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ASSESSING COGNITIVE AND SELF-REGULATED WRITING STRATEGIES FOR BIOLOGY LAB REPORTS

A Thesis in

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ABSTRACT

This study developed and validated a self-report instrument to measure students' use of cognitive and self-regulation writing strategies for biology lab reports. Initial psychometric properties were collected, along with three sources of validity evidence to support the interpretation and use of the instrument. Specifically, evidence based on item content was examined through expert judgements, evidence based on internal structured was examined through exploratory factor analysis, and evidence based on relationships with biology writing self-efficacy and lab report performance was analyzed. The results showed that after content modifications to each item, the overall instrument had good alignment with the strategies to be measured. The final instrument rested on 22 items that reflected six strategies for lab report writing: self-regulation, revision based on peer feedback, revision based on TA feedback, planning, drafting, and evaluation of writing mechanics. Furthermore, discriminant validity between the strategies and biology self-efficacy was supported, and there was partial support for criterion validity. Revisions based on TA feedback and drafting strategies were significantly predictive of writing performances on full biology lab reports. Finding suggest that the instrument can be valid theory-based assessment tool to examine cognitive and self-regulation strategies in writing biology lab reports. Limitations and further research are also discussed.

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Chapter 1

Introduction

Writing across the disciplines is complex and cognitively demanding. Proficient writing requires sufficient amount of content knowledge, good writing mechanics, strategic behaviors, high levels of self-regulation and motivation (Harris, Graham, MacArthur, Reid, & Mason, 2011; Hidi & Boscolo, 2006; MacArthur, Graham, & Fitzgerald, 2006; Zimmerman & Risemberg, 1997). Many college students recognize the importance of vocabulary, grammar and deep understanding of the writing content. However, they are less aware of cognitive strategies, and how to strategically self-regulate their thoughts, feelings and writing behaviors towards pre-set goals for the writing outcome. Cognitive and self-regulation strategies for general academic domains have been widely studied and even taught in a variety of curricula (Azevedo & Cromley, 2004; Boekaerts & Corno, 2005). However, less attention has been focused on strategies tailored to the writing domain, and discipline specific writing tasks, such as biology lab reports.

Writing lab reports is a critical method for college biology students to learn how to conduct science experiments, as well as become familiarized with the disciplinary discourse in biology (Carter, 2007; Carter, Ferzli, & Wiebe, 2007). The components of the lab report; introduction, methods, results, discussion; provides a guideline for scientific reasoning. Reports have been viewed as an apprenticeship genre where students can learn and practice the specific language in which expert biologists use to communicate significant findings.

Unfortunately, strategies for writing lab reports are not always included in the science curriculum (Balgopal & Wallace, 2013; Puttick, Drayton, Cohen, & Cohen, 2015; Simmons, Larios-Sanz, Amin, & Rosell, 2014). One possibility could be that science educators struggle with understanding the underlying mechanics to teach strategies for lab report writing. Another possibility is that they often face the dilemma of balancing time spent on teaching writing and instruction time for course content. However, the focus of this current study is to provide science educators a better understanding of which cognitive strategies are typically employed by biology students to write lab reports, and how are students self-regulating the writing process. To achieve these goals, this study developed and validated a self-report instrument that measures cognitive writing strategies and self-regulation strategies that are essential to constructing biology lab reports. Exploratory factor and multiple regression analysis were used to collect multiple validity evidence to support the interpretation and use of this instrument. The following section provides an overview of the literature that drives this study.

Chapter 2

Review of the Literature

Conceptualization of the General Writing Process

Earlier models of writing portrayed complex interactions among writing behaviors directly tied to the composition process. According to Flower and Hayes (1980;1981) cognitive process model, writing was conceptualized as a recursive and strategic activity, rather than a linear sequence of stages. Essentially, three core cognitive and behavioral processes lay the foundation for any writing process: (1) planning or structuring of ideas, (2) translating or drafting ideas into written text and (3) reviewing the text or plan so far.

Planning consists of three functions for creating and structuring ideas to be written: generation, organization and goal setting. During generation, information relevant to the writing task is retrieved from prior memory. Then, the organization process helps determine the most useful ideas that were generated and structures them into a cohesive writing plan. Thereafter, overall writing or personal goals are set to guide task completion. After creating a general writing plan, the translating process will occur in which connected ideas are transform into complete and cohesive written sentences. Finally, writers review the text in the plan or the main document at different levels of language to make revisions and improve writing quality (Flower & Hayes, 1981; Glaser & Brunstein, 2007; Hayes & Flower, 1980).

