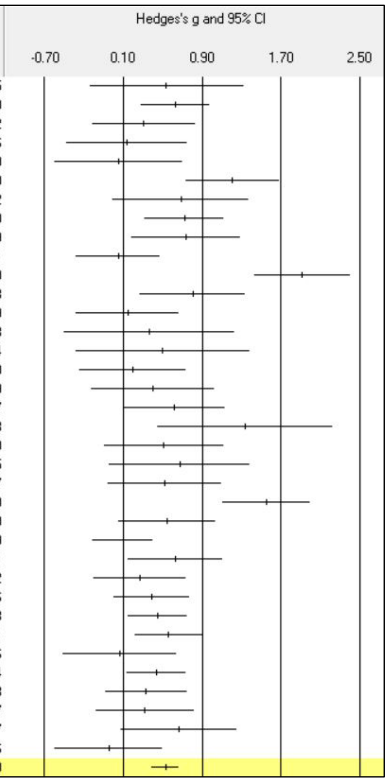
In this section, I provide the overall effect size and the subgroup effect sizes for (a) scaffolding; (b) training; (c) training and scaffolding; (d) more complex means of measuring the learning outcomes; and (e) less complex means of measuring the learning outcomes. For each effect size, I provide statistical tests of heterogeneity. Additionally, I provide statistical tests for regression and bias.

As shown in Figure 15, the overall effect size for SRL interventions is 0.531. Figure 16 is an enlarged version of Figure 15.

Figure 15

Overall Random Effects Model for Self-Regulated Learning Interventions

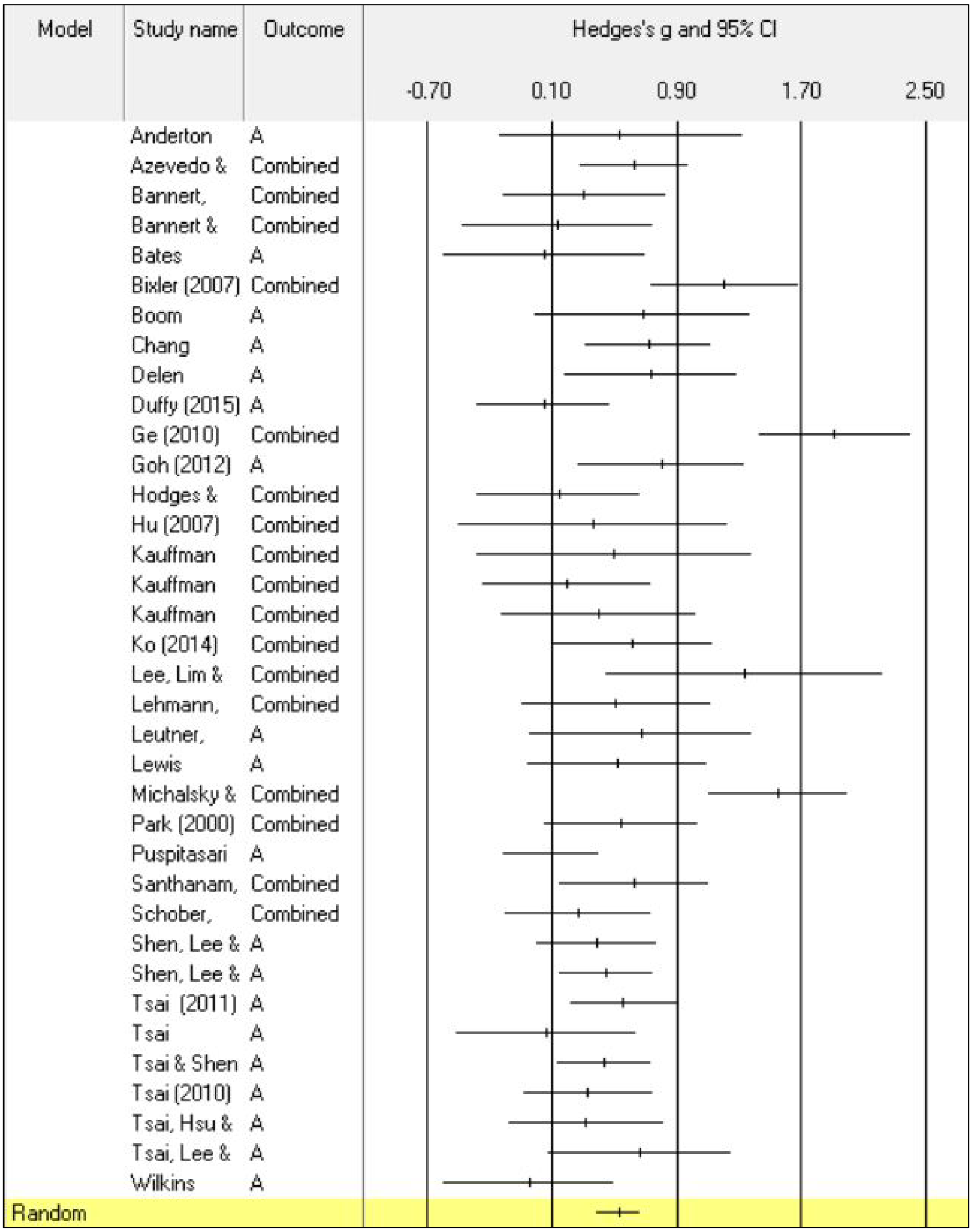
Model	Study name	Outcome	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Anderton	A	0.538	0.397	0.158	-0.240	1.317	1.356	0.175
	Azevedo &	Combined	0.634	0.178	0.032	0.284	0.983	3.552	0.000
	Bannert,	Combined	0.304	0.266	0.071	-0.216	0.825	1.145	0.252
	Bannert &	Combined	0.135	0.312	0.097	-0.477	0.747	0.432	0.666
	Bates	A	0.050	0.331	0.109	-0.598	0.698	0.151	0.880
	Bixler (2007)	Combined	1.211	0.243	0.059	0.734	1.688	4.976	0.000
	Boom	A	0.684	0.351	0.123	-0.005	1.373	1.947	0.052
	Chang	A	0.721	0.206	0.043	0.317	1.125	3.495	0.000
	Delen	A	0.737	0.283	0.080	0.183	1.291	2.605	0.009
	Duffy (2015)	A	0.049	0.218	0.047	-0.378	0.477	0.227	0.821
	Ge (2010)	Combined	1.916	0.248	0.061	1.431	2.402	7.733	0.000
	Goh (2012)	A	0.811	0.274	0.075	0.274	1.348	2.960	0.003
	Hodges &	Combined	0.144	0.266	0.071	-0.378	0.666	0.540	0.589
	Hu (2007)	Combined	0.368	0.440	0.193	-0.494	1.230	0.837	0.403
	Kauffman	Combined	0.502	0.450	0.202	-0.379	1.383	1.116	0.264
	Kauffman	Combined	0.194	0.274	0.075	-0.344	0.731	0.706	0.480
	Kauffman	Combined	0.399	0.317	0.101	-0.223	1.021	1.257	0.209
	Ko (2014)	Combined	0.622	0.261	0.068	0.112	1.133	2.388	0.017
	Lee, Lim &	Combined	1.336	0.453	0.205	0.449	2.223	2.953	0.003
	Lehmann,	Combined	0.507	0.308	0.095	-0.097	1.111	1.646	0.100
	Leutner,	A	0.675	0.366	0.134	-0.042	1.392	1.845	0.065
	Lewis	A	0.523	0.295	0.087	-0.056	1.101	1.771	0.077
	Michalsky &	Combined	1.550	0.226	0.051	1.106	1.994	6.847	0.000
	Park (2000)	Combined	0.549	0.252	0.064	0.054	1.043	2.176	0.030
	Puspitasari	A	0.097	0.158	0.025	-0.213	0.406	0.614	0.539
	Santhanam,	Combined	0.630	0.246	0.061	0.147	1.113	2.557	0.011
	Schober,	Combined	0.273	0.238	0.057	-0.194	0.739	1.146	0.252
	Shen, Lee &	A	0.389	0.195	0.038	0.007	0.771	1.998	0.046
	Shen, Lee &	A	0.449	0.152	0.023	0.151	0.746	2.954	0.003
	Tsai (2011)	A	0.563	0.173	0.030	0.224	0.903	3.251	0.001
	Tsai	A	0.061	0.293	0.086	-0.514	0.635	0.207	0.836
	Tsai & Shen	A	0.437	0.153	0.024	0.136	0.737	2.849	0.004
	Tsai (2010)	A	0.334	0.211	0.045	-0.079	0.748	1.585	0.113
	Tsai, Hsu &	A	0.321	0.255	0.065	-0.178	0.820	1.262	0.207
	Tsai, Lee &	A	0.664	0.301	0.091	0.074	1.255	2.205	0.027
	Wilkins	A	-0.047	0.278	0.078	-0.593	0.499	-0.169	0.866
Random			0.531	0.070	0.005	0.393	0.670	7.544	0.000



Note. Random effects model for all included studies.

Figure 16

Overall Random Effects Model for Self-Regulated Learning Interventions Enlarged



Note. Random effects model for all included studies shown in enlarged view.

In Figure 17, the heterogeneity is shown for the fixed effect model. Heterogeneity is the extent of the dispersion or spread of the effects and the p-value and I-squared indicate to what extent this is larger than would be expected for a set of similar studies. In this case, the heterogeneity is moderate (an I-square of 65%), indicating that there may well be features of the included studies that could be used to explain this variation (Borenstein et al., 2009).

Figure 17

Heterogeneity for All Studies

Heterogeneity			
Q-value	df (Q)	P-value	I-squared
99.109	35	0.000	64.685

Note. Heterogeneity for all included studies under the fixed effect model.

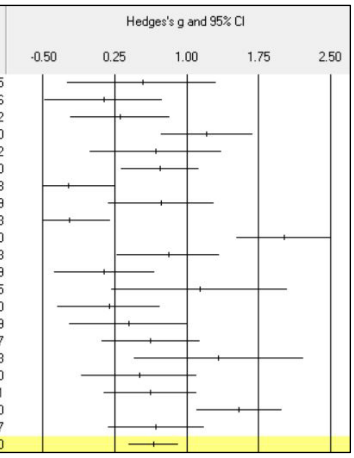
In the next phase of this meta-analysis, I organized the interventions by subgroups using the characteristics that I captured in the coding process. The subgroups are as follows: (a) scaffolding; (b) training; (c) scaffolding and training; (d) more complex; and (e) less complex. These subgroups align to my research questions.

The overall effect size for scaffolding is 0.652 as shown in Figure 18. Figure 19 is an enlarged version of Figure 18.

Figure 18

Overall Random Effects Model for Self-Regulated Learning Interventions with Scaffolding

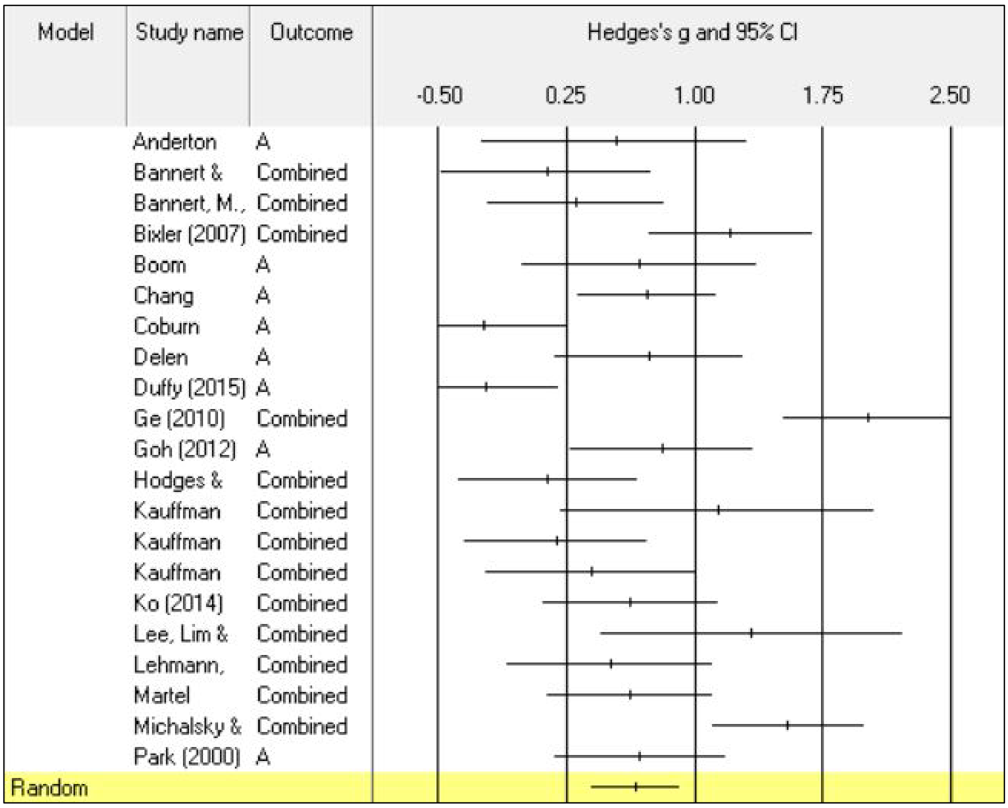
Model	Study name	Outcome	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Anderton	A	0.538	0.397	0.158	-0.240	1.317	1.356	0.175
	Bannert &	Combined	0.135	0.312	0.097	-0.477	0.747	0.432	0.666
	Bannert, M.,	Combined	0.304	0.266	0.071	-0.216	0.825	1.145	0.252
	Bixler (2007)	Combined	1.211	0.243	0.059	0.734	1.688	4.976	0.000
	Boom	A	0.684	0.351	0.123	-0.005	1.373	1.947	0.052
	Chang	A	0.721	0.206	0.043	0.317	1.125	3.495	0.000
	Coburn	A	-0.230	0.256	0.065	-0.732	0.271	-0.901	0.368
	Delen	A	0.737	0.283	0.080	0.183	1.291	2.605	0.009
	Duffy (2015)	A	-0.221	0.219	0.048	-0.649	0.208	-1.009	0.313
	Ge (2010)	Combined	2.015	0.253	0.064	1.519	2.511	7.969	0.000
	Goh (2012)	A	0.811	0.274	0.075	0.274	1.348	2.960	0.003
	Hodges &	Combined	0.144	0.266	0.071	-0.378	0.666	0.540	0.589
	Kauffman	Combined	1.137	0.468	0.219	0.220	2.054	2.429	0.015
	Kauffman	Combined	0.194	0.274	0.075	-0.344	0.731	0.706	0.480
	Kauffman	Combined	0.399	0.317	0.101	-0.223	1.021	1.257	0.209
	Ko (2014)	Combined	0.622	0.261	0.068	0.112	1.133	2.388	0.017
	Lee, Lim &	Combined	1.336	0.453	0.205	0.449	2.223	2.953	0.003
	Lehmann,	Combined	0.507	0.308	0.095	-0.097	1.111	1.646	0.100
	Martel	Combined	0.626	0.247	0.061	0.142	1.110	2.536	0.011
	Michalsky &	Combined	1.550	0.226	0.051	1.106	1.994	6.847	0.000
	Park (2000)	A	0.682	0.255	0.065	0.183	1.181	2.677	0.007
Random			0.652	0.131	0.017	0.394	0.909	4.957	0.000



Note. Random effects model for included studies coded with scaffolding.

Figure 19

Overall Random Effects Model for Self-Regulated Learning Interventions with Scaffolding Enlarged



Note. Random effects model for all included studies with scaffolding shown in enlarged view.

In Figure 20, the heterogeneity is shown for all of the studies with scaffolding under the fixed effect model. In this case, the heterogeneity is moderate (an I-square of 69%), indicating that there may well be features of the included studies that could be used to explain this variation (Borenstein et al., 2009).

Figure 20

Heterogeneity for All Studies with Self-Regulated Learning Intervention with Scaffolding

Heterogeneity			
Q-value	df (Q)	P-value	I-squared
61.857	19	0.000	69.284

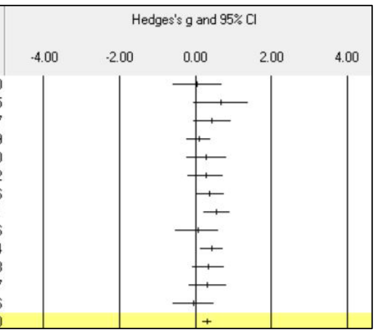
Note. Heterogeneity for all included studies with scaffolding under the fixed effect model.

The overall effect size for training is 0.318 as shown in Figure 21. Figure 22 is an enlarged version of Figure 21.