The cognitive process model proposed several important features of writing (Flower & Hayes, 1981; Hayes & Flower, 1980). First, writing is goal directed, and skilled writers establish different types of literacy goals before, during and after composition. Goals can be tied directly to the quality of the writing, or they can be related to managing the writer's cognition and behaviors. Second, cognitive writing processes are flexible and progress in a non-linear fashion.

One might think that they proceed in the sequence of planning, translating and then reviewing, but this is not always the case. For instance, a writer might start from translating all the ideas that come into mind without a plan and then rearranging the ideas into an organized fashion. Third, each process can interrupt another process at any given time during composing. For instance, revising and idea generation processes has been found to frequently interrupts all other processes (Hayes & Flower, 1980).

Based on the complex nature of writing, the cognitive process model highlights that proficient writing requires self-regulation for monitoring and managing the many aspects of this activity (Glaser & Brunstein, 2007; Hayes, 1996; Hidi & Boscolo, 2006). When students write, they need to make plans and decisions about what and how to write their ideas, but also about when to work on the task, where would be the best writing environment, reflect on the strategies that has been used, and so on. In other words, writing demands cognitive strategies, as well as self-regulation strategies. Self-regulation of writing refers to self-initiated thoughts, feelings, and actions to strategically attain writing goals (Graham & Harris, 2006; Harris et al., 2011; Zimmerman & Risemberg, 1997). These processes are influenced by the environmental contexts which includes the physical or social settings, personal processes that involves writers' cognitive beliefs and affective states related to writing, and behavioral changes that occurs during writing.

Self-regulated writers are meta-cognitively and motivationally active when pursuing literary goals (Hidi & Boscolo, 2006; Zimmerman, 1995). These writers are knowledgeable of cognitive strategies to plan, draft and revise their written products and use these strategies effectively. More importantly, self-regulated writers uses meta-cognitive strategies to manage and control the writer's self-generated thoughts and behaviors. Meta-cognitive procedures allows the writer to be self-directed and strategic when juggling with demands and constraints throughout the writing processes. It also helps the writer flexibly switch attention across different task, and assists the writer in deciding when to move from one process or procedure to the next (Brunstein & Glaser, 2011; Flower & Hayes, 1980; Glaser & Brunstein, 2007). For instance, they constantly set goals throughout the writing process and evaluate factors that are helping or harming the writing task. These writers often monitor the writing progress by examining how much time has been spent on the writing task and asking oneself questions about whether they have sufficient content knowledge. Typically, they also reflect on the effectiveness of their cognitive strategies and then continues or revises the writing techniques.

Motivational and affective factors are core mechanisms driving self-regulated writing, and one of these processes are writers sense of self-efficacy in writing (Hidi & Boscolo, 2006; MacArthur et al., 2006; Zimmerman & Risemberg, 1997). Writing self-efficacy refers to perceptions of one's own competence and confidence in writing, such as one's certainty about getting a high grade on an essay (Pajares, 1996). Self-efficacy typically has a reciprocal and positive relationship with self-regulation processes. Writers who are self-regulated tend to produce high quality writing and this typically boosts up students' confidence in their writing abilities (MacArthur et al., 2006). On the other hand, writers who are highly efficacious in writing tend to exhibit more knowledge of regulation strategies, employ more regulation over the writing processes and typically lead to better performance (Graham, Harris, & Mason, 2005; MacArthur, Philippakos, & Ianetta, 2014).

Previous research has recognized the important role of examining self-regulation strategies in writing from at least three aspects (Graham, R. Harris, & Harris, 2000; K. R. Harris et al., 2011; MacArthur et al., 2006). First, skilled writers are more likely to be knowledge about self-regulation procedures and effective use these strategies during writing. Second, a positive association between use of self-regulation strategies and writing performances has been found. Third, knowledge and use of self-regulation strategies is not static, it can be taught to students through effective instruction.

A host of recent studies have examined effects of cognitive writing strategies and self-regulations strategies on writing performances through strategy instruction. The Self-regulated strategy development (SRSD) instructional model is built from the cognitive process model (Flower, & Hayes, 1981) and the self-regulated writing framework (Zimmerman & Risemberg, 1997). It has consistently shown that teaching a combination of cognitive writing strategies and self-regulation procedures enhances writing performance (Glaser & Brunstein, 2007; MacArthur et al., 2006). Writing instruction embedded in SRSD typically occurs across multiple stages that gradually shapes students into strategic and self-regulated writers (K. R. Harris, Graham, Friedlander, Laud, & Dougherty, 2013).