Figure 21

Overall Random Effects Model for Self-Regulated Learning Interventions with Training

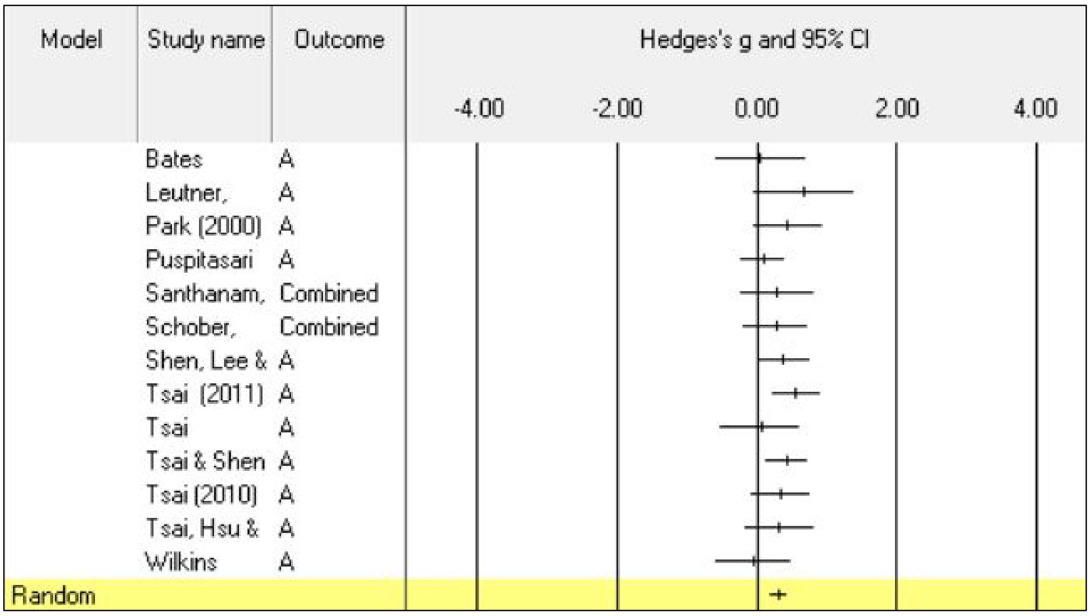
Model	Study name	Outcome	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Bates	A	0.050	0.331	0.109	-0.598	0.698	0.151	0.880
	Leutner,	A	0.675	0.366	0.134	-0.042	1.392	1.845	0.065
	Park (2000)	A	0.444	0.251	0.063	-0.047	0.935	1.771	0.077
	Puspitasari	A	0.097	0.158	0.025	-0.213	0.406	0.614	0.539
	Santhanam,	Combined	0.298	0.265	0.070	-0.221	0.817	1.126	0.260
	Schober,	Combined	0.273	0.238	0.057	-0.194	0.739	1.146	0.252
	Shen, Lee &	A	0.389	0.195	0.038	0.007	0.771	1.998	0.046
	Tsai (2011)	A	0.563	0.173	0.030	0.224	0.903	3.251	0.001
	Tsai	A	0.061	0.293	0.086	-0.514	0.635	0.207	0.836
	Tsai & Shen	A	0.437	0.153	0.024	0.136	0.737	2.849	0.004
	Tsai (2010)	A	0.334	0.211	0.045	-0.079	0.748	1.585	0.113
	Tsai, Hsu &	A	0.321	0.255	0.065	-0.178	0.820	1.262	0.207
	Wilkins	A	-0.047	0.278	0.078	-0.593	0.499	-0.169	0.866
Random			0.318	0.061	0.004	0.199	0.438	5.223	0.000



Note. Random effects model for all included studies with training.

Figure 22

Overall Random Effects Model for Self-regulated Learning Interventions with Training Enlarged



Note. Random effects model for all oincluded studies with training shown in enlarged view.

In Figure 23, the heterogeneity is shown for all of the studies with training under the fixed effect model. In this case, the heterogeneity is only as great as would be expected for a similar set of studies. The p-value is not significant and the I-square is 0%. This indicates that a similar set of studies has been identified and the adoption of training reduces the variability of impact for these interventions (Borenstein et al., 2009).

Figure 23

Heterogeneity for All Studies with Self-Regulated Learning Interventions with Training

Heterogeneity			
Q-value	df (Q)	P-value	I-squared
9.099	12	0.694	0.000

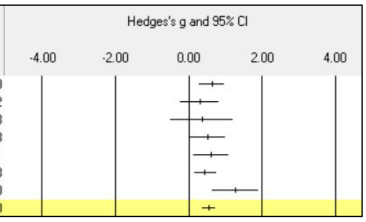
Note. Heterogeneity for all included studies with training under the fixed effect model.

The overall effect size for training and scaffolding is 0.568 as shown in Figure 24. Figure 25 is an enlarged version of Figure 24.

Figure 24

Overall Random Effects Model for Self-Regulated Learning Interventions with Training and Scaffolding

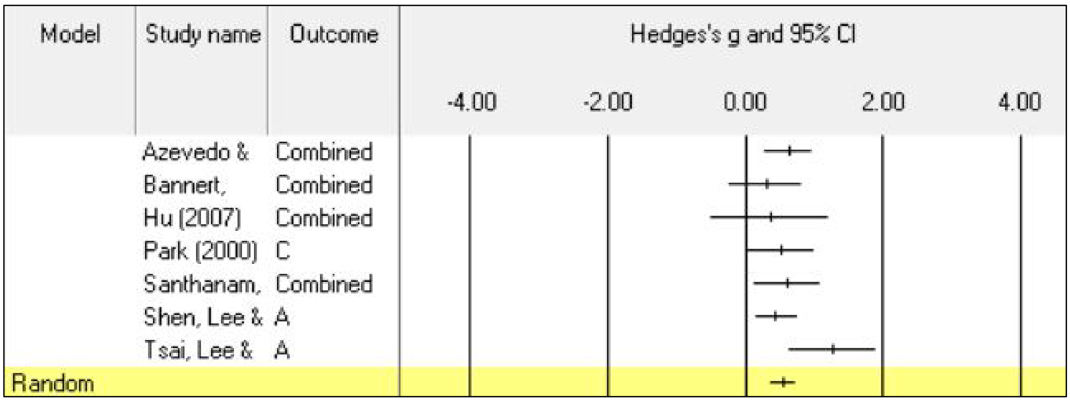
Model	Study name	Outcome	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Azevedo &	Combined	0.634	0.178	0.032	0.284	0.983	3.552	0.000
	Bannert,	Combined	0.304	0.266	0.071	-0.216	0.825	1.145	0.252
	Hu (2007)	Combined	0.368	0.440	0.193	-0.494	1.230	0.837	0.403
	Park (2000)	C	0.521	0.252	0.063	0.028	1.015	2.071	0.038
	Santhanam,	Combined	0.630	0.246	0.061	0.147	1.113	2.557	0.011
	Shen, Lee &	A	0.449	0.152	0.023	0.151	0.746	2.954	0.003
	Tsai, Lee &	A	1.276	0.322	0.104	0.644	1.908	3.958	0.000
Random			0.568	0.094	0.009	0.384	0.753	6.032	0.000



Note. Random effect size for al included studies with training and scaffolding.

Figure 25

Overall Random Effects Model for Self-Regulated Learning Interventions with Training and Scaffolding Enlarged



Note. Random effects model for all included studies with training and scaffolding shown in enlarged view.

In Figure 26, the heterogeneity is shown for all included studies with training and scaffolding under the fixed effect model. Although in this case the heterogeneity is not significant (p = 0.334), the I-squared shows that it is present (I-Squared = 12.6%) suggesting that there are some differences between the training and scaffolding studies which might be explained by other factors (Borenstein et al., 2009).

Figure 26

Heterogeneity for All Studies with Self-regulated Learning Interventions Training and Scaffolding

Heterogeneity			
Q-value	df (Q)	P-value	I-squared
6.861	6	0.334	12.554

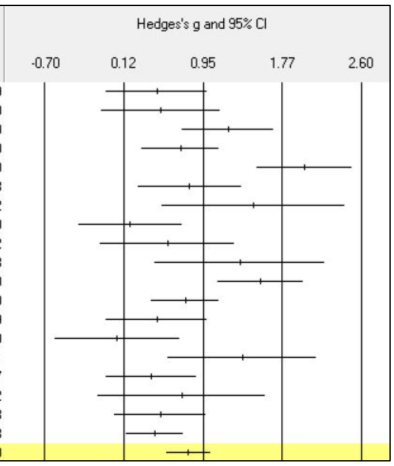
Note. Heterogeneity for all studies with training and scaffolding under the fixed effect model.

The overall effect size for more complex means of measuring the learning outcomes is 0.800 as shown in Figure 27. Figure 28 is an enlarged version of Figure 27.

Figure 27

Overall Random Effects Model for Studies with More Complex Means of Measuring Learning Outcomes

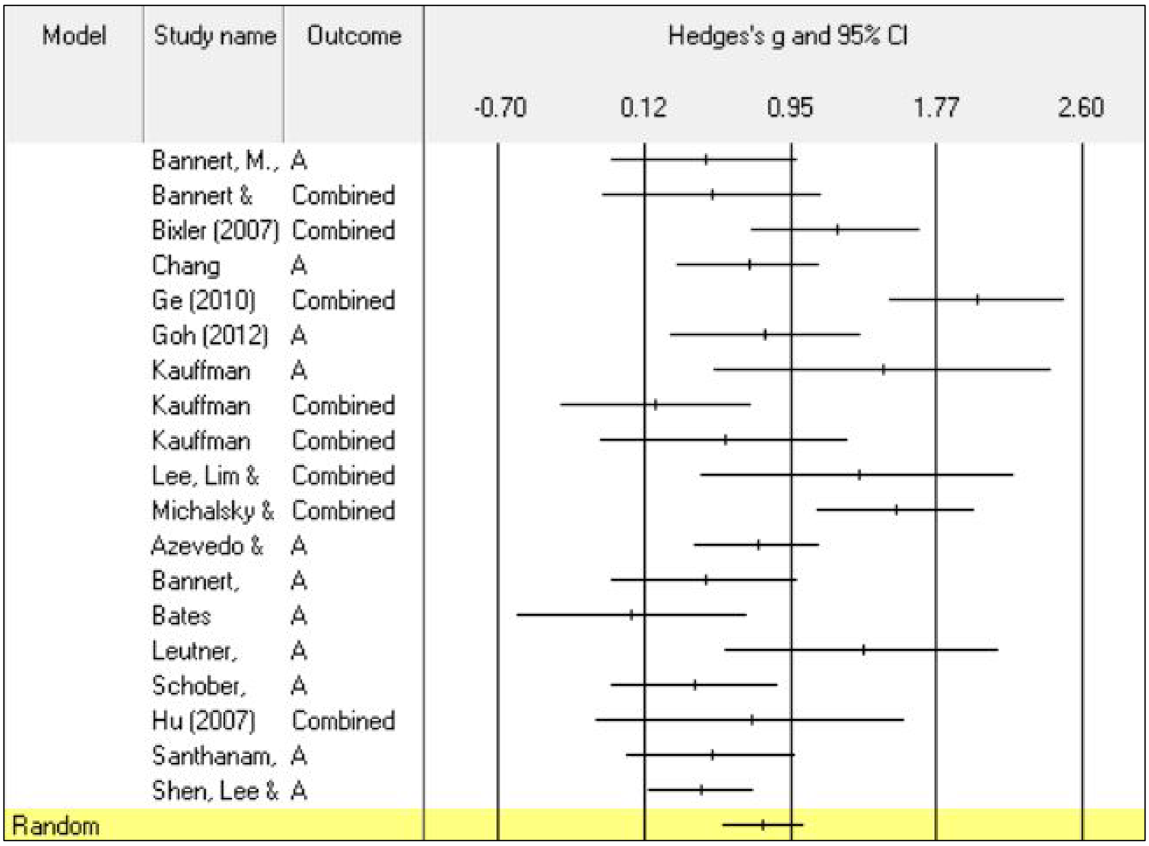
Model	Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Bannert, M.,	A	0.470	0.267	0.072	-0.054	0.994	1.758	0.079
	Bannert &	Combined	0.504	0.315	0.099	-0.114	1.122	1.600	0.110
	Bixler (2007)	Combined	1.211	0.243	0.059	0.734	1.688	4.976	0.000
	Chang	A	0.721	0.206	0.043	0.317	1.125	3.495	0.000
	Ge (2010)	Combined	2.015	0.253	0.064	1.519	2.511	7.969	0.000
	Goh (2012)	A	0.811	0.274	0.075	0.274	1.348	2.960	0.003
	Kauffman	A	1.477	0.488	0.238	0.521	2.434	3.028	0.002
	Kauffman	Combined	0.194	0.274	0.075	-0.344	0.731	0.706	0.480
	Kauffman	Combined	0.582	0.356	0.127	-0.116	1.279	1.634	0.102
	Lee, Lim &	Combined	1.336	0.453	0.205	0.449	2.223	2.953	0.003
	Michalsky &	Combined	1.550	0.226	0.051	1.106	1.994	6.847	0.000
	Azevedo &	A	0.769	0.180	0.032	0.415	1.122	4.265	0.000
	Bannert,	A	0.470	0.267	0.072	-0.054	0.994	1.758	0.079
	Bates	A	0.050	0.331	0.109	-0.598	0.698	0.151	0.880
	Leutner,	A	1.360	0.396	0.157	0.584	2.137	3.433	0.001
	Schober,	A	0.408	0.239	0.057	-0.060	0.877	1.709	0.087
	Hu (2007)	Combined	0.730	0.446	0.199	-0.145	1.604	1.636	0.102
	Santhanam,	A	0.508	0.244	0.060	0.029	0.986	2.079	0.038
	Shen, Lee &	A	0.449	0.152	0.023	0.151	0.746	2.954	0.003
Random			0.800	0.118	0.014	0.568	1.032	6.769	0.000



Note. Random effects model size for all included studies with more complex means of measuring learning outcomes.

Figure 28

Overall Random Effects Model for Studies with More Complex Means of Measuring Learning Outcomes Enlarged



Note. Random effects model for all included studies with more complex means of measuring learning outcomes shown in enlarged view.

In Figure 29, the heterogeneity is shown for all the studies with more complex means of measuring the learning outcomes under the fixed effect model. In this case, the heterogeneity is significant (p = 0.00) and large (I-squared = 70.6%) suggesting that these studies may differ from each other other than the characteristic of having more complex means of measuring outcomes (Borenstein et al., 2009).

Figure 29

Heterogeneity for All Studies with More Complex Means of Measuring Learning Outcomes

Heterogeneity			
Q-value	df (Q)	P-value	I-squared
64.711	19	0.000	70.639

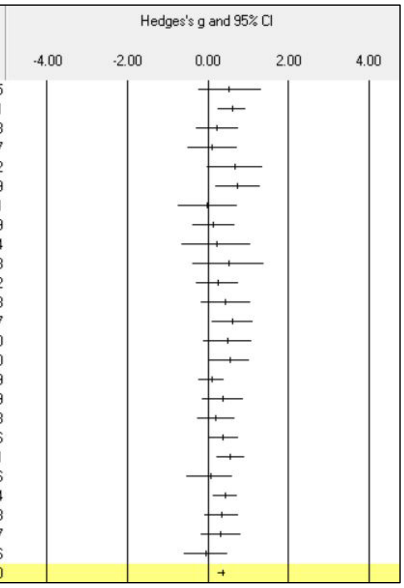
Note. Heterogeneity for all studies with more complex means of measuring learning outcomes under the fixed effect model.

The overall effect size for less complex means of measuring the learning outcomes is 0.364 as shown in Figure 30. Figure 31 is an enlarged version of Figure 30.