Several meta-analytic reviews have shown that the SRSD framework of writing and self-regulation strategies improve writing performances across a wide range of writing abilities, age groups, writing genres and academic domains (Graham & Harris, 2006b; Graham & Perin, 2007). For instance, Graham and Harris (2006) conducted a meta-analysis on 39 research studies that implemented variations of this strategy instruction with students from 2nd to 12th grade. On average, large effect sizes were found on writing achievement outcomes at posttest (ES = 1.15) and maintenance (ES = 1.32). These improvements were seen in writing quality, schematic structure, and revisions. These effects were found in students with learning disabilities, as well as poor, average and good writers. The beneficial effect of SRSD did not differ for younger or older students, nor did it differ for narrative versus expository writing genres.

In addition, students who learn the full range of writing and self-regulation strategies within the SRSD framework was found to improve writing performances compared with learning subsets of strategies. Graham and Harris (2006) meta-analytic review also found that the average effect sizes of studies that used SRSD models (ES = 1.57) were significantly higher than studies using non-SRSD instructional procedures (ES = 0.89). The non-SRSD studies included some but not all instructional elements of SRSD. They differed in the degree of interactive learning, individualization of instruction, but most importantly, the range of cognitive and self-regulation strategies that were instructed.

A variety of cognitive strategies and self-regulation strategies for writing has been examined. The present study focuses on three cognitive writing strategies and four self-regulation strategies to be built in a self-report instrument. Cognitive writing strategies includes planning, drafting, and revision (Flower et al., 1981; Hayes, 1996). Whereas the four self-regulation strategies includes goal setting, task management, progress monitoring and reflection (Graham & Harris, 2006b; K. R. Harris et al., 2011; MacArthur et al., 2014) . Goal setting involves setting either a learning or performance goal for the lab report. Task management refers to the student's thoughts about the time and effort needed for the writing. In progress monitoring, the student determines if additional content knowledge is needed and the effectiveness of the writing strategies that were employed. Reflection refers to whether the student thinks about which strategies were helpful.

Although the importance of cognitive and self-regulated strategies has been widely recognized, research is still lacking in two major areas: exploring effects of cognitive and self-regulated strategies for completing science writing tasks, and systematic assessment procedures for evaluating student use of these processes.

Writing in the Sciences

Writing plays a critical role in learning and conducting science. Scientists frequently use written language to document ideas and discovers, make arguments and claims, and instruct students on scientific concepts and the underlying reasoning (Carter, 2007; Carter et al., 2007; Yore, Hand, & Prain, 2002, 1999). Good writing skills are required for composing grant proposals, teaching materials, technical reports and journal articles. In addition, written documents can be viewed as an external storage of thought processes, which allows time for students to reflect and make changes to their thinking.

In science classrooms, educators conceptualize two main types of writing activities: those that focus on writing to learn the subject matter versus learning to write in the discipline (Carter, 2007; Carter et al., 2007). There have been controversies on distinguishing the functions between these two types of writing tasks. Writing-to-learn activities has been described as "writing as a means of acquiring information, understanding concepts, and appreciating significant in any discipline." Whereas learning-to-write is described as "acquiring the socially-mediated communication skills and genre knowledge appropriate to a specific discipline" (Broadhead, 1999; Carter et al., 2007; McLeod, 1989). Tasks for writing-to-learn are characterized as short and simple activities (e.g. one-page write ups) that focuses on expressing what the student has learned about the course content. Whereas learning-to-write tasks, such as biology lab reports, centers around acquiring and practicing disciplinary language, the ways of knowing and doing within a specific academic domain (Carter, 2007).

Carter et al. (2007) argued that the dichotomy between these two types of writing tasks weakens the focus on students acquiring subject matter knowledge when engaged in a learning-to-write activity. He states that when students are taught how to use disciplinary language and think in a disciplinary specific way, students also need to process the subject matter content as well. Instead, the difference between the two writing activities resides in their definitions of learning. Writing-to-learn activities directly requires students to organize and express their understandings of the science materials in a written format with no emphasis on the writing mechanics and quality. Whereas learning-to-write activities requires students to learn scientific concepts in addition to learning about discipline specific ways of communicating knowledge (e.g. lab reports) and the ways of doing science (e.g. lab experiments).