Figure 30

Overall Random Effects Model for Studies with Less Complex Means of Measuring Learning Outcomes

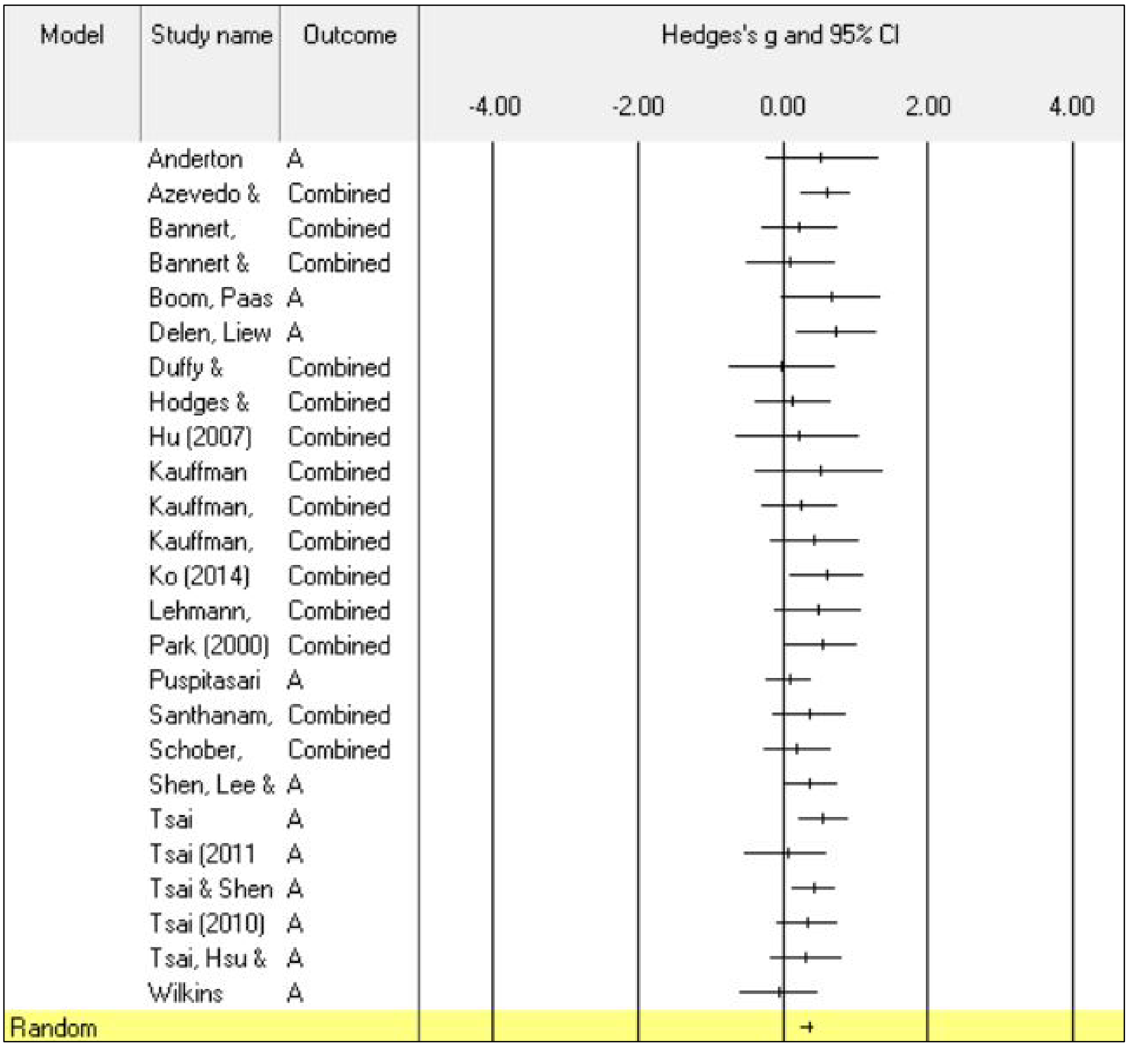
Model	Study name	Outcome	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Anderton	A	0.538	0.397	0.158	-0.240	1.317	1.356	0.175
	Azevedo &	Combined	0.609	0.178	0.032	0.260	0.958	3.417	0.001
	Bannert,	Combined	0.221	0.265	0.070	-0.297	0.740	0.836	0.403
	Bannert &	Combined	0.113	0.311	0.097	-0.497	0.723	0.362	0.717
	Boom, Paas	A	0.684	0.351	0.123	-0.005	1.373	1.947	0.052
	Delen, Liew	A	0.737	0.283	0.080	0.183	1.291	2.605	0.009
	Duffy &	Combined	-0.004	0.375	0.140	-0.738	0.730	-0.011	0.991
	Hodges &	Combined	0.144	0.266	0.071	-0.378	0.666	0.540	0.589
	Hu (2007)	Combined	0.214	0.437	0.191	-0.642	1.070	0.490	0.624
	Kauffman	Combined	0.517	0.452	0.204	-0.369	1.402	1.143	0.253
	Kauffman,	Combined	0.245	0.269	0.072	-0.282	0.773	0.911	0.362
	Kauffman,	Combined	0.447	0.316	0.100	-0.173	1.067	1.413	0.158
	Ko (2014)	Combined	0.622	0.261	0.068	0.112	1.133	2.388	0.017
	Lehmann,	Combined	0.507	0.308	0.095	-0.097	1.111	1.646	0.100
	Park (2000)	Combined	0.549	0.252	0.064	0.054	1.043	2.176	0.030
	Puspitasari	A	0.097	0.158	0.025	-0.213	0.406	0.614	0.539
	Santhanam,	Combined	0.365	0.259	0.067	-0.143	0.872	1.408	0.159
	Schober,	Combined	0.205	0.237	0.056	-0.261	0.670	0.863	0.388
	Shen, Lee &	A	0.389	0.195	0.038	0.007	0.771	1.998	0.046
	Tsai	A	0.563	0.173	0.030	0.224	0.903	3.251	0.001
	Tsai (2011	A	0.061	0.293	0.086	-0.514	0.635	0.207	0.836
	Tsai & Shen	A	0.437	0.153	0.024	0.136	0.737	2.849	0.004
	Tsai (2010)	A	0.334	0.211	0.045	-0.079	0.748	1.585	0.113
	Tsai, Hsu &	A	0.321	0.255	0.065	-0.178	0.820	1.262	0.207
	Wilkins	A	-0.047	0.278	0.078	-0.593	0.499	-0.169	0.866
Random			0.364	0.049	0.002	0.267	0.460	7.419	0.000



Note. Random effects model for all included studies with less complex means of measuring the learning outcomes.

Figure 31

Overall Random Effects Model for Studies with Less Complex Means of Measuring Learning Outcomes Enlarged



Note. Random effects model for all included studies with less complex means of measuring the learning outcomes shown in enlarged view.

In Figure 32, the heterogeneity is shown for all of the studies with less complex means of measuring the learning outcomes under the fixed effect model. Interestingly this group of studies does appear to be more similar as the heterogeneity is not significant and only as large as would be expected for this number of studies (Borenstein et al., 2009).

Figure 32

Heterogeneity for All Studies with Less Complex Means of Measuring Learning Outcomes

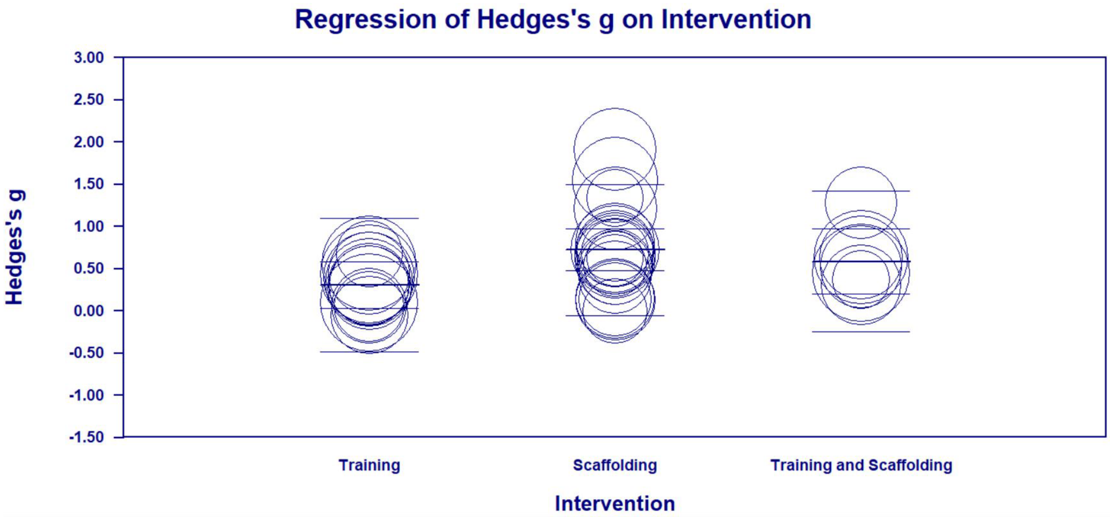
Heterogeneity			
Q-value	df (Q)	P-value	I-squared
17.648	24	0.820	0.000

Note. Heterogeneity for all included studies with less complex means of measuring the learning outcomes under the fixed effect model.

The regression of training, scaffolding, and training and scaffolding interventions is shown in Figure 33. Training studies are more tightly clustered than scaffolding studies.

Figure 33

Regression for Training, Scaffolding, and Training and Scaffolding

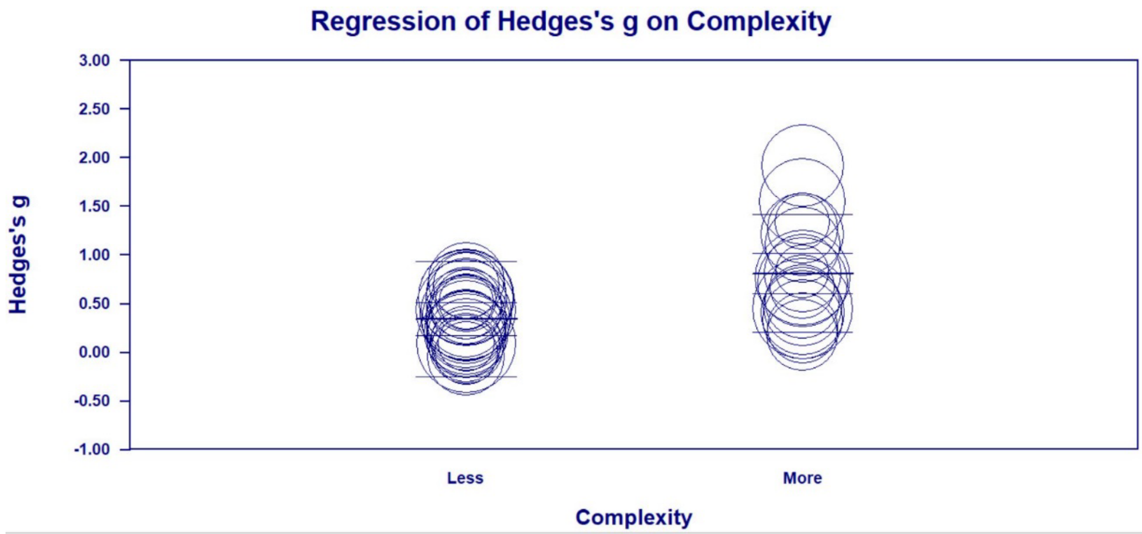


Note. Regression of Hedges's g for scaffolding, training, and training and scaffolding.

The regression of less and more complex means of measuring learning outcomes is shown in Figure 34. Studies with less complex outcomes are more tightly clustered than studies with more complex outcomes, but also tend to be less effective.

Figure 34

Regression of Less and More Complex of Measuring Learning Outcomes

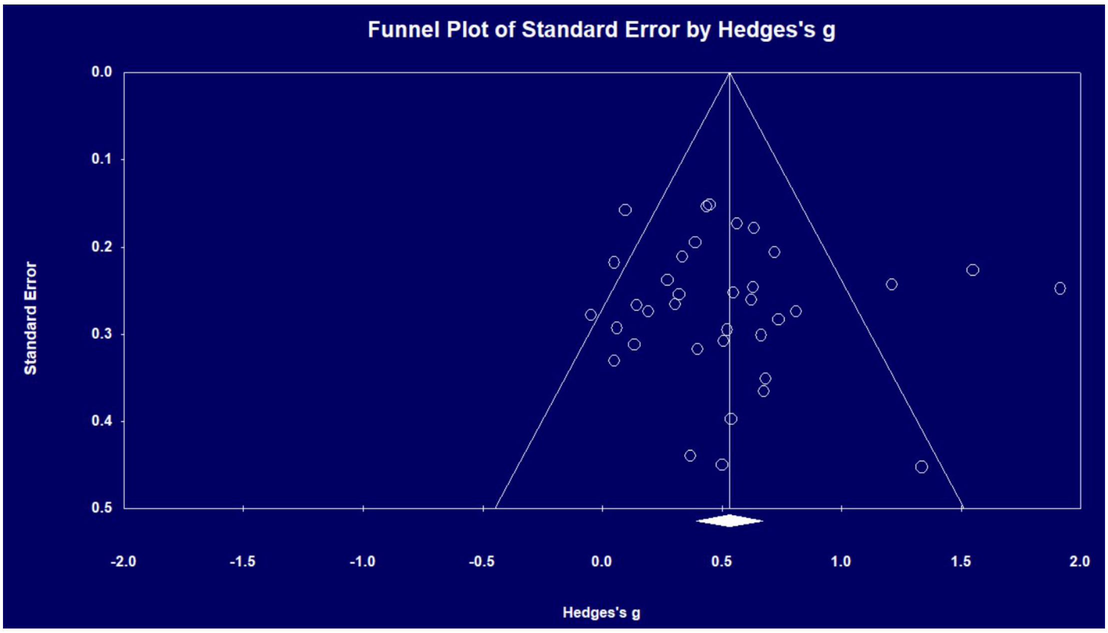


Note. Regression of Hedges's g for less and more complex.

As noted in the previous chapter, a number of sensitivity analyses were undertaken to explore the possibility of publication bias. The results of the funnel plot for all studies based on standard error by Hedges's g are shown in Figures 35 and 36. Ideally the plot should be symmetrical. However, there are some studies on the far right side of the plot. This may indicate that there is some publication bias in this data set (Sterne & Harbord, 2004), however it may also be the case that certain studies are implemented more successfully.

Figure 35

Funnel Plot

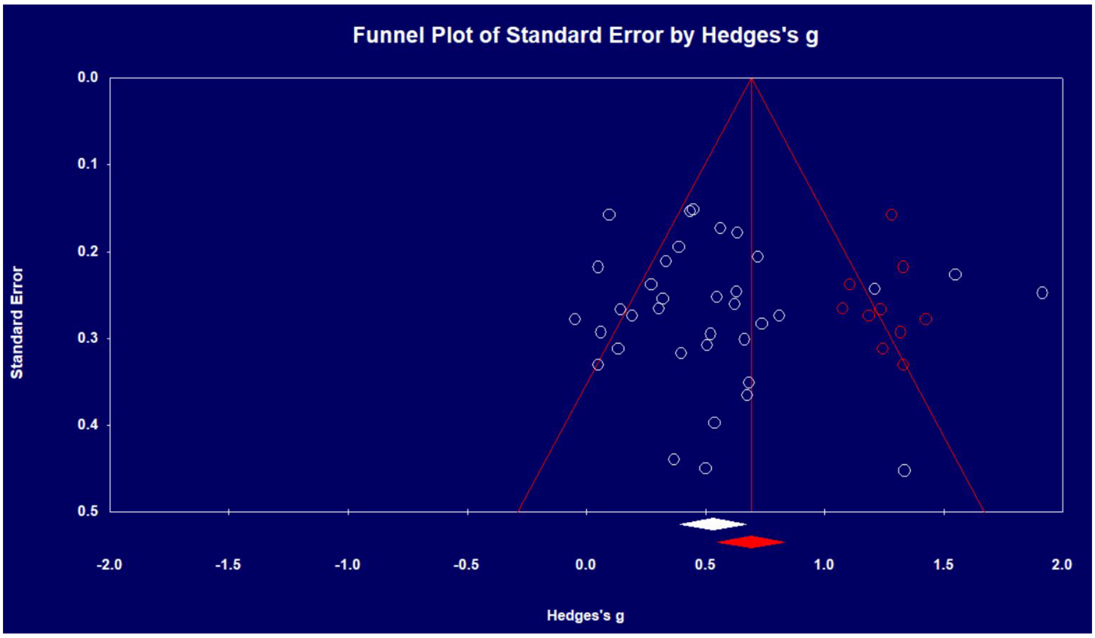


Note. Funnel plot based on standard error by Hedges's g.

The imputed results of the funnel plot for all studies based on standard error by Hedges's g are shown in Figure 36.

Figure 36

Imputed Funnel Plot



Note. Imputed funnel plot based on standard error by Hedges's g.

The results of Rosenthal's Classic Fail-safe N are shown in Figure 37. This suggests that publication bias is not a serious concern as it would take over 1,400 further studies to overturn this positive result.

Figure 37

Classic Fail-safe N

Classic fail-safe N	
Z-value for observed studies	12.51999
P-value for observed studies	0.00000
Alpha	0.05000
Tails	2.00000
Z for alpha	1.95996
Number of observed studies	36.00000
Number of missing studies that would bring p-value to > alpha	1433.00000

Note. Rosenthal's Classic Fail-Safe N.

The results of Orwin's Fail-safe N are shown in Figure 38. This takes into account the extent of the difference (in this case set to an effect size of 0.2) and indicates that more than 59 contradictory studies would be needed to reduce the effect size to a less meaningful difference.

Figure 38

Orwin's Fail-safe N

Orwin's fail-safe N

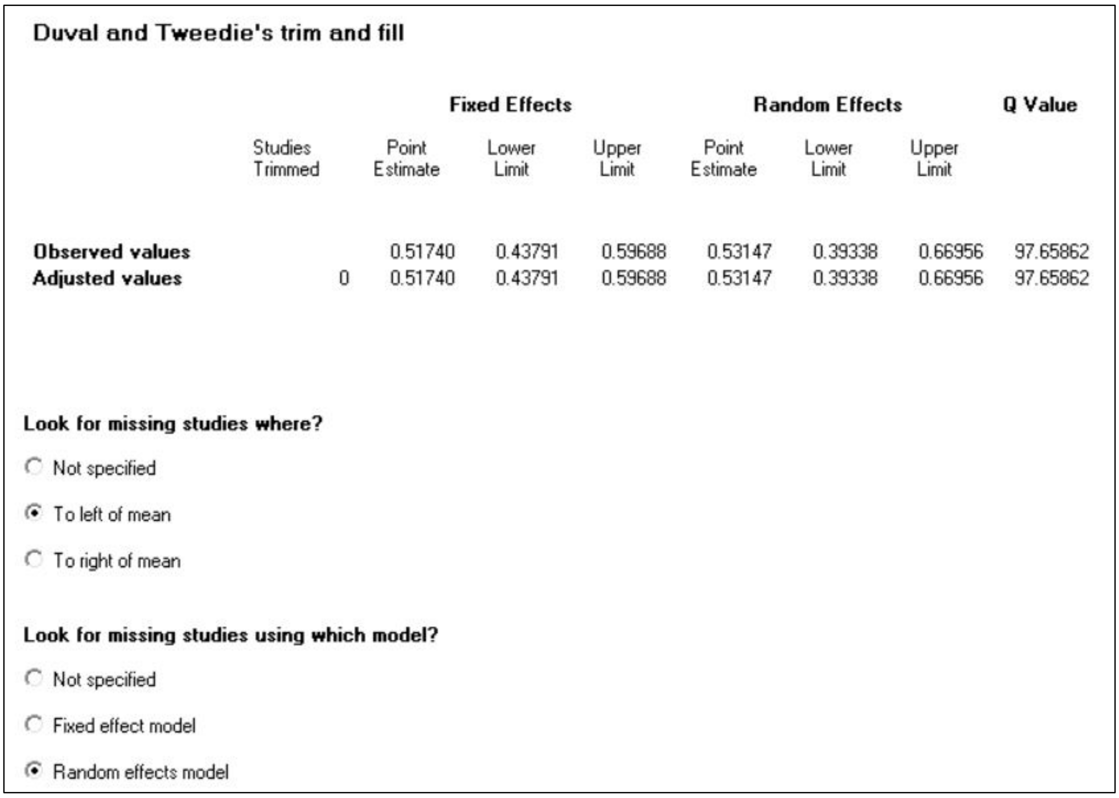
Std diff in means in observed studies	0.52334
Criterion for a 'trivial' std diff in means	0.20000
Mean std diff in means in missing studies	0.00000
Number missing studies needed to bring std diff in means under 0.2	59.00000

Note. Orwin's Fail-Safe N.

The results of Duval and Tweedie's Trim and Fill method are shown in Figure 39. When selecting to the left of mean 0 studies were trimmed. The adjusted values are equal to the observed values.

Figure 39

Duval and Tweedie's Trim and Fill, Left of Mean



Duval and Tweedie's trim and fill

		Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	
Observed values		0.51740	0.43791	0.59688	0.53147	0.39338	0.66956	97.65862
Adjusted values	0	0.51740	0.43791	0.59688	0.53147	0.39338	0.66956	97.65862

Look for missing studies where?

- Not specified
- (•) To left of mean
- To right of mean

Look for missing studies using which model?

- Not specified
- Fixed effect model
- (•) Random effects model

Note. Trim and Fill left of mean.

The results of Duval and Tweedie's Trim and Fill method are shown in Figure 40. When selecting to the right of the mean, 10 studies were trimmed. The adjusted values are somewhat higher that the observed values.

Figure 40

Duval and Tweedie's Trim and Fill, Right of Mean

Duval and Tweedie's trim and fill

		Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	
Observed values		0.51740	0.43791	0.59688	0.53147	0.39338	0.66956	97.65862
Adjusted values	10	0.67424	0.60371	0.74476	0.69139	0.55020	0.83258	169.49972

Look for missing studies where?

- ○ Not specified
- ○ To left of mean
- ◉ To right of mean

Look for missing studies using which model?

- ○ Not specified
- ○ Fixed effect model
- ◉ Random effects model

Note. Trim and Fill right of mean.

Summary of Findings

This chapter presented the findings of this study including a detailed description of the systematic search process, effects models from the collected data and a number of sensitivity tests to explore heterogeneity and bias. In the next chapter, these findings will be discussed, specifically the overall effect size of SRL interventions (ES=0.531 with an I-square of 69%) and characteristics of the subgroups for SRL training (ES=0.318 with an I-square of 0%), SRL scaffolding (ES=0.652 with an I square of 69%), SRL training and scaffolding (ES=0.568 with an I-square of 12.5 %), more complex means of measuring the learning outcomes (ES=0.800 with an I-square of 70.6%) and less complex means of measuring the learning outcomes (ES=0.364 with an I-square of 0%).

Chapter 5 - Discussion

Preface

This study used a systematic search and meta-analysis to examine 15 years of data from 36 studies and tried to understand the relationship between SRL interventions and learning outcomes in higher education e-learning environments. I examined two moderating effects: (a) how the interventions were implemented i.e. training, scaffolding and training with scaffolding; and (b) the means of measuring the learning outcomes i.e. more or less complex. The following discussion addresses my two hypotheses and my four research questions. First, I will report on the overall effectiveness of SRL interventions in higher education e-learning environments (research question one) and then I will discuss the moderators for which I created subgroups (research questions two and three and hypotheses one and two). Second, I will address the defining characteristics of the more effective SRL interventions (research question four). Third, I will discuss the results of the tests of heterogeneity and bias. Fourth, I will address the limitations of this study.

Throughout my discussion, I may refer to effect sizes as beings small, medium or large. Cohen's rules of thumb are widely accepted methods for assessing the practical value of an intervention. According to Cohen's rules of thumb, an effect size of .8 or higher is considered to have a large effect on the intervention group. An effect size of .5 through .8 indicates a medium effect and an effect size below .5 indicates a small effect (Cohen, 1988). Cohen set up the medium effect size to be one that was large enough so that people would naturally recognize it, the small effect size to be one that was noticeably smaller but not insignificant, and the large effect size to be the same distance above the medium effect size as small was below it (Cohen, 1988).

Research Question One

How are SRL interventions more or less connected with learning outcomes in higher education e-learning environments?

To address this question, I will begin by referring to Figure 15 on the overall effect size of SRL interventions (ES=0.531) in higher education e-learning environments. This number represents a medium effect size according to Cohen's rules of thumb which leads me to believe that SRL interventions are more than less connected with learning outcomes in higher education e-learning environments. The connection between SRL interventions and learning outcomes is likely due to the following reasons: (a) training regarding how to use SRL strategies is provided; and/or (b) scaffolding that promotes SRL strategy use is present during the learning experience. These approaches will be discussed in more detail in the research questions to follow, but I think it is plausible that SRL interventions overall are connected to improved learning outcomes in higher education e-learning environments.

Research Question Two and Hypothesis One

What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when scaffolding, training or training with scaffolding are implemented?

This research question addresses hypothesis one: The more effective SRL interventions will be associated with specific implementation characteristics i.e. implementation strategy.

Given the variation in the effects sizes for the subgroups, the implementation features of SRL interventions appear to be related and support hypothesis one. Referring to Figure 18, the effect size for SRL scaffolding (ES=0.652) is medium. The effect size for SRL training (ES=0.318), as shown in Figure 21, is small. Referring to figure 24, the effect size for SRL training and scaffolding (ES=0.568) is medium. The differences in these effect sizes lead me to think that SRL scaffolding is more effective for the learner. With scaffolding, SRL interventions are embedded into the learning experience and it seems likely that learners benefit from these types of interventions as they are progressing through new concepts and assignments in their courses. In contrast, SRL training may only occur prior to a learning experience, so this approach may not be as beneficial as when embedded into the learning experience. For training with scaffolding, the smaller effect size could be caused by overwhelming learners with tasks and content, creating a distraction from the learning goals. Another reason could be that instructor preparation of the learning experience is diminished from having multiple interventions to create and manage. Furthermore, I think it is helpful for educators to know that it could be more beneficial for learners when the focus of SRL interventions is on scaffolding. Also, it is common nowadays for institutions to provide SRL strategy training as part of orientation or through a preparation course, particularly in online learning. That said, educators might consider the types of SRL interventions and their characteristics according to learner needs and institutional situations. For example, some of the more successful studies included in this meta-analysis implemented SRL training interventions aimed at lower performing students.

Research Question Three and Hypothesis Two

What is the effect of SRL interventions on learning outcomes in higher education e-learning environments when more complex means of measuring learning outcomes are used compared to when less complex means of measuring learning outcomes are used?

This research question addresses hypothesis two: The effectiveness of SRL interventions will be greater when more complex tasks compared to when low complex tasks are used as the means of measuring the learning outcomes. Comparing the subgroups, studies with more complex means of measuring the learning outcomes appear to be more effective and seem to support hypothesis two. Referring to Figure 27, the effect size for SRL interventions for more complex tasks (ES=0.800) is large. Referring to Figure 30, the effect size for SRL interventions for less complex tasks (ES=0.364) is small. These findings may not be particularly surprising to educators familiar with the use of higher and lower order thinking tasks. However, it is not my intention here to convey that SRL interventions are less effective in situations where an educator is measuring learning by means of lower order thinking such as multiple choice questions. What seems interesting is SRL intervention's plausibility to assist learners through more complex tasks such as problem based learning.

Research Question Four

What are the defining characteristics of the more effective SRL interventions with regard to higher education e-learning environments?

This section of the discussion provides an account of the studies with more effective SRL interventions. I will discuss the studies in the order of effect sizes, moving from large to medium. Details about the SRL interventions and the means of measuring the learning outcomes are provided. I provide all of the effect sizes of the more effective studies even though some effect sizes within the studies are small whereas others are medium to large. This level of detail will help educators isolate the more successful interventions. In addition, I will explain how the interventions that were tested in the studies connect to the SRL theories and models presented in Chapter 1.

Ge et al. (2010) developed a Web-based cognitive support system to assist students' problem solving performance in a college pharmacy course. The purpose of the system was to provide modeling and scaffolding for students' problem solving steps and self-regulatory abilities. Based around a case study and characterized by mentorship and social interactions, the system consisted of five problem solving steps, question prompts, peer review, expert modeling and self-reflection. For example, Step 4 "Choose, justify and implement a plan" would present the following questions:

1. Which option would you implement as a plan?
2. Why is this plan the best choice?
3. How will you implement the plan?

Student's responses were stored in a database where they could be commented on by peers and revised according to the feedback that they received. Learning outcomes were measured by a written report. In this study, the treatment groups were more likely to have better problem representation and their answers were more detailed.

Building on other researchers' findings such as Kauffman (2004) and theoretical constructs from Vygotsky (1934/1987b), this study makes certain connections to models and theories of SRL. For example, this study used scaffolding strategies in the form of question prompts and supports such as feedback to elicit students' reflection on their problem solving process. According to Vygotsky's (1934/1987b) sociocultural theory, supports provided by more knowledgeable people help learners move from their current level of understanding to a higher level. Although no reference to a specific SRL model is mentioned, the visual provided in this study aligns more with the model from Järvelä & Hadwin (2013) due to the study's emphasis on collaborative learning and metacognition.

In Table 4, the effect sizes, treatments and means of measuring learning outcomes are shown for the five steps of the problem solving process used in this study.

Table 4

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Ge et al. 2010

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
1.675	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Identify problem situation
1.591	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Identify problem situation (second submission)
2.479	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Examine the problem
2.713	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Examine the problem (second submission)
1.850	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - List and evaluate alternative solutions (second submission)
2.741	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - List and evaluate alternative solutions
1.453	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Choose, justify and implement a plan
1.533	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Choose, justify and implement a plan (second submission)
1.631	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Evaluate the plan
1.497	Scaffolding - Embedded question prompts, review of peer feedback, expert responses and self-reflection	More complex - Evaluate the plan (second submission)

Note. From “A Cognitive Support System to Scaffold Students’ Problem-Based Learning in a Web-Based Learning Environment,” by X. Ge et al. 2010, *Interdisciplinary Journal of Problem-Based Learning*, 4(1) 30-56. (https://doi:10.7771/1541-5015.1093).

Michalsky and Kramarski (2015) investigated Web-based question prompts in an undergraduate teacher preparation course. Representing an acronym for a teaching model, the study approach consisted of introducing new concepts, metacognitive questioning, practicing, reviewing and reducing difficulties, obtaining mastery, verification and enrichment (IMPROVE). The IMPROVE model guided the development of the question prompts and were designed to elicit judgement in the form of "think back" strategies and modifications in the form of "think ahead" strategies. This study examined the two types of question prompts separately and in combination with each other. The results of this study revealed that students who received judgement and modification prompts in combination exhibited gains, followed by the modification prompts alone.

For the task, students analyzed a lesson plan and responded to questions in an online forum where they would receive peer feedback and discuss. The questions, for example, consisted of:

1. What is the lesson about? Explain.
2. What is the lesson design? Explain.
3. What was done? Why? Explain.
4. What could be done differently? Explain.
5. What was the best/worst solution? Explain.
6. How can I modify the solution? Explain.

Building on other researchers' findings such as Ge et al. (2010) and Kauffman et al. (2008) and theoretical constructs from Pintrich (2000) and

Zimmerman (1998), this study makes certain connections to models and theories of SRL. For example, this study used two types of reflection prompts: (a) judgment; and (b) modification. Zimmerman's SRL theory (2000) emphasizes the importance of conditions where learners set goals, select strategies, monitor their progress, self-evaluate and adapt their strategies as needed. Although no reference to a specific SRL model is mentioned, this study seems connected with the theoretical constructs from Pintrich (2000) and Zimmerman and Moylan (2009) due to the complexity of the research design and emphasis on task analysis, planning, monitoring and evaluation.

In Table 5, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 5

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Michalsky and Kramarski 2015

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
1.843	Scaffolding - Judgement and modification question prompts	More complex - Identify learning objectives
1.512	Scaffolding - Judgement and modification question prompts	More complex - Select content
1.677	Scaffolding - Judgement and modification question prompts	More complex - Plan didactic material
1.168	Scaffolding - Judgement and modification question prompts	More complex - Design the learning environment
0.7143	Scaffolding - Judgement question prompts	More complex - Identify learning objectives
0.375	Scaffolding - Judgement question prompts	More complex - Select content
1.378	Scaffolding - Judgement question prompts	More complex - Plan didactic material
0.667	Scaffolding - Judgement question prompts	More complex - Design the learning environment
1.063	Scaffolding - Modification question prompts	More complex - Identify learning objectives
.938	Scaffolding - Modification question prompts	More complex - Select content
1.410	Scaffolding - Modification question prompts	More complex - Plan didactic material
0.995	Scaffolding - Modification question prompts	More complex - Design the learning environment

Note. From "Prompting Reflections for Integrating Self-Regulation into Teacher Technology Education," by T. Michalsky and B. Kramarksi 2015, *Teachers College Record*, 117(5), pp. 1-38. (https://doi: 10.1177/016146811511700507).

Lee et al. (2009) studied computer-based, generative learning strategies and metacognitive feedback in an undergraduate science course. The generative learning strategies asked students to highlight important sentences and construct personal meaning in a note-taking field. The metacognitive feedback prompted students to revisit certain material and refine their understanding. In the findings for this study, learners who received generative learning strategy prompts with metacognitive feedback performed better than the control group with regard to comprehension. In contrast, there were no differences between learners who received just the generative learning strategy prompts alone and the control group.

Building on other researchers' studies such as Azevedo and Cromley (2004) and theoretical constructs from Zimmerman (1998), this study makes certain connections to models and theories of SRL. For example, this study used embedded, adjunct questions and note-taking fields to engage students in creating personal meaning. In addition, this study used metacognitive feedback to activate learners' SRL processes. Although no reference to a specific SRL model is mentioned, this study provides a framework in the form of a visual that seems connected with the model by Zimmerman (1998) due to the simplicity of the research design and the emphasis on using metacognitive feedback to improve performance.

In Table 6, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 6

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Lee et al. 2009

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
1.515	Scaffolding - Generative learning strategy and metacognitive feedback	More complex - Generate own meaning of complex science topics
1.157	Scaffolding - Generative learning strategy	More complex - Generate own meaning of complex science topics

Note. From "Generative Learning Strategies and Metacognitive Feedback to Facilitate Comprehension of Complex Science Topics and Self-Regulation," by H. W. Lee et al. 2009, *Journal of Educational Multimedia and Hypermedia*. 18 (1), pp. 5-25. (https://www.learntechlib.org/p/26119).

Bixler (2007) investigated the effects of reflective question prompts on students' problem solving processes in a college level online course in information technology. The online learning environment was provided through the LMS. The assigned problem was to create a Website for a group of band members. Instead of providing students with instructions on how to complete the problem, the online learning screens in the LMS consisted of questions that prompted students to think about the problem and write down their thoughts in a Web-based, note-taking tool. A typical screen in the LMS displayed the following types of question prompts:

1. How do I define the problem?
2. What are the parts of the problem?
3. Am I on the right track and how do I know?
4. What information is already provided?
5. What information do I need to generate?
6. This is an example of…?
7. This is similar to…?
8. What would be a new example of…?
9. What did the other members of your group think about…?

Academic achievement was measured on four different levels of problem solving by means of: (a) representing the problem; (b) developing solutions; (c) making justifications and (d) monitoring and evaluation. In this study, students who worked with reflective question prompts significantly outperformed students who did not work with reflective question prompts in all four levels of problem solving.

Building on other researchers' studies such as Ge and Land (2003) and theoretical constructs from Bandura (1986) and Pintrich (2000), Bixler's study makes certain connections to models and theories of SRL. For example, this study used scaffolded question prompts that aligned to the conceptual phases of the problem and were intended to support cognitive and metacognitive thinking processes. Although no reference to a specific SRL model is mentioned, this study provides a framework that seems connected with the model by Pintrich (2000) due to the emphasis on prompts for organizing key information, summarizing important points and monitoring progress. In addition, there are connections to the model by Järvelä & Hadwin (2013) due to the study's emphasis on collaborative learning.

In Table 7, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 7

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Bixler 2007

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
1.498	Scaffolding - Embedded question prompts	More complex - Represent the problem
1.189	Scaffolding - Embedded question prompts	More complex - Develop solutions
1.250	Scaffolding - Embedded question prompts	More complex - Make justifications
.907	Scaffolding - Embedded question prompts	More complex - Monitor and evaluate

Note. From "The Effects of Scaffolding Student's Problem Solving Process via Question Prompts on Problem Solving and Intrinsic Motivation in an Online Learning Environment," by B. Bixler 2007, *Dissertation Abstracts International*, (Order No. 3284910).

Kauffman (2004) studied the use of Web-based instructional prompts in an undergraduate educational psychology course. There were three factors in the design of the experiment. First, two types of note taking approaches were used: (a) free form; and (b) matrix. In the matrix notes, topics were listed in columns and categories were listed in rows. The free form version provided the same topics and categories across the top of a blank page. Second, there were self-monitoring prompts that asked students to make a confidence judgment about the completeness of their notes. Third, there was self-efficacy building feedback designed to boost students' confidence. The findings of this study were three-fold: (a) students who took notes in the matrix tool achieved higher than students who took free form notes.; (b) students who received self-monitoring prompts achieved higher that students who did not; and (c) students who received self-efficacy prompts achieved higher than students who did not, but only when matrix notes were used.