Lab reports are learning-to-write activities. They are a formal write up that organizes and records the procedures done in the lab and what is learned from the experiment (Carter, 2007; Mackenzie & Gardner, 2006; Yore et al., 2002). Lab reports are a predominant writing genre of the science fields (Yore, Hand, & Florence, 2004). It provides a guideline of the scientific way of knowing through its components, normally including an introduction, methods, results, discussion. It has also been viewed as an apprenticeship genre where students can learn and practice the expert way of scientific reasoning. Carter et al, (2007) conducted interviews with college students on their views of the relationships between writing biology lab reports and learning biology content knowledge. Students expressed that various aspects of the biology lab report writing process helped them strengthen their biology knowledge, and also learn the structure of a lab experiment and the scientific way of discovering knowledge.

Unfortunately, many faculty members in the sciences struggle with how to effectively teach lab report writing (Armstrong, Wallace, & Chang, 2008; Carter et al., 2007; Conner, 2007; Puttick et al., 2015). From their perspective, writing is a general skill that is taught outside of the discipline (Carter, 2007). Some hold the view that writing skills should be taught by English teachers, and they expect students to learn how to write lab reports from freshman composition courses. A more common complaint centers around balancing instructional time on writing lab reports versus content knowledge (Balgopal & Wallace, 2013; Puttick et al., 2015). Many choose to sacrifice the former for the latter, providing only general writing guidelines and rubrics to help students learn how to write lab reports. However, research suggests that most first-year college science majors need explicit instruction on writing lab reports. A survey conducted by Simmons and colleagues (2014) reported that in the year 2010, 56% of first year biology undergraduates have never read a scientific article in a peer-reviewed journal. Thus, it is safe to say that biology college students have little understanding of science writing, in terms of the structure, style, and most importantly, strategies that are essential for proficient science writing.

Strategies for Biology Writing

College biology students may benefit from instruction on cognitive writing strategies and procedures to regulate their thinking and actions while writing biology essays and lab reports. Several studies have investigated strategies that students most often use to help them write biology essays, but research on lab reports is limited (Armstrong, Wallace, & Chang, 2008; Conner, 2007; Morgan, Fraga, & Macauley, 2011; Simmons et al., 2014). For instance, Armstrong et al., (2008) found that emphasizing argumentative standpoints in a biology essay had minimal impact on writing performance and learning outcomes. Interestingly, the amount and type of strategies students used during writing varied. The strategies that were employed included writing strategies such as planning and revising, and strategies that served a regulation function. Furthermore, students who produced higher quality essays are typically those who reported the most use of meta-cognitive regulation strategies (e.g. monitoring and self-questioning) and writing strategies (e.g. planning).

Similar findings were derived from a study by Conner (2007), which examined students use of meta-cognitive strategies for writing biology essays and journals. The researcher found that students seem to know a variety of strategies, but do not always execute the strategies properly. For instance, one of the student stated that he has a plan for choosing the relevant information and how he would write the biology essay. However, the researchers noted there was a lack of actual planning before and during the writing process. After this student finished the essay and was asked how did he plan his writing, he responded with “I just wrote it.”

To examine the strategic behaviors and thinking of college students in a more comprehensive and systematic way, it is crucial to understand how expert science writers approach biology writing tasks such as lab reports. Examining writing procedures of experts will help inform which strategies are most essential for students to use and produce high quality science writing.

A study by Yore and colleagues (2002) portrayed characteristics of the typical expert science writer through interviews. In their study, 17 faculty members in departments of science, applied science, or psychology provided their perceptions strategies that they utilize to help with the writing demands. The majority of scientists reported using a combination of cognitive writing strategies and regulatory procedures. All scientists talked about the planning, translating and revising processes of their writing experience and the writing strategies tailored to each phase. The main writing strategies mentioned included using mental or physical outline, following procedural guidelines, properly structure the format, and obtaining feedback or external verification from colleagues. Many scientists approach the writing plan and subsequent writing drafts with a clear purpose. It was acknowledged that having the audience in mind was crucial for setting the style and language. All of the scientists also expressed revision as a key strategy for producing the best writing quality across different writing genres.

Expert science writers also used self-regulation strategies to manage the writing processes (Yore et al., 2004, 2002), although they were mentioned less frequent than cognitive writing strategies. For instance, scientists monitor the writing progress by doing library research constantly before, during and after the actual writing process. Scientists set different goals to inform and persuade the audience with the results of their experiments. They also focus on including enough detail for the readers to understand their work and make informed decisions.