Building on other researchers' studies such as Igo et al. (2003) and theoretical constructs from Butler and Winne (1995), Pintrich (2000), and Zimmerman (1998), this study makes certain connections to models and theories of SRL. For example, this study used a note taking organizer and scaffolded question prompts that were intended to support cognitive, metacognitive and motivational components of SRL. Mentioned in the study, the research design seems more connected with the model by Butler and Winne (1995) due to the emphasis on self-monitoring prompts for generating internal feedback about one's own performance.

In Table 8, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 8

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Kauffman 2004

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
0.624	Scaffolding - Matrix note taking, self-monitoring and self-efficacy	Less complex - Factual test
0.502	Scaffolding - Matrix note taking, self-monitoring and self-efficacy	Less complex - Procedural test
1.377	Scaffolding - Matrix note taking, self-monitoring and self-efficacy	More complex - Scenario based test
0.190	Scaffolding - Free form note taking, self-monitoring and self-efficacy	Less complex - Factual test
0.030	Scaffolding - Free form note taking, self-monitoring and self-efficacy	Less complex - Procedural test
0.288	Scaffolding - Free form note taking, self-monitoring and self-efficacy	More complex - Scenario based test

Note. From “Self-Regulated Learning in Web-Based Environments: Instructional Tools Designed to Facilitate Cognitive Strategy Use, Metacognitive Processing, and Motivational Beliefs,” by D. Kauffman 2004, *Journal of Educational Computing Research*, 30(1-2), pp. 139-161. (https://doi:10.2190/AX2D-Y9VM-V7PX-0TAD).

Tsai, Lee and Shen (2013) studied the effects of SRL and problem-based learning (PBL) with low-achieving, first year college students who were learning Microsoft Office productivity tools in a hybrid course setting. There were three groups in this study. The first group received scaffolded, Web-based PBL during learning and SRL training prior to learning. The second group received Web-based, PBL scaffolding only and the third group received neither PBL nor SRL. In this study, students in the PBL and SRL group significantly outperformed students in the control group. The PBL only group performed better than the control group, but not significantly.

Building on his own earlier study Tsai (2010) and theoretical constructs from Winne and Hadwin (1998), this study makes certain connections to models and theories of SRL. For example, this study was designed to help students develop regular learning habits. Mentioned in the study, the research design seems more connected with the model by Winne and Hadwin (1998) due to the emphasis on cognitive processes that are used in the phases of solving problems and producing products.

In Table 8, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.9

Table 9

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Tsai et al. 2013

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
1.276	Training and scaffolding - SRL instruction prior to activity and use of PBL prompts during learning	More complex - Applied skill test
0.496	Scaffolding - PBL prompts during learning	More complex - Applied skill test

Note. From "Developing Long-Term Computing Skills Among Low-Achieving Students via Web-Enabled Problem-Based Learning and Self-Regulated Learning." by C. Tsai et al. 2013, *Innovations in Education and Teaching International.* 50(2), pp. 121-132. (https://doi: 10.1080/14703297.2012.760873).

Kauffman et al. (2008) randomly assigned students in an undergraduate case-based psychology course to one of four conditions in a Web-based module: (a) an intervention group that received a metacognitive prompt designed to focus learner attention on problem identification and a reflection prompt designed to elicit learner confidence in their identification of the problem along with an opportunity to make revisions to their answer; (b) an intervention group with metacognitive prompts only; (c) an intervention group with reflection prompts only; or (d) a control group that did not receive any metacognitive or reflection prompts. Overall, Kauffman found that students who received metacognitive prompts were better problem solvers and wrote higher quality responses than students who did not. Likewise, students who received reflection prompts were also better performers, but only when they received metacognitive prompts.

Building on his own prior research such as Kauffman (2004) and the works of others such as Ge and Land (2003) along with theoretical constructs from Butler and Winne (1995) and Pintrich (2000), this study makes certain connections to models and theories of SRL. For example, this study used reflective prompts to encourage confidence judgments and self-monitoring, focusing the learners' attention on problem solving. Although no reference to a specific SRL model is mentioned, this study provides a framework that seems connected with theoretical constructs from Butler and Winne (1995) due to the emphasis on prompts for generating internal feedback about one's own performance. In addition, there are connections to the theoretical constructs from Pintrich (2000) due to the emphasis on prompts for organizing key information, summarizing important points and monitoring progress.

In Table 10, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 10

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Kauffman et al. 2008

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
0.244	Scaffolding - Problem solving prompts and reflection prompts	More complex - Problem solving
0.247	Scaffolding - Problem solving prompts and reflection prompts	More complex - Problem solving
1.024	Scaffolding - Problem solving prompts and reflection prompts	More complex - Writing quality
1.219	Scaffolding - Problem solving prompts and reflection prompts	More complex - Writing quality
-0.102	Scaffolding - Problem solving prompts	More complex - Problem solving
0.870	Scaffolding - Problem solving prompts	More complex - Problem solving
-0.501	Scaffolding - Problem solving prompts	More complex - Writing quality
0.440	Scaffolding - Problem solving prompts	More complex - Writing quality
-0.560	Scaffolding - Reflection prompts	More complex - Problem solving
-0.014	Scaffolding - Reflection prompts	More complex - Problem solving
-0.507	Scaffolding - Reflection prompts	More complex - Writing quality
-0.027	Scaffolding - Reflection prompts	More complex - Writing quality

Note. From “Prompting in Web-based Environments: Supporting Self-Monitoring and Problem Solving Skill in College Students,” by D. Kauffman et al. 2008, *Journal of Educational Computing Research*. 38(2), pp. 115-137. (https://doi: 10.2190/EC.38.2.a).

Kauffman et al. (2011) investigated conditions under which note taking methods and self-monitoring prompts were most effective for facilitating information collection and achievement in an undergraduate level, Web-enhanced course in educational psychology. Students took notes in a Web-based forum using: (a) matrix; (b) outline; or (c) or conventional methods. The main page provided a brief introduction to the topic and instructed students to take notes from the linked Web-based tutorials in preparation for a series of tests on statistical procedures. In each of the three note taking methods, there was a self-monitoring group and a no self-monitoring group. The self-monitoring groups received prompts that encouraged them to monitor their progress. The prompts were inserted at the end of the Web-based tutorial and just prior to the test questions. In the prompts, students were provided with a sample test question and asked if they wanted to move forward to the test or return to the Web-based tutorials. Students could also review their notes. The results of this study revealed five main effects: (a) matrix note takers collected more notes than outline note takers who collected more notes than conventional note takers; (b) students who received self-monitoring prompts collected more notes than students who did not receive self-monitoring prompts; (c) the presence of self-monitoring prompts increased note taking in conventional note takers more than it did in matrix note takers; (d) students who used the matrix note taking tool scored significantly higher on the tests than students who used the outline or conventional note taking tools and; (e) students who received the self-monitoring prompts outperformed students who did not receive the self-monitoring prompts.

Building on his own prior research such as Kauffman et al. (2008) and the works of others such as Azevedo and Cromley (2004) along with theoretical constructs from Butler and Winne (1995) and Mayer (1996), this study makes certain connections to models and theories of SRL. For example, this study used self-monitoring prompts to encourage confidence judgments and an enhanced note taking tool that allowed for indexing information by topic and category. Mentioned in this study, the research design seems more connected with theoretical constructs from Butler and Winne (1995) due to the emphasis on self-monitoring prompts for generating internal feedback about one's own performance. In addition, there are connections to the theoretical constructs from Pintrich (2000) due to the emphasis on prompts for organizing key information, summarizing important points and monitoring progress.

In Table 11, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 11

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Kauffman et al. 2011

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
0.416	Scaffolding - Matrix note taking and self-monitoring prompts	Less complex – Propositions
0.513	Scaffolding - Matrix note taking and self-monitoring prompts	Less complex - Factual test
0.507	Scaffolding - Matrix note taking and self-monitoring prompts	Less complex - Procedural test
1.134	Scaffolding - Matrix note taking and self-monitoring prompts	More complex - Application test
0.555	Scaffolding - Outline note taking and self-monitoring prompts	Less complex – Propositions
0.302	Scaffolding - Outline note taking and self-monitoring prompts	Less complex - Factual test
0.219	Scaffolding - Outline note taking and self-monitoring prompts	Less complex - Procedural test
-0.185	Scaffolding - Outline note taking and self-monitoring prompts	More complex - Application test
0.938	Scaffolding - Conventional note taking and self-monitoring prompts	Less complex – Propositions
0.526	Scaffolding - Conventional note taking and self-monitoring prompts	Less complex - Factual test
0.052	Scaffolding - Conventional note taking and self-monitoring prompts	Less complex - Procedural test
-0.186	Scaffolding - Conventional note taking and self-monitoring prompts	More complex - Application test

Note. From "Effects of Online Note Taking Formats and Self-Monitoring Prompts on Learning from Online Text: Using Technology to Enhance Self-Regulated Learning," by D. Kauffman et al. 2011, *Contemporary Educational Psychology.* 36(4), pp. 313-322. (https://doi:10.1016/j.cedpsych.2011.04.001)

Goh et al. (2012) studied the use of persuasive text messaging in a first year, Web-enhanced, undergraduate information systems course to foster SRL in lower performing students. In tandem with the course modules, one to two text messages were sent each week and served as reminders to students about completing course assignments and making effective use of resources. In addition, the messages were designed to motivate students by providing positive reinforcement and familiar abbreviated language commonly found in texting such as “ur” for your or “4get” for forget. In this study, the persuasive messaging intervention had a significant effect on grade performance.

Building on the works of other researchers such as Chang (2007) and Pintrich and De Groot (1990) along with theoretical constructs from Pintrich (2000), this study makes certain connections to models and theories of SRL. For example, this study used self-monitoring prompts to encourage confidence judgments and an enhanced note taking tool that allowed for indexing information by topic and category. Although there is no mention of a specific model, the research design seems more connected with theoretical constructs from Pintrich (2000) due to the emphasis on self-monitoring and motivational prompts.

In Table 12, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 12

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Goh et al. 2012

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
.811	Scaffolding - Persuasive short messaging	More complex - Complete Web design and database project

Note. From "The Impact of Persuasive SMS on Students' Self-Regulated Learning," by T. Goh et al. 2012, *British Journal of Educational Technology*. 43(4), pp. 624-640. (https://doi:10.1111/j.1467-8535.2011.01236.x).

Delen et al. (2014) examined the effectiveness of interactive video-based content on learners' self-regulation skills. Participants were graduates and undergraduates from various disciplines who were unfamiliar with the topic of the video content. In the treatment group, students were provided with a tool for generating notes, supplemental resources and practice questions. The control group had only the regular video functions such as play, pause and rewind. In this study, leaners who received the interactive tools scored significantly higher on the recall test that was administered after the interactive video.

Building on other researcher's work such as Kauffman (2004) and theoretical constructs from Pintrich (2000), Vygotsky) (1934/1987b) and Zimmerman (1989), this study makes certain connections to models and theories of SRL. For example, this study used self-monitoring questions to encourage confidence judgments and an enhanced note taking tool that allowed for indexing information by topic and category. Mentioned in this study, the research design seems more connected with theoretical constructs from Pintrich (2000) due to the emphasis on note taking prompts for summarizing key information and self-monitoring prompts for generating internal feedback about one's own performance. Although there is no mention of a specific model, the research design seems more connected with theoretical constructs from Pintrich (2000) due to the emphasis on self-monitoring and motivational prompts.

In Table 13, the effect size, treatment and means of measuring the learning outcomes are shown for this study.

Table 13

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Delen et al. 2014

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
.737	Scaffolding - Embedded, interactive video to promote SRL	Less complex - Recall test

Note. From "Effects of Interactivity and Instructional Scaffolding on Learning: Self-Regulation in Online Video-Based Environments," by E. Delen et al. 2014, *Computers & Education*, 78, pp. 312-320. (https://doi:10.1016/j.compedu.2014.06.018).

Ko (2013) investigated the effectiveness of structured, reflective online discussions in an undergraduate, Web-enhanced computer course. In this study, self-monitoring and self-reflective components were provided to learners as scaffolding. There were two experimental groups. The first group received the structured, reflective online discussions and teacher feedback whereas the second group received only the structured, reflective online discussions. Prior to the discussions, the learners in the experimental group were asked to self-judge their level of understanding for various concepts on a scale of 0 (completely unclear) to 10 (completely clear) and then reflect on their judgement in the class discussion board. The control group did not receive a self-judgment prompt prior to participating in the discussion forum. Findings indicated that students in both experimental groups performed better than the control group, particularly for the group that also received teacher feedback.

Building on other researcher's work such as Puzziferro (2008) and theoretical constructs from Pintrich (2000) and Zimmerman (1998), this study makes connections to theories and Models of SRL. For example, the self-judgement prompt served as a goal setting and self-monitoring tool and the teacher feedback facilitated learner reflection and revision. Although there is no mention of a specific model, the research design seems more connected with theoretical constructs from Pintrich (2000) due to the emphasis on forethought, reflection and revision.

In Table 14, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 14

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Ko 2013

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
.486	Scaffolding - Reflective discussions	Less complex - Exam
.759	Scaffolding - Reflective discussions and teacher feedback	Less complex - Exam

Note. From "The Effect of an Adaptive Online Learning Support in an Undergraduate Computer Course: An Exploration of Self-Regulation in Blended Contexts," by C. Ko 2013, *ProQuest Dissertations & Theses Global*, (Order No. 3538997).

Santhanam et al. (2008) examined the effects of SRL training in an undergraduate, Web-enhanced business course in Web design. In this study, students were assigned to one of four conditions during an online training module: (a) an intervention group that received pre-training and midpoint scripts designed to encourage students to follow SRL strategies; (b) an intervention group with SRL pre-training scripts only; (c) an intervention group with SRL midpoint scripts only; or (d) a control group that did not receive any SRL information. The pre-training script was designed to focus learner attention on learning goals and task analysis whereas the midpoint script prompted students to reflect on their progress. This study found a significant difference in learning achievement for the group that received pre-training and midpoint scripts.

Building on other researcher's work such as Kaufman (2004) and theoretical constructs from Zimmerman (1998), this study makes connections to SRL theories and models. For example, the pre-training scripts served as a goal setting and task analysis tool and the midpoint script facilitated learner reflection on their progress. In this study, Zimmerman's (1998) Academic Learning Cycle Phases model for SRL is shown and the study seems connected to this model due to emphasis on forethought and reflection.

In Table 15, the effect sizes, treatments and means of measuring the learning outcomes are shown for this study.

Table 15

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Santhanam et al. 2008

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
.508	Training and scaffolding - SRL pre-training and midpoint scripts	More complex - Hands-on performance
.752	Training and scaffolding - SRL pre-training and midpoint scripts	Less complex - Declarative knowledge
.303	Training - SRL pre-training scripts	More complex - Hands-on performance
.293	Training - SRL pre-training scripts	Less complex - Declarative knowledge
.049	Scaffolding - SRL midpoint scripts	Less complex - Declarative knowledge
.209	Scaffolding - SRL midpoint scripts	More complex - Hands-on performance

Note. From "Using Self-Regulatory Learning to Enhance E-Learning-Based Information Technology Training," by R. Santhanam et al. 2008, *Information Systems Research*, 19(1), pp. 26-47. (https://doi.org/10.1287/isre.1070.0141).

Chang (2007) investigated the effects of self-monitoring on the learning outcomes of college students in a freshman level, Web-based, English language course. Students in the treatment group were provided with a Web-based, self-monitoring tool while students in the control group were not. The purpose of this self-monitoring intervention was to help students better manage their time, evaluate their own learning and make adaptions as needed in order to improve academic performance. Upon logging into the online course, students in the treatment group were provided with an interface that asked them to record the starting time, the place they studied and the person(s) with whom they studied. In addition, students were asked to predict their score for the post-lesson. Each time students logged into the course a history of time spent on task was shown to them. Students' scores, which included grades from comprehension, discussion and assignments, were used as the means for measuring academic performance. Chang found that the Web-based, self-monitoring tool had a significant effect on learning outcomes.

Building on his own prior research such as Chang (2005) along with theoretical constructs from Pintrich (2000) and Zimmerman (1998), this study makes certain connections to models and theories of SRL. For example, this study investigated a self-monitoring tool that prompted students to make a confidence judgement about their familiarity with the content as a way to help them self-evaluate and plan their efforts. In addition, this study used mechanisms for recording and tracking time on task. Although no reference to a specific SRL model is mentioned, this study provides a framework that seems connected with theoretical constructs from Pintrich (2000) due to the emphasis on forethought, self-monitoring and self-control.

In Table 16, the effect size, treatment and means of measuring the learning outcomes are shown for this study.

Table 16

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Chang 2007

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
.721	Scaffolding - Self-monitoring prompts and tracking	More complex - Use of English vocabulary

Note. From "Enhancing Web-Based Language Learning Through Self-Monitoring," by M-M. Chang 2007, *Journal of Computer Assisted Learning*, 23, pp. 187-196. (https://doi:10.1111/j.1365-2729.2006.00203.x).

Azevedo and Cromley (2004) studied the effectiveness of SRL training to facilitate undergraduate, college students' learning with interactive, digital content for a unit on the human circulatory system. Students in the treatment group attended a 30-minute, face-to-face training on the use of SRL strategies designed to facilitate their conceptual understanding of complex topics while students in the control group did not attend any SRL training. In the SRL training, students were provided with descriptions and examples of the phases of SRL from Pintrich (2000), including planning (prior activation of knowledge, goals, and sub goals), monitoring (feeling of knowing, judgment of learning and identifying adequacy of information), strategy use (note taking, mnemonics, and help seeking), task demands (time and effort planning) and interest (curiosity towards the domain of the content). In addition, a visual of the model from Butler (1997) was provided. The training session lasted 30 minutes and was held in a face-to-face setting. During interacting with the content on the human circulatory system, students were reminded to reference the SRL material from the training session. Learning was measured by means of a declarative test on the components of the human circulatory system. The results of this study indicated that students in the treatment group gained a deeper understanding of the circulatory system than students in the control group.

Building on his own prior research such as Azevedo (2002) and theoretical constructs from Butler (1997), Pintrich (2000) and Winne and Hadwin (1998), this study makes connections to SRL models and theories. For example, the objective of the intervention was for learners' to be able to recognize self-regulatory strategies and apply these strategies during learning with regard to improving academic performance. Models from Butler (1997) and Pintrich (2000) were provided to students prior to and during the learning activity as a means of facilitating self-regulatory processes.

In Table 17, the effect sizes, treatment and means of measuring the learning outcomes are shown for this study.

Table 17

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Azevedo and Cromley 2004

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
0.684	Training and scaffolding - Scripted guide on SRL prior to and during learning	More complex - Mental models, essay and flow diagram
0.449	Training and scaffolding - Scripted guide on SRL prior to and during learning	Less complex – Matching
0.769	Training and scaffolding - Scripted guide on SRL prior to and during learning	Less complex – Labeling

Note. From "Does Training on Self-Regulated Learning Facilitate Students' Learning with Hypermedia?" by R. Azevedo and J. Cromley 2004, *Journal of Educational Psychology*. 96(3), pp. 523-535. (https://doi:10.1037/0022-0663.96.3.523).

Hu (2007) compared the performance of students who did and did not receive online training about SRL strategies as part of their course of study. The participants in this study were undergraduate students in a Web-enhanced, college success course. Prior to learning students, received a Web-based tutorial on basic concepts of SRL along with practice activities. During learning, students received staged emails asking them to complete an online study plan including goal setting and planning strategies. Students were also asked to complete self-evaluation forms at the end of each period of study. In this study, Hu found that the students who received the SRL interventions performed significantly higher on the tests and assignments than the students who did not receive the interventions.

Building on theoretical constructs from Bandura (1986) and Pintrich (2000), this study makes connections to SRL models and theories. The Web-based tutorials, for example, were designed to elicit student use of SRL strategies based on Pintrich (2000) such as goal setting, evaluating, planning, monitoring and time management. In addition, the teacher modeled social interactions based on Bandura (1986) by sharing personal anecdotes about thinking and reasoning with regard to SRL.

In Table 18, the effect sizes, treatment and means of measuring the learning outcomes are shown for this study.

Table 18

Effect Sizes, Treatments and Means of Measuring Learning Outcomes, Hu 2007

Effect size(s)	Treatment(s)	Means of measuring the learning outcomes(s)
-0.384	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	Less complex - Test
0.091	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	Less complex - Test
0.619	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	Less complex - Test
0.061	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	Less complex - Test
0.683	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	Less complex - Final exam
0.652	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	More complex - Project
0.853	Training and scaffolding - Web-based training on SRL with goal setting and reflection during learning	More complex - Paper

Note. From "Effects of Self-regulated Learning Strategy Training on Learners' Achievement, Motivation and Strategy Use in a Web-enhanced Instructional Environment," by H. Hu 2007, Doctoral Dissertation. (Order No. 3301559).

Bias and Heterogeneity

Bornstein et al. (2009) recommends procedures and statistical tests for researchers to employ when undergoing systematic searches and meta-analytic studies in order to address bias and heterogeneity. Bias is an area, for example, where the researcher should take steps to locate all plausible studies, including studies that are not statistically significant or unpublished studies. Heterogeneity is an area that can show researchers variation across studies that are not the same; the opposite of heterogeneity is homogeneity, meaning the studies are similar and show a similar effect. Investigating sameness and differences helps researchers grasp factors which influence an intervention. Here, I will discuss what was done with regard to bias and heterogeneity in the context of this thesis.

To address Bias, the first step in my systematic search was to make every reasonable effort to locate possible studies, including ones that were not readily indexed by popular databases, identifying grey literature. The second step was to abide by a pre-established criteria to determine which studies to include, coming to 100% agreement with associates. The third step was to look for outliers i.e. studies with noticeably low or high effect sizes. To identify outliers, I used the funnel plot feature in CMA as shown in Figures 35 and 36. I found two studies where I had entered incorrect data and corrected those. I then double checked all other data entries to be sure. I also made sure I had no duplicate studies. The fourth step was to identify dependencies, meaning studies that reported more than one outcome (Borenstein et al., 2009). Studies with dependencies were flagged and configured in CMA to be calculated as dependencies. Once I was confident with my data, I used statistical tests in CMA such as Rosenthal's Classic Fail-safe N which is designed to check for publication bias in meta-analysis (Borenstein et al., 2009).

To address heterogeneity, the first step was to use the random effects versus the fixed effect model in CMA because the random effects model is designed to assist with variation from study to study e.g. sample size (Borenstein et al., 2009). The second step was to form subgroups in order to help describe any variation (Borenstein et al., 2009). Subgroups were formed according to type of SRL interventions used and means of complexity of measuring learning outcomes; subgroups are shown in Figures 18, 21, 24, 27 and 30. The third step was to run regression analysis in CMA. Just as in primary studies, regression can be used to study relationships between variables and effect sizes in meta-analytic studies (Borenstein et al., 2009). Regression as shown in Figures 33 and 34 represents the mean effect size with the dispersion of effects about this mean. The third step was to run tests for Q and I^2 statistics. Similarly to the regression models, the data for Q and I^2 as shown in Figures 17, 20, 23, 26, 29 and 32 represents dispersion around the mean or variation amongst the effect sizes. In some cases, the use of subgroups helped reduce variance as shown in Figures 33 and 34, particularly for subgroups named training (an I-square of 0%) and less complex means of measuring the learning outcomes (an I-square of 0%). Moreover, a moderate to high I^2 could be an indicator that some studies were more successfully implemented than others with regard to intervention characteristics or means of assessment, particularly for subgroups named scaffolding (an I-square of 69%) and more complex means of measuring the learning outcomes (an

I-square of 70.6%). The fourth step was to investigate the variance and this was accomplished by parsing out the more effective studies and closely examining their characteristics. These SRL interventions are described and shown in Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17.

Limitations

A limitation of this study is the smaller number of studies, 36, that met the inclusion criteria. Upon undertaking this study, my research interests aligned to higher education e-learning environments, specifically where SRL interventions were investigated by means of learning outcomes. In hindsight, broadening the inclusion criteria to include secondary learners would have increased the number of studies. In addition, a larger number of studies might have strengthened the data for subgroups.

Summary

In this chapter, I discussed SRL interventions in higher education e-learning environments, specifically the overall effect size and the effect sizes of the subgroups i.e. training, scaffolding, training with scaffolding, more complex means of measuring the learning outcomes and less complex means of measuring the learning outcomes. Finally, I presented an account of the studies that used the more effective SRL interventions. To summarize, I would like to reflect on my observations of the more effective studies as a way of pulling together features of the SRL interventions that could be beneficial.

My first observation is that SRL interventions with scaffolding features that are designed to prompt students during the phases of completing a task are beneficial, particularly for more complex tasks that are completed in phases such as problem solving or projects. The SRL interventions that were designed to assist with phased-based tasks often contained opportunities for the learner to define the task, propose options, make justifications, receive feedback, reflect and make revisions. These SRL approaches differ from instances where the instructor simply assigns a problem to be solved or explains about a course project in that metacognitive prompts are provided. In addition, the types of SRL scaffolding interventions appear to mirror aspects of the various SRL models presented in Chapter 1.

My second observation is also about scaffolding, but with a different use case than my prior observation. Reflecting on the more effective studies, SRL scaffolding in the form of a digital study tool seems beneficial, particularly in cases where learners are preparing for a summative assessment such as an exam. Although each of these digital study tools were uniquely designed, they offered features such as note taking prompts, self-monitoring prompts, embedded tutorials or branching to resources based on confidence with the content or learning estimates. Characteristics of these tools also seem to mirror the various SRL models presented in Chapter 1.

My third observation is regarding the moderate degree of variation across the 36 studies (an I-square of 65%). For this reason, it is important to refer to each study at the end of the chapter (research question 4) to understand how it was or was not successfully implemented, especially for studies with multiple interventions and interventions that combined variables. You will notice that in certain cases combined variables resulted in high, but also low effect sizes.

Although I formulate further suggestions in the final chapter, I wanted to summarize my thoughts above regarding these two different use cases of scaffolding which I observed to be more effective as well as the importance of looking closely at the studies with combined variables.

Chapter 6 - Conclusions

Preface

Models and theories about SRL have shown continuous development since the 1980s, becoming an important area in educational psychology research (Bandura, 1986; Boekaerts, 1988; Butler & Winne, 1995; Ekflides, 2006; Järvelä & Hadwin, 2013; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 1989). Based on these prominent models and theories, numerous empirical studies of SRL interventions and their effect on academic achievement have been conducted, particularly in the area of e-learning.

The present thesis aimed to identify studies beginning from 1998 (the approximate onset of online learning) and meta-analyze the effects of SRL interventions on learning outcomes in higher education e-learning environments. For this meta-analyses, e-learning included online, hybrid and Web-enhanced; 36 studies were identified.

Consistent with prior meta-analyses, this meta-analysis confirmed an overall positive, medium effect size of SRL interventions (ES=0.531) on learning outcomes. With the use of subgroups, this meta-analysis further investigated the characteristics of the SRL interventions i.e. SRL training (ES=0.318), SRL scaffolding (ES=0.652), SRL training and scaffolding (ES=0.568), more complex means of measuring the learning outcomes (ES=0.800) and less complex means of measuring the learning outcomes (ES=0.364). These findings leave me to conclude that it is important for educators to: (a) recognize possible benefits to learners as a result of implementing SRL interventions; and (b) be able to implement findings from the more effective SRL interventions into their professional practice.

Implications

Given the potential of SRL interventions to improve learning outcomes, I have formulated some suggestions to help educators become more involved. These suggestions are not difficult or overly time consuming to implement. Additionally, most institutions offer pedagogical and technical resources to assist with implementation.

A good starting point is to inquire as to how your institution addresses student support for SRL. Some institutions have existing resources that students are introduced to as part of orientation or as a credit bearing course. These resources typically cover time management, goal setting, learning strategies and so on. Some institutions maintain resources that can easily be linked and provided to a student when they are having difficulty with a specific area such as learning strategies. Often these types of resources are maintained through a learning center, online learning unit or library. When these resources are available, it may make sense to have an area in your course in the LMS to refer students to as needed. Additionally, when SRL resources are part of the overall institutional strategy for student support, it doesn't seem necessary to focus on SRL training at the course level. In short, understanding institutional support for SRL will help you determine what types of interventions you might implement.

To begin the process of applying SRL interventions at the program or course level, it may make sense to explore the different SRL models and theories presented in this thesis. Reviewing these models either independently or with your department, may help you discover ones that are more or less a better fit for your discipline and meet an educational need for your students.

Additionally, having a model in mind helps provide a foundation for the design characteristics of SRL interventions.

Prior to implementing SRL interventions, there are a few items for your consideration. First, reviewing the more effective SRL interventions presented in this thesis will help you determine which one(s) might lead to better outcomes for your students. Second, you might identify a particular area or assignment where students are underperforming e.g. audience consists of learners who are facing difficulties with the material. Third, you might think about SRL interventions with regard to how the learning outcomes are measured e.g. a multiple choice exam, problem solving or project. For my own courses, I found the studies that used question prompts most relevant because I mainly use project-based learning. Fourth, you might consider the time needed for designing and implementing SRL interventions or any support you may need.

Most institutions offer services to support instructional strategies, both their pedagogical and technical aspects. For example, you might partner with an instructional designer to assist with designing question prompts or rubrics that could be used as scaffolding in your course. Instructional designers are also skilled at making tool recommendations and providing training for technology that will help facilitate your vision. Keep in mind that many of the SRL interventions presented in this thesis would simply require use of the LMS. However, if your vision requires technology beyond the LMS, there may be support provided when an educational need can be demonstrated. In addition, it is becoming more common for publishers to embed SRL prompts into the content, so you could look for these when evaluating material.

In summary, presented above are easy to follow action items that educators can take to become involved with SRL interventions. Understanding your institution's approach to SRL will help you get started. From there, having an SRL model to refer to and familiarity with the more effective SRL interventions will help you in the design process. Finally, you should be able to leverage pedagogical and technical support resources at your institution to assist with implementation.

Further Research

Two future areas of research are suggested. First, more recent SRL interventions that are made possible through emerging technologies such as adaptive learning, built-in progress checkers, collaborative white boards, digital note taking or electronic journals are an important area of study. These technologies often offer insights into learner performance through the use of digital dashboards or the ability to track student progress. Second, studying SRL models and interventions in relation to specific disciplines and age groups could advance our understanding of SRL models and test even further the effectiveness of SRL interventions with different types of populations e.g. executive education, faculty development and job specific training.

Summary

Broadly speaking, SRL is a term used to describe learners' intentional efforts to manage and direct learning activities towards the successful completion of academic goals and involves cognitive, metacognitive and motivational processes (Zimmerman & Schunk, 2001). Since the 1980's, research on SRL has steadily increased, becoming an important area in educational psychology. This longevity and expansion of SRL research is a sign that it will continue to be beneficial for educators to understand how SRL interventions are relevant to their teaching practice. It is equally as important for educators to recognize the more effective SRL interventions so that they can evaluate and implement ones that are more likely to improve learning outcomes. Given the long history of SRL models, theories and research, my hope is that educators will take this information into consideration when designing and developing their courses, particularly when (a) adopting courseware; (b) creating instructional prompts; (c) designing instruments for measurement; (e) determining where it makes sense to provide scaffolding; (c) facilitating collaborative learning; (d) providing feedback mechanisms; or (d) selecting technology. Finally, I would like to suggest that educators engage in developing new SRL models, approaches and research, advancing the field and helping us understand how to design interventions that lead to the best possible outcomes for learners.

Final Reflection

In closing, I provide a personal reflection on what I have gained from undertaking this study. I recognized heading into this study that meta-analysis provides a rigorous framework for researchers to detect significant effects. I found the ability to systematically gather and analyze data beyond a single study to be very powerful. For example, the pooling of effect sizes allowed me to critically examine the effectiveness of different types of SRL interventions, particularly with the use of subgroups. The use of subgroups was valuable for discovering which SRL interventions I might use or recommend to educators. Then, through the literature review, I recognized the potential for SRL models and theories to inform the design of SRL interventions. For example, an educator might gravitate towards a particular SRL model depending on discipline, educational need or type of assignment. I think it is useful to have an SRL model in mind to help inform the design and I can now justify the importance of using a model based on the long history of SRL research in educational psychology. The literature review also provided me with a rich perspective on what researchers consider important and worthwhile with regard to supporting students to develop SRL skills. Having gained a historical perspective on SRL coupled with data on effectiveness, I am confident that I will be able to apply SRL interventions to my own teaching practice as well guide educators with selecting, designing and implementing SRL interventions.