The existing research on strategies that novices and experts use for science writing is minimal, and less for biology lab report writing. However, it is important for biology educators to be knowledgeable about effective strategies they can teach to their students to improve lab report performances. The first step to gain an understanding of lab report strategies is to construct sound methodology for assessing these cognitive and meta-cognitive processes that students are engaging in when writing biology lab reports. After measuring these strategies, science educators can then be informed about which strategies are typically being used, which ones are most effective for producing high quality lab reports, and the relationships among using multiple strategies.

Assessing Cognitive and Self-Regulated Writing Strategies

Past research has employed a variety of methods to study cognitive writing strategies, as well as self-regulation strategies (Kellogg, 1994; Wolters & Benzon, 2013; Zimmerman, 2008). Cognitive strategies have been examined through lab-based experiments, “think-aloud” studies with protocol analysis, and text analyses studies (Flower & Hayes, 1981; Kellogg, 1994;

MacArthur et al., 2014). For instance, lab-based experiments analyze the effects of a certain strategy by comparing writing performances between student who received strategy instruction and those who did not (Brunstein & Glaser, 2011; K. Harris, Graham, & Mason, 2006; MacArthur et al., 2014). Early works by Flowers and Hayes (1981) used think-aloud techniques to study the underlying cognitive processes through writers' verbalizations and observable behaviors during writing. Methods for assessing general self-regulation strategies includes interviews, direct observations, think-alouds and trace methods (Cleary, Callan, & Zimmerman, 2012; Wolters & Benzon, 2013; Zimmerman, 2008). However, few studies have focused on developing methodology for assessing self-regulation strategies specific to lab report writing.

One of the most common ways to evaluate use of cognitive and self-regulation strategies across academic domains is through forced-choice surveys or inventories, in which participants' respond to various items using a Likert-scale (Cleary, 2006; Malpique & Veiga-Simão, 2014; Zimmerman, 2008). Malpique and Veiga-Simao (2014) reported cross-cultural validation on 12 self-regulated strategies that includes cognitive writing strategies for ninth grade writing. In addition, their EFA and CFA results indicated that the strategies loaded on three underlying higher order variables: environmental, behavioral and personal processes of self-regulated writing. Kaplan, Lichtinger and Gorodetsky (2009) also employed a self-report questionnaire to assess ninth grade students use of various self-regulation techniques and cognitive strategies. The instrument included 14 strategies measuring cognitive, metacognitive, motivational and behavioral strategies for writing. They found that learning environments and levels of writing achievement contributed to self-regulated writing processes, use of cognitive strategies and achievement goal adoption.

Measuring cognitive and self-regulation strategies using self-report instruments comes with advantages and disadvantages in research. A key advantage of surveys is that responses can be collected quickly and efficiently at low cost. In addition, these instruments have been found to be reliable and valid for complex quantitative analyses that measures various cognitive processes (Cleary et al., 2012; Wolters & Benzon, 2013; Zimmerman, 2008). However, there are also limitations to self-report surveys. For instance, they rely on the accuracy of participants' retrospective recall of how they engaged in past academic situations. The use of pre-written test items also restricts the potential strategies that students might use but are not reflected through the items. Also, the item content might not actually reflect the constructs being measured. Given these limitations, this study used rigorous methods to minimize the potential risks when developing self-report instruments. More specifically, three sources of validity evidence were collected in this study to support the interpretation and use of the cognitive and self-regulated strategy instrument for lab report writing.

Validity Evidence

According to the latest *Standards for Educational and Psychological Testing* (APA, AERA & NCME, 2014), the validation process is a fundamental aspect for developing instruments. Validity is a unitary concept, and it is the extent to which accumulated evidence supports the intended interpretation of scores and the proposed use. The process of validation provides sound scientific arguments for the constructs that are being measured. Adequate support for proper interpretation and use is derived from multiple sources of validity evidence. In this study, three sources of validity evidence for the Cognitive and Self-Regulated Writing Strategies instrument was gathered and examined. The sources of validity include: (a) evidence based on content, (b) evidence based on internal structure, and (c) evidence based relationships with other variables.

Evidence based on content. Evidence based on content examines the relationship between the themes, wording, and format of each item on instrument and the constructs it is intended to measure (APA, AERA & NCME, 2014). It is proposed that this instrument measures three cognitive strategies (i.e. planning, drafting and reviewing), and four self-regulation strategies (i.e. goal setting, task management, progression monitoring and reflection). Validation of the instrument content came from expert judgements on initial items that were constructed to reflect these strategies. Examining expert ratings on quality of item content will provide an initial step to guide proper interpretation of the constructs reflected by the instrument. Specifically, this process will identify the items that has good content alignment with the strategies. It will also document the process of which modifications were made for obtaining representative items.

Evidence based on internal structure. Examining the internal structure of the instrument can indicate the extent to which the relationships among the items corresponds to the strategies to be measured (APA, AERA & NCME, 2014). After the initial examination of content representativeness, the internal structure of the remaining items will be analyzed using an exploratory factor analysis. The conceptual framework for this instrument implies that seven strategies for lab report writing are expected to emerge from this analysis. The factor analysis will examine the intercorrelations among the items, and describe the distinct dimensions of each strategies for lab report writing that are derived from the instrument. This will provide further statistical evidence to support proper interpretation and use of the instrument.

Evidence based on relationships with other variables. Developing an instrument on cognitive and self-regulation strategies implies that these constructs should be related to other variables. Evidence for criterion validity was gathered by analyzing the relationship between cognitive and self-regulation strategies, writing self-efficacy, and lab report performances. Specifically, an analysis of discriminant and predictive validity of the instrument will be provided.

Discriminant validity. Discriminant validity will provide evidence that writing self-efficacy is a distinct construct from self-regulation and cognitive strategies. In other words, items that measure writing self-efficacy are expected to converge onto one factor, and strategy items would converge onto separate factors different from the self-efficacy variable.

Previous studies have shown that use of writing strategies are determined in part by student's self-motivational beliefs such writing self-efficacy (Brunstein & Glaser, 2011; Graham & Harris, 2006a). More specifically, students who are highly efficacious in their writing competency were more likely to be self-regulated writers as well (Hidi & Boscolo, 2006; Macarthur et al., 2014). Therefore, it is expected that cognitive and self-regulation strategies for lab report writing will have a distinct, yet positive relationship with biology writing self-efficacy. Discriminant validity will be examined through an exploratory factor analysis, and these procedures will provide evidence for the conceptual and statistical distinction between strategies for lab report writing and writing self-efficacy.

Criterion validity. Criterion validity provides evidence that the self-regulation and cognitive strategies to be measured predicts writing performances on lab reports. Examining whether strategies are potential predictors of a criterion performance will indicate its utility value for science educators. Strategic and regulatory processes have been found to positively predict writing performances on a wide range of general academic writing tasks (Brunstein & Glaser, 2011; Macarthur et al., 2014). This study will extend existing on past findings and examine whether the predictive power of strategies for writing generalizes to biology lab report performances.

Criterion validity will be examined by a multiple regression analysis on whether use of strategies for lab reports significantly predicts lab report writing achievements. Control variables includes biology writing self-efficacy and lab section that students are enrolled in. Previous studies have shown that writing self-efficacy is a strong predictor of writing performances therefore should be accounted for when examining effects of strategies on writing quality (Pajares, 2003). The lab sections students enrolled in were self-selected, therefore this was controlled to accounted for any individual differences among students across sections.

The Present Study and Research Questions

The purpose of this study is to develop and validate a new self-report instrument to assess cognitive and self-regulation strategies for biology lab report writing. Based on established frameworks of cognitive writing processes and self-regulated writing, seven strategies tailored to lab reports will be examined. To support the interpretation and use of this instrument, three sources of validity evidence are being collected and analyzed: evidence based on content, evidence based on internal structure, and evidence based on relations to other variables. The following research questions will be investigated in this study:

1. Is there evidence to support the item content of the instrument to reflect cognitive and self-regulated strategies for biology lab report writing?

2. Is there evidence for the internal structure of the instrument to reflect cognitive and self-regulated strategies for biology lab report writing?

3. Is there evidence to support discriminant and predictive relationships between strategies for biology lab report writing and other variables?

a. Are strategies for biology lab report writing distinct from biology writing self-efficacy?

b. Does use of strategies for biology lab report writing predict lab report performances?

Chapter 3

Methods

Participants

Expert participants. Two professors from the Department of Biology and one from Department of Educational Psychology were recruited at a research university to provide content validity judgements. The biology professors served as experts on biology lab report writing, whereas the educational psychology professor was an expert on writing self-regulation and writing strategies. On a 5-point Likert Scale, experts were asked to provided their judgements on the ease of comprehending each item (1 is very hard to understand, 5 is very easy to understand), appropriateness of format and wording (1 is very inappropriate, 5 is very appropriate), and representativeness of each item content (1 does not reflect at all, 5 is accurately reflect this construct). They were also asked to write any modifications they suggest for each item. See Appendix A for the Cognitive and Self-Regulated Writing Strategies Instrument for biology lab report (Initial 32 Items) and Appendix B for a sample of the form that was administered to experts.