Appendix A

Coding Instrument

1. Coder name __________

2. Study identification number __________

Study, Researcher, Subjects and Contextual Characteristics

1. Citation for the document:

2. Researcher:

    1. Teacher
    2. Graduate student
    3. Other __________
    4. Unknown

3. Search source (how the document was located):

4. Type of publication:

    1. Journal article
    2. Book
    3. Book chapter
    4. Report
    5. Dissertation
    6. Conference paper

5. Types of learners:

    1. Undergraduate
    2. Graduate
    3. Military
    4. Vocational
    5. Industry or business
    6. K-12 (exclude)
    7. Other __________

6. Average age:

    1. __________
    2. Unknown

7. Gender information:

    1. __________
    2. Unknown

8. Country:

    1. __________
    2. Unknown

9. Subject matter:

    1. Math
    2. Language arts (including second language learning)
    3. Physical and natural sciences
    4. Social sciences
    5. Psychology
    6. Philosophy
    7. Computer science
    8. Information technology
    9. Industrial arts
    10. Education
    11. Health sciences (including medicine, environmental health and nursing)
    12. Business
    13. Other __________

10. E-learning mode:

    1. Online
    2. Blended
    3. Web assisted
    4. None (exclude)

Research Methods

11. Study design:

    1. Randomized controlled trial
    2. Quasi-experimental
    3. Single subject (exclude)
    4. Qualitative (exclude)
    5. Not randomized
    6. Balanced
    7. Other __________

12. If not randomized, treatment and control groups were similar at the start of the experiment:

    1. Similar
    2. Somewhat similar
    3. Not similar

13. Pretest:

    1. Yes
    2. No

14. Bias was minimized:

    1. Minimized + +

    2. Somewhat minimized +

    3. Not minimized -

15. Type of SRL intervention:

    1. Prompting for SRL strategies and/or
    2. Providing SRL training

Description:

____
____
____
____
____
____
____
____
____
____
____
____
____

16. Description of the control group:

    1. No treatment
    2. Treatment description
    ____
    3. No E-learning mode

17. Goal to improve:

    1. Learning outcomes
    2. Achievement
    3. Neither (exclude)

18. Means of evaluation:

    1. Test
    2. Project
    3. Essay
    4. Other __________

19. Means of measuring the learning outcomes according to cognitive processes in order of their complexity from lower to higher order thinking skills:

    1. Remember
    2. Understand
    3. Apply
    4. Analyze
    5. Evaluate
    6. Create

20. Duration of the treatment:

    1. One time
    2. Throughout
    3. Other __________
    4. Unknown

Effect Size Data

21. Type of data effect size is based on:

    1. Means and standard deviations
    2. t-value or F-value
    3. Chi-square
    4. None available or could not be provided by the author

22. Sample sizes, means and standard deviations:

1. Treatment condition ____
   Control condition ____
   Treatment n __________ Control n __________

   a) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   b) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   c) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   d) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   e) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   f) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________
   g) Treatment M __________ Control M __________
      Treatment SD __________ Control SD __________
      Means of measuring outcome ______________________

23. Other data if means and standard deviations were not provided:

24. Page number(s) where effect size data is found:

1. __________
2. __________

Appendix B

Study Count

Study number	Study name	Title
1	Anderton, E. K. (2005)	An evaluation of strategies to promote self-regulated learning in pre-service teachers in an online class.
2	Azevedo, R., & Cromley, J. G. (2004)	Does training on self-regulated learning facilitate students' learning with hypermedia?
3	Bannert, M., Hildebrand, M., & Mengelkamp, C. (2008)	Effects of a metacognitive support device in learning environments.
4	Bannert, M., & Reimann, P. (2012)	Supporting self-regulated hypermedia learning through prompts.
5	Bates, C. H. (2006)	The effects of self-regulated learning strategies on achievement, control beliefs about learning, and intrinsic goal orientation.
6	Bixler, B. (2007)	The effects of scaffolding student's problem solving process via question prompts on problem solving and intrinsic motivation in an online learning environment.
7	Boom, G., Paas, F., & Merrienboër, J., G. (2007)	Effects of elicited reflections combined with tutor or peer feedback on self-regulated learning and learning outcomes.
8	Chang, M-M. (2007)	Enhancing web-based language learning through self-monitoring.
9	Delen, E., Liew, J., & Willson, V. (2014)	Effects of interactivity and instructional scaffolding on learning: Self-regulation in online video-based environments.
10	Duffy, M. C., & Azevedo, R. (2015)	Motivation matters: Interactions between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system.
11	Ge, X., Planas, L. G., & Er, N. (2010)	A cognitive support system to scaffold students' problem-based learning in a web-based learning environment.
12	Goh, T., Seet, B., & Chen, N. (2012)	The impact of persuasive SMS on students' self-regulated learning.
13	Hodges, C. B., & Kim, C. (2010)	Email, self-regulation, self-efficacy, and achievement in a college online mathematics course.
14	Hu, H. (2007)	Effects of self-regulated learning strategy training on learners' achievement, motivation and strategy use in a web-enhanced instructional environment.

Study number	Study name	Title
15	Kauffman, D. (2004)	Self-regulated learning in web-based environments: Instructional tools designed to facilitate cognitive strategy use, metacognitive processing, and motivational beliefs.
16	Kauffman, D., Ge, X., Xie, K., & Chen, C-H. (2008)	Prompting in web-based environments; Supporting self-monitoring and problem solving skill in college students.
17	Kauffman, D., 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.
18	Ko, C. (2013)	The effect of an adaptive online learning support in an undergraduate computer course: An exploration of self-regulation in blended contexts.
19	Lee, H. W., Lim, K. Y., & Grabowski, B. (2009)	Generative learning strategies and metacognitive feedback to facilitate comprehension of complex science topics and self-regulation.
20	Lehmann, T., Hähnlein, I., & Ifenthaler, D. (2014)	Cognitive, metacognitive and motivational perspectives on preflection in self-regulated online learning.
21	Leutner, D., Leopold, C., & den Elzen-Rump, V. (2007)	Self-regulated learning with a text-highlighting strategy.
22	Lewis, J. P. (2006)	Effects of self -regulated learning on metacognitive strategies, academic performance, and transfer of preservice teachers in an educational technology class.
23	Michalsky, T. & Kramarski, B. (2015)	Prompting reflections for integrating self-regulation into teacher technology education.
24	Park, H. K. (2000)	The effects of different ways of employing self -regulated learning strategies in computer -based instruction (CBI): Detached instruction of self -regulated learning strategies, embedded self-regulated learning strategies, and a combination of the two.
25	Puspitasari, K. (2012)	The effects of learning strategy intervention and study time management intervention on students' self-regulated learning, achievement, and course completion in a distance education learning environment.
26	Santhanam, R., Sasidharan, S., & Webster, J. (2008)	Using self-regulatory learning to enhance e-learning-based information technology training.

Study number	Study name	Title
27	Schober, B., Wagner, P., Reimann, R., & Spiel, C. (2008)	Vienna e-lecturing (VEL): Learning how to learn self-regulated in an internet-based blended learning setting.
28	Shen, P-D., Lee, T-H., & Tsai, C-W. (2007)	Applying web-enabled problem-based learning and self-regulated learning to enhance computing skills of Taiwan's vocational students: A quasi-experimental study of a short-term module.
29	Shen, P-D., Lee, T-H., & Tsai, C-W. (2011)	Applying blended learning with web-mediated self-regulated learning to enhance vocational students' computing skills and attention to learn.
30	Tsai, C-W. (2011)	An online learning community integrated with web-enhanced collaborative learning and self-regulated learning.
31	Tsai, C-W. (2011)	How much can computers and internet help? A long-term study of web-mediated problem-based learning and self-regulated learning.
32	Tsai, C-W., & Shen, P-D. (2011)	The application of web and educational technologies in supporting web-enabled self-regulated learning in different computing course orientations.
33	Tsai, C-W. (2010)	The effects of feedback in the implementation of web-mediated self-regulated learning.
34	Tsai, C-W., Hsu, P-F., & Tseng, H-J. (2013)	Exploring the effects of web-mediated game-based learning and self-regulated learning on students' learning.
35	Tsai, C-W., Lee, T-H., & Shen, P-D. (2013)	Developing long-term computing skills among low-achieving students via web-enabled problem-based learning and self-regulated learning.
36	Wilkins, D. L. (2014)	The effect of self-regulated learning strategy training and question generation on metacognitive awareness and achievement among college students enrolled in science courses.

Appendix C

Publication

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Instructional Design Interventions for Supporting Self-Regulated Learning: Enhancing Academic Outcomes in Postsecondary E-Learning Environments

Frances A. Rowe
Jennifer A. Rafferty

Abstract

Theories and models about self-regulated learning are important to educators attempting to understand why some learners succeed and others have difficulty in academic settings. Understanding self-regulation in e-learning environments is critical because there is much agreement in the literature that e-learning requires a higher degree of self-regulation than face-to-face learning. Furthermore, empirical studies of the effects of self-regulated learning intervention on learning outcomes of students in e-learning environments indicate that support for self-regulated learning fosters significantly higher academic outcomes. In this paper, the authors will focus on: (1) what educators should know about the different types of self-regulated learning interventions that have been studied; and (2) how educators might apply self-regulated learning interventions to the design of e-learning environments in order to support self-regulated learning processes.

Keywords: social cognitive theory, metacognition, cognition, motivation, learning outcomes, academic achievement, self-regulation, constructivism, higher education, online learning, virtual classroom, blended learning, distance learning.

Introduction to Self-regulated Learning

Self-regulation is a process that keeps people focused on monitoring their task completion progress and assists with multiple areas of human functioning, such as management of a chronic illness, athletic training, or learning in academic settings (Bandura, 1991; Caprara et al., 2008). Zimmerman (2000) defines self-regulation as “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals” (p. 14). Educational researchers in particular have found that students who self-regulate their learning activities perform better than students who do not self- regulate their learning, irrespective of their course of study (Chen, 2002; Pintrich & Degroot, 1990; Pintrich, Wolters, & Baxter, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992).Self-regulated learning (SRL) is a process that involves students’ intentional efforts to manage and direct complex learning activities toward the successful completion of academic goals (Zimmerman & Schunk, 2001). Zimmerman (1989) referred to SRL as the degree to which students are able to become active participants in the process of monitoring their own learning. Pintrich (2000) describes SRL as an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior in the services of those goals. Some key self-regulatory processes that affect learning outcomes include goal setting and time management, self-monitoring and reflection, modification of learning strategies, regulation of feedback, help seeking, and resource oriented learning (Bandura, 1991; Pintrich, 2000; Zimmerman & Schunk, 2001; Zimmerman, 1989).

Models and theories of SRL emerged in the 1980s in an effort to describe the attributes of academically successful students (Bandura, 1986; Kuhl, 1984; Pintrich, 2000; Zimmerman, 1989). Zimmerman and Schunk (2001) reviewed various models and theoretical perspectives of SRL, including operant, information processing, and social cognitive. All of these models tend to agree that SRL has cognitive, metacognitive, and motivational components, but theorists differ on which components to emphasize and which are more likely to improve learning outcomes. While operant theorists emphasize the role of external reinforcement in the SRL process, information processing theorists stress the role of memory, tactics, and knowledge. From the social cognitive perspective, SRL is a multidimensional construct that involves interactions between cognitive strategy use, metacognition, and motivation (Bandura, 1986; Kauffman, 2004; Pintrich & De Groot, 1990; Zimmerman, 1989).

Components of SRL

SRL's cognitive component refers to any learning strategies used to accomplish a given task and includes activities that support students' active manipulation of academic content (Kauffman, 2004; Zimmerman, 1989). SRL's metacognitive component involves the knowledge and self-awareness students have to self-monitor their understanding and cognitive processes (Kauffman, 2004; Whipp & Chiarelli, 2004). Metacognitive strategies refer to the skills that help students regulate their cognitive processes (Kauffman, 2008). Almost all SRL models presume that motivation is a key factor of academic success (Pintrich & DeGroot, 1990; Zimmerman, Bandura, & Martinez-Pons, 1992; Zimmerman & Schunk, 2001). Motivation, or the will to learn, involves students' confidence in their abilities to organize tasks and make judgments in executing the necessary course of action to achieve explicit types of outcomes (Kauffman, 2004).

Stages and Processes of SRL in Social Cognitive Theory

Social cognitive theory and research have contributed significantly to our understanding of how SRL, its components, and its processes are developed (Bandura, 1986; Pintrich, 2000; Zimmerman, 2000).Table 1 from Pintrich (2000) illustrates the social cognitive perspective of SRL. In this table, the self- regulatory processes are organized according to four stages: (a) planning and goal setting; (b) self- monitoring; (c) controlling; and (d) reflecting. Within each of these stages, self-regulation processes are structured into four areas: (a) cognition; (b) motivation; (c) behavior; and (d) context. Pintrich's illustration represents a comprehensive sequence that learners progress through as a task is being carried out. The stages produce various interactions among the different SRL processes as described below and as shown in Table 1.

The self-regulating processes begin in the planning stage with essential activities such as goal setting and activation of prior knowledge of the domain. The cognitive area recognizes the resources and strategies that are helpful in addressing the task. Metacognitive awareness recognizes the difficulty of the task and identifies the knowledge and skills needed for addressing the task. Motivational beliefs, such as efficacy for completing the task or value given to the task, influence learner behavior toward the task, such as planning time and effort and the activation of perceptions regarding the task and the contextual area.

Within the self-monitoring stage, learners become aware of their own state of cognition and motivation and use of time and effort, as well as conditions of the task and the context. Processes in this stage include self-observation of comprehension and competency, as well increased awareness of the goals that will subsequently direct behaviors and understanding of how performance will be evaluated.

The activities in the controlling stage embody the selection and utilization of cognitive, metacognitive, and motivational strategies, as well as those strategies related to regulation of diverse academic tasks such as atmosphere and structure of the task.

The final stage of reflecting includes evaluations that learners make regarding execution of the task. Processes in this stage include comparison of the executed task to previously established criteria that were determined by the learner and/or provided by the instructor, internal and external feedback about the results of the task, consequences for the results, behavior to be followed, as well as overall assessments about the task.

Table 1
Stages and Components of SRL

Stages	Cognition	Motivation	Behavior	Context
Planning and goal setting	Setting target goals Activating prior knowledge of the domain Recognizing the difficulty of the task Identifying knowledge and skills needed for completing the task	Accepting responsibility for goals Judging confidence for completing the task Perceiving the difficulty of the task Generating interest in the task	Planning for time, effort, and self-observation	Perceiving the context of the task
Self-monitoring	Checking for comprehension	Being aware of motivation and interest	Being aware of effort and need to seek help	Checking for changes in the task and context conditions
Controlling	Selecting and adapting strategies for making meaning	Selecting and adapting strategies for controlling motivation and interest	Increasing and decreasing effort Persevering or giving up Seeking help	Restructuring the task Changing or leaving the context
Reflecting	Making judgments about understanding	Having reactions Making acknowledgements	Analyzing feedback	Assessing the task within the context
Table 1				

Note. Stages and processes of self-regulated learning. Adapted from "The role of goal orientation in self- regulated learning". *Handbook of self-regulation* (p. 454), by P. R. Pintrich, 2000, San Diego, CA: Academic Press. Copyright 2000 by Academic Press.

Empirical Studies of SRL Interventions in Post-secondary E-learning Environments

Following is an in-depth review of the different SRL interventions that have been found to enhance learning outcomes in adult e-learning environments. Frequently studied SRL interventions include providing training and prompting students to follow SRL strategies and processes. Prompting is an instructional method for guiding and supporting students to perform a specific activity as part of a learning situation. Essentially, prompts instruct students to stop and reflect on their own thoughts or consider the efficiency of their own learning strategies. Training, by contrast, provides explicit instruction in the components of SRL such as cognition, metacognition, and motivation.

Within this paper, e-learning will serve as an umbrella term that encompasses all forms of computer and web-based learning environments such as interactive and hypermedia, computer-assisted, distance, virtual, web-enhanced, hybrid, blended, and online.

The more recent, empirical studies from post-secondary literature will be referred to in this paper, and rather than review the implications for e-learning environments without SRL intervention, the discussion will focus on: (a) what educators should know about the different types of SRL interventions that have been studied, and (b) how educators might apply SRL interventions to the design of e-learning environments in order to support SRL processes. In all of the studies, the SRL interventions were treated as the independent variable, and the academic outcomes were treated as the dependent variable.

For example, Bannert, Hildebrand, and Mengelkamp (2008) analyzed the learning outcomes of university students in an educational media course who either did or did not receive computer-assisted training on why metacognitive activities are useful and when to apply them. After the training, students completed a learning task that required them to study theories of using multimedia in learning environments and be able to teach these concepts to other students. During the learning task, students in the intervention group were given a diagram visualizing all of the metacognitive activities from the training to serve as a prompt. Immediately after learning, students' academic performance was measured on three different levels by means of recall, knowledge, and transfer to tasks. Students in the intervention group scored significantly higher than the students in the control group on all three levels, especially in transfer to tasks.

Bixler (2007) investigated the effects of reflective question prompts on students' problem-solving processes in a college level online course in information technology. The online learning environment was provided through the LMS. The assigned problem was to create a website for a group of band members. Instead of providing students with instructions on how to complete the problem, the online learning screens in the LMS consisted of questions that prompted students to think about the problem and write down their thoughts in a web-based note-taking tool. A typical screen in the LMS displayed the following question prompts:

1. How do I define the problem?
2. What are the parts of the problem?
3. Am I on the right track and how do I know?
4. What information is already provided?
5. What information do I need to generate?

Academic outcomes were measured on four different levels of problem solving by means of: (a) representing the problem; (b) developing solutions; (c) making justifications; and (d) monitoring and evaluation. The results of this study showed that students who worked with reflective question prompts significantly outperformed students who did not work with reflective question prompts in all four levels of problem solving.

Chang (2007) examined the effects of self-monitoring on the learning outcomes of college students in a freshman level, online, English language course. Students in the intervention group were provided with a web-based, self-monitoring prompt, while students in the control group were not. After logging in to the online course, students in the intervention group were prompted to record the starting time, the place they studied, and the person(s) with whom they studied. Students were also asked to predict their score for the post-lesson quiz and adjust time spent on lesson materials in order to improve their score. The self-monitoring prompt was designed to help students better manage their time, evaluate their own learning, and make adaptions as needed in order to improve academic performance. Chang found that the self-monitoring prompts had a significant effect on learning outcomes.

Hu (2007) compared the performance of students who did and did not receive online training about SRL strategies. The participants in this study were undergraduate students in a web-enhanced, college success course. Prior to the intervention, a modified version of the Motivated Strategies Learning Questionnaire (MSLQ) was used as a pretest to determine students' existing levels of motivation and experience with learning strategies. At the end of the intervention period, the same instrument and questions were used as a post-test to measure students' motivation and reported use of strategies. During learning, students received an online tutorial on the basic concepts of SRL and how to use them in a web-enhanced environment. The tutorial instructed students to plan for completion of assignments, evaluate outcomes, and choose SRL strategies.

In this study, Hu found that the students who received the SRL intervention performed significantly higher on the assignments and final exam than the students who did not receive the intervention.