Student participants. Student participants were recruited from thirty-eight sections of a Physiology Laboratory course at a large university. The original sample consisted of 554 participants. The final sample included 433 students after using a list-wise deletion method for 2% of the data that were missing. Some students did not complete the survey, and some other students entered duplicate responses. The mean age was 19 years old. The ethnicity of the students was predominantly White (77.8%), followed by Asian (7.7%), African American (5.4%), Hispanic (4.5%), and other (4.3%). The majority of the students were female (77.8%).

Most students were sophomore year (39.9%), followed by freshman (22.2%), junior (20.9), seniors (12.9) and year 5 of undergrad (4.1%).

Near the end of the semester, the biology students were administered a revised writing and self-regulation strategies instrument through Qualtrics, which is an online survey software. The 28 items were generated from the expert judgements on content validity. More details are provided in the materials and results section. Extra credit points were provided to students as a compensation.

Materials

Cognitive and Self-Regulated Writing Strategies instrument for lab reports. The author constructed 32 initial items to assess three types of writing strategies, and four self-regulation strategies for lab report writing. See Appendix A for a full list of the initial items, and Table 1 for an overview of each strategy. The 32 initial items were reduced and modified into 28 items based on expert judgements on content representativeness. Thereafter, biology students were administered the 28 item instrument to examine its internal structure. On a Likert scale from not at all true of me (1) to very true of me (7), students were asked to rate the strategies that they would to write a lab report. A final reduction was conducted based on results from the factor analysis and it consisted of 22 items that measured writing and self-regulation strategies for lab report writing. A full discussion of the reduction processes will be provided in the results section.

Table 1

Initial Seven Factors for the Cognitive and Self-Regulated Writing Strategies Instrument (32 Items).

Strategy	No. of Items	Sample Item
Cognitive Strategies		
Planning (P)	7	For writing a biology lab report, I would make a writing plan by analyzing the overall requirements
Drafting (D)	4	For writing a biology lab report, I would use the plan and draft supporting details of the main ideas
Reviewing (REV)	5	For writing a biology lab report, I would revise the drafts based on given feedback
Self-Regulation Strategies		
Goal Setting (GS)	3	For writing a biology lab report, I would set short term goals
Task Management (TM)	5	I would manage how much effort I use for writing a biology lab report
Progress Monitoring (PM)	4	For writing a biology lab report, I would write without asking myself any questions about the writing process
Reflection (REF)	4	After writing a biology lab report, I would reflect and consider what goals to set for the next assignment

Biology writing self-efficacy scale. The biology writing self-efficacy scale was adopted from the Baldwin, Ebert-May and Burns., (1999) study and measured students' judgements in their capability to write and critique various aspects of a biology lab report. On a scale from 0 (not confident at all) to 100 (totally confident), students were instructed to rate their confidence in writing the introduction, procedures, methods, results and conclusions of their lab report, as well as critiquing different aspect of a lab report to other students. The instrument showed high internal reliability with a Cronbach's alpha of 0.912. See Appendix C for the full instrument.

Biology lab report grades. Biology lab report grades were obtained from the final writing assignment in the Physiology Laboratory course where students were recruited. The final lab report followed a traditional four section structure, including an introduction, methods, results and discussion. Students were instructed to write the lab report on an exercise physiology experiment they conducted in class. They were given detailed guidelines that included brief descriptions on what typically goes into each section of a lab report, and specific questions that needed to be answered related to the experiment. All of the writing assignments were graded by teaching assistants, and points were given based on quality of content, appropriate structure of the report, and language mechanics. The final lab report had a total of 20 points, in which 3 points was assigned to introduction, 3 points for methods, 5 points for results, 4 points for discussion, 1 point for references, and 4 point for style and grammar.

Chapter 4

Results

Evidence Based on Content

On a 5-point rating scale, the average expert ratings across 32 initial items on the instrument was 3.84 (SD = 0.603). For each aspect of test content rated across experts, the average ease of comprehension was 3.85 (SD = 0.682), average individual item content representativeness was 4.08 (SD = 0.66), and average appropriateness of format was 3.61 (SD = 0.68), with each scale having a maximum of 5 points. To maximize the alignment of item content and the cognitive and self-regulation strategies they intended to reflect, the author conducted modifications to the items based on expert recommendations, low ratings on either aspect of each item and a final consultant with two other Educational Psychology professors. Specifically, several items were either deleted, reworded, or replaced with new items. In addition, A few items were merged or split into multiple items to provide a better representation of the constructs.