Kauffman (2008) randomly assigned students in an undergraduate case-based, psychology course to one of four conditions in a web-based module: (a) an intervention group that received a metacognitive prompt, designed to focus learner attention on problem identification, and a reflection prompt, designed to elicit learner confidence in their identification of the problem, along with opportunities to make revisions to their answer; (b) an intervention group with metacognitive prompts only; (c) an intervention group with reflection prompts only; or (d) a control group that did not receive any metacognitive or reflection prompts. Overall, Kauffman found that students who received metacognitive prompts were better problem solvers and wrote higher quality responses than students who did not. Likewise, students who received reflection prompts were also better performers, but only when they received metacognitive prompts.

Kauffman, Zhao, and Yang (2011) investigated conditions under which note-taking methods and self- monitoring prompts were most effective for facilitating information collection and achievement in an undergraduate level, web-enhanced course in educational psychology. Students took notes using matrix, outline, or conventional methods in a web-based form. The main page of the form provided a brief introduction to the topic and instructed students to take notes from the linked web-based tutorials in preparation for a series of tests on statistical procedures. In each of the three note-taking methods, there was a self-monitoring group and a no self-monitoring group. The self-monitoring groups received prompts that encouraged them to monitor their progress. The prompts were inserted at the end of the web-based tutorial and just prior to the test questions. In the prompts, students were provided with a sample test question and asked if they wanted to move forward to the test or return to the web-based tutorials. Students could also review their notes. The results of this study revealed five main effects: (a) matrix note takers collected more notes than outline note takers, who collected more notes than conventional note takers; (b) students who received self-monitoring prompts collected more notes than students who did not receive self-monitoring prompts; (c) the presence of self-monitoring prompts increased note taking in conventional note takers more than it did in matrix note takers; (d) students who used the matrix note taking tool scored significantly higher on the test than students who used the outline or conventional note taking tools; and (e) students who received the self-monitoring prompts significantly outperformed students on the test than students who did not receive the self-monitoring prompts.

Saito and Miwa (2007) examined the effects of self-reflection prompts on learning outcomes of university students in a freshman level, web-enhanced course in information fluency. Students in the intervention group were prompted to complete reflective exercises as part of their Internet searching process while students in the control group were not. The design of the intervention included a search-process feedback system with two types of reflection: (a) a schematic visualization of the search process and (b) question prompts designed to help students reflect on their own search processes presented by the system. For example, students were asked what kinds of keywords were used and how these keywords were combined, how many results of search pages were browsed per search and how many links per page were clicked. The results of this study indicated that the students who engaged in reflective exercises as part of their Internet searching process significantly outperformed students who did not.

Santhanam, Sasidharan, and Webster (2008) randomly assigned students in an undergraduate business course in Web design to one of four conditions during an online module: (a) an intervention group that received pre-training and midpoint scripts designed to encourage students to follow SRL strategies; (b) an intervention group with SRL pre-training scripts only; (c) an intervention group with SRL midpoint scripts only; or (d) a control group that did not receive any SRL information. Student learning outcomes were measured by a declarative knowledge test and a hands-on performance task. Santhanam et al. found a significant difference in learning achievement for the group that received pre- training and midpoint scripts with SRL information.

Schober, Spiel, Reimann, and Wagner (2008) evaluated the effects of online modules designed to prompt university students in a psychology course to learn more effectively by completing different tasks. The modules were based in SRL principles and structured according to the phases of activation, action, and reflection from Zimmerman (2000). Upon logging in to a module, students in the intervention group were provided with a description of the module and a question that activated prior knowledge of the subject. Students in the control group did not receive the online modules. Goals specifying the learning objectives of the module were provided followed by any projects that needed to be accomplished. A project deliverable checklist was provided for the group project. The instructor, group members, and peer groups gave group specific feedback about the project deliverables. Self-tests allowed students to individually monitor their understanding of the concepts during the module. The module culminated with students reflecting on their ability to plan, organize, and complete projects individually and in groups. Academic achievement was measured on three different levels by means of recall, comprehension, and production. Students in the intervention group achieved better results in completing more complex "comprehension" and productive "production" items.

Shen, Lee, & Tsai (2007) randomly assigned college freshmen in a web-enabled computer software applications course to one of four groups: (a) SRL with problem-based learning; (b) SRL only; (c) problem-based learning only; or (d) no SRL or problem-based learning. The SRL groups received a two- hour training on how to manage study time and self-regulate their learning. Content of the SRL training was on the following four processes: (a) self-evaluation and monitoring; (b) goal setting and strategy planning; (c) strategy implementation; and (d) monitoring the outcome of the strategy. Students were taught how to apply these four processes to become more self-regulated learners. Additionally, students were required to record their learning behavior on a weekly basis. The problem-based learning (PBL) group received an authentic problem situation along with a web-based multimedia application that helped students construct their own models for problem solving. Student learning outcomes were measured by their skills in using the application software to create graphs and tables with accuracy and artistry. Overall, Shen, et al. (2007) found that the students who received the SRL intervention performed significantly better than students who did not. Likewise, students who received the PBL intervention were also better performers, especially when they received it in combination with the SRL intervention.

Tsai, Shen, and Tsai (2011) explored the effects of providing students with SRL training and web- enabled prompts in a college level, blended course in database management. Delivered in the classroom, the SRL training discussed how students could manage study time and regulate their learning by implementing four SRL processes: (a) self-evaluation and monitoring; (b) goal setting and strategy planning; (c) strategy implementation; and (d) monitoring of the outcome strategy. Students recorded the data of their learning behaviors in the course website. In the assessment section of the course website, assignment link prompts instructed students to submit by certain due dates and then became unavailable when the time was up. To measure the learning outcomes, students were required to solve simulated problems by designing and building a database for a customer. The results of this study revealed that students' skills in using database management software were significantly higher when they received SRL training and SRL web-enabled prompts.

Researchers seem to agree that embedding SRL prompts within the course design has a positive effect on student learning. These empirical studies of SRL interventions strongly suggest that there are benefits for students' academic success when SRL prompts or training are incorporated into the design of e-learning environments. Instructional design, therefore, can play a key role in supporting and expanding the use of SRL interventions in this context. An important practical implication of these studies is that self-regulation could be incorporated into already established standards and models for e- learning course design.

Recommendations and Conclusions

While it may seem challenging to apply SRL interventions to the design of e-learning environments, there are multiple prompting and training strategies that can be employed toward achieving this goal. Both pedagogical interventions as well as the design of learning activities and course content can take advantage of a vast array of software and tools that are readily available through a LMS. It is important to acknowledge when considering these recommendations, however, that attention should be placed on the learning objectives and pedagogical goals and not the tool, as a number of other technologies can be configured to accomplish the same task. Following are specific examples of tools and instructional design interventions, along with practical advice for encouraging and supporting SRL.

First, online discussion boards, journals, and Wikis are all tools that can be used to activate the SRL processes of planning, self-monitoring, and reflection. The Wiki feature provides a collaborative area where learners can be prompted to: (a) define a problem; (b) generate possible solutions; (c) make arguments for solutions; (d) take next steps and consider steps an expert would take; (e) identify what information is needed to solve the problem; (f) view examples that are related to the problem; and (g) share points of view with peers about how to approach the problem. Electronic journals, typically used for student to instructor communication, can be employed to elicit reflection about difficulties that students encounter or strategies that facilitate learning. For example, students might be asked:

1. What did I learn in this module?
2. How did I learn the material?
3. How confident am I about my knowledge of this module?
4. What was challenging for me in learning the material?
5. What strategies helped me learn the material?
6. What changes will I make in my approaches to studying for the upcoming module?

Comparably, a discussion board can be used at the onset of a course to trigger the SRL processes of planning and goal setting. Students can be prompted to engage in a dialogue about their goals and expectations, study strategies, and learning styles. An inventory such as the Visual, Aural, Read/Write, Kinesthetic (VARK) questionnaire, will help students identify their learning preferences before they share this information in the discussion board. Once students have shared their own profile, they can be prompted to interact with their peers to compare study strategies and summarize learning style trends for the class.

Second, the design of learning activities and course content can play a major role in stimulating SRL processes. The syllabus, for example, should provide a detailed road-map for the student who navigates through course content and deliverables in an e-learning environment. Setting the stage for students, the syllabus relays important details about course requirements, deadlines, and academic policies. Careful thought should be given to the way in which this information is presented and how students can better retain it. For example, to reinforce the organization and timing of assignment due dates, a syllabus can include a graphic prompt that illustrates patterns in course assignment due dates. Table 2 illustrates how a two-week module could be depicted to learners in a course syllabus. Instructors can call upon this visual aid when creating a syllabus overview presentation.

Table 2

Module Requirements

Module One	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.
Week 1	Syllabus quiz	Self-assessment		Comprehension check	Blog post		Paper
Week 2	Response to blog posts				Quiz		Partner activity

To make the most of this kind of graphic, an instructor can visually display the table at the onset of a course in a voice over presentation that covers syllabus content. The instructor's narration and computer screen can be recorded using a screen capture tool or some other multimedia presentation application. For further reinforcement, learners can be evaluated for their understanding of course syllabus by incorporating an assessment with multiple choice and true false questions. Figure 1 illustrates examples of questions from a "syllabus scavenger hunt," which can be deployed using the test feature of a LMS. Students can then be prompted to check and evaluate their own test results. Test settings to consider include: (a) the availability of the assessment such as time limit and date range; (b) number of attempts; and (c) feedback options. These kinds of pedagogical interventions and learning activities on course policies and assignment deadlines will encourage the SRL processes of planning and goal setting before students have been immersed in the discipline-specific content of the course.

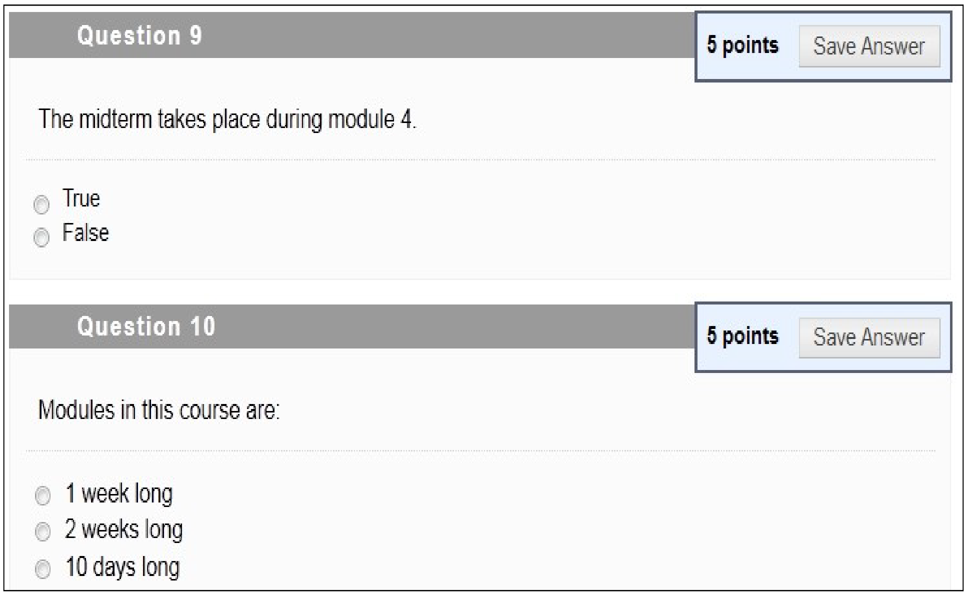

Figure 1. Sample questions from a syllabus scavenger hunt.

Third, testing for prior knowledge is a cognitive intervention that can easily be integrated through a LMS. Students can be introduced to the learning objectives of a given module, and then they can be prompted to take a short survey to gauge their familiarity with the module concepts. This kind of learning activity will assist students in the process of planning as they identify the skills that will be needed to carry out the assignments in the module. The assessment also draws on the SRL processes of controlling and reflecting as students must select strategies and assess their level of understanding. Figure 2 illustrates a question format that prompts students to determine their level of familiarity with content that they will encounter. The prior knowledge assessment serves as a primer, and it is the first activity students complete upon starting a new module. Prior knowledge assessments can also be designed to test students' actual knowledge of the learning outcomes so that they have a starting point from which to approach the course material.

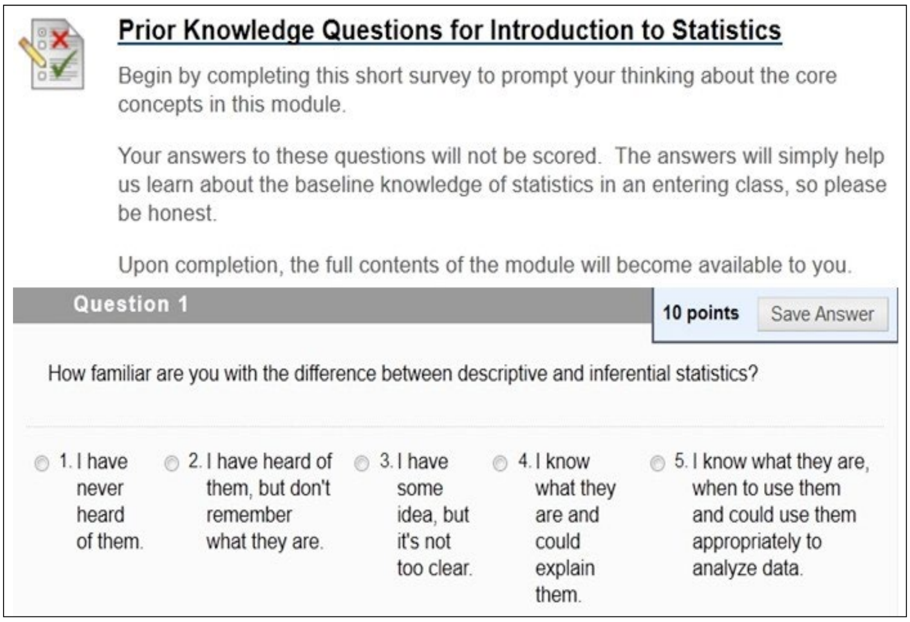

Figure 2. Sample prompt and question from an assessment of prior knowledge.

Fourth, another approach that can be taken for supporting SRL in e-learning environments is to provide explicit training on skills associated with the SRL processes. For example, the authors of this paper created a video series on the topic of time management to encourage student reflection on behaviors that lead to academic success.

The videos could be integrated into the course activities in multiple ways:

- embedding the video link in an online course and integrating its content into the learning objectives during the first week of the course,
- requiring students to watch the videos and take a short follow-up quiz on the content,

- creating a discussion board activity that prompts students to discuss the content of the video, or
- attaching the videos to instructor commentary when providing feedback to students.

Another SRL training approach could be to have students respond to statements about their study habits as shown in Figure 3.

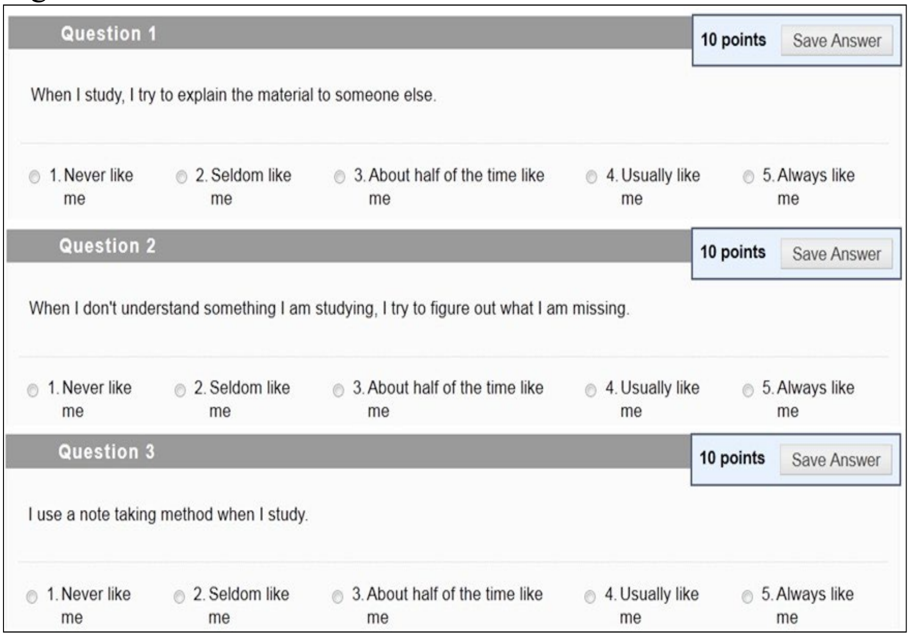

Figure 3: Sample statements about study habits

This kind of questionnaire could be set up to provide suggestions for improving study skills after the student has submitted the assessment. The feedback would be specific to those questions that the student did not answer correctly. An SRL training of this kind would prompt students to analyze their behaviors in relation to the suggestions provided by the questionnaire. Adaptive settings could be utilized to prevent students from proceeding to subsequent modules until they have completed the questionnaire and any other tasks associated with the SRL training.

From prompting to training, the aforementioned examples for supporting SRL are not difficult to implement. Appropriately used, a LMS or web-based tool can support educators applying SRL strategies in their instruction. Tool selection and the design of the intervention should be based on the learning goals and the literature on SRL.

In closing, the authors wish to encourage educators and designers of e-learning environments to reflect upon the empirical studies and recommendations provided in this paper and find ways to use SRL interventions in their courses. A key point that this paper has tried to reinforce is that students' academic performance in e-learning environments is significantly higher when the design of the course supports SRL. To that end, instructional design models and quality standards for e-learning environments could consider SRL interventions as a key indicator for improving student learning outcomes.

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