One of the main revisions was substituting technical words such as “analyze” and “genre elements” with more commonly used words such as “think” and “parts of a lab report”. The purpose was to help undergraduates better comprehended each item and provide more accurate responses. The final item pool resulted in 28 items and was administered to biology students to examine the internal structure. See Appendix D for descriptive statistics of the ratings and revisions that were made for each item. Appendix E presents the revised items used in analysis of the internal structure and criterion validity.

Evidence Based on Internal Structure

The initial results show that the correlation matrix is appropriate for factor analysis, based the Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy (0.844), and Bartlett's Test of Sphericity, chi-square = 4732.037, df = 378, p = 0.000. See Appendix F for the pattern matrix of EFA results for the 28-item instrument. Overall, 6 items were removed from the 28-item instrument. Among them, four items did not load on any factors, including the only two items that were intended to measure task management (RTM21 "When I decide how to work on the lab report, I think about how much time I need to finish it" and RTM22 "I think the result of my lab report is related to how hard I work on it"). The other two items with low loadings were planning (RP6 "I write down whatever comes to my mind") and drafting items (RD8 "I follow a plan when writing the draft"). Two more items were removed due to a high amount of cross loading on two different factors (RGS19 "Before I begin writing my lab report, I set a goal for the grade I would like to get on this assignment", and RP5 "I think about the guidelines given and then create a plan for my writing"). After removing these items mentioned above, 22 items were retained, each with item loadings of 0.3 or greater on one and only one factor.

The remaining items were submitted to a second EFA and three criteria were used for determining the final instrument factors, including retaining factors with eigenvalues greater than 1, a visual analysis of the scree plot, and examining factor loadings to determine representativeness and meaningfulness of each item. Six factors emerged with eigenvalues greater than 1.0. These six factors accounted for 64% of the total variance. See Table 2 for descriptive statistics of the six-factor instrument, and Appendix G for a full list of items in the Cognitive and Self-Regulated Writing Strategies instrument.

Table 2

Descriptive Statistics of Six-Factor Solution with 22 items.

Factors	Factor Label	No. Items	M(SD)	alpha	Eigenvalues	% variance explained
1	Self-Regulation Strategies	7	3.445 (0.672)	0.802	5.987	27.212
2	Revision Based on Peer Feedback	3	2.824 (1.055)	0.878	2.560	11.638
3	Revision Based on TA Feedback	3	2.872 (1.183)	0.864	1.746	7.937
4	Drafting	3	3.421 (0.949)	0.799	1.183	5.376
5	Planning	4	3.904 (0.622)	0.709	1.514	6.884
6	Evaluation of Writing Mechanics	2	4.573 (0.553)	0.569	1.097	4.989

According to the item loadings for the six-factor solution (see Appendix H for pattern matrix of EFA results for the 22-item instrument), the first factor was labeled self-regulation strategies. These items measured reflection, goal setting and progress monitoring aspects of self-regulated writing. The self-regulation strategies factor accounted for 26% of the variance, and item loadings ranged from 0.888 to 0.35.

Factors 2, 3 and 6 were intended to measure a single reviewing strategy. However, the pattern matrix shows that these items reflected three factors instead of one. They were individually labeled as Revision Based on Peer Feedback (factor 2), Revisions Based on TA Feedback (factor 3), and Evaluation of Writing Mechanics (factor 6). Revisions Based on Peer Feedback included accounted for the second largest amount of variance (11%), and item loadings ranged from 0.964 to 0.695. Revisions Based on TA Feedback accounted for the third largest amount of variance (7.722 %), and loadings ranged from 0.993 to 0.7. Evaluation of Writing Mechanics accounted for 4.772% of the variance, and the item loadings were 0.728 and 0.582.

Factor 4 included 3 out of the 4 items that was hypothesized to measure students' use of single and multiple drafts before they hand in their final lab report. The Drafting strategy accounted for 5.62% of variance, and item loadings ranged from 0.931 to 0.478. Factor 5 included 4 out of the 6 items that was hypothesized to measure planning as a strategy for writing lab reports. Planning accounted for 7.032% of the variance. Item loadings ranged from 0.778 to 0.419.

In general, 5 out of the 6 factors had moderate to good reliabilities, in which the range of Cronbach's alpha was 0.709 (Drafting) to 0.878 (Revision Based on Peer Feedback). Not surprisingly, due to only having two items, evaluation of writing mechanics had the lowest reliability, alpha = 0.569. After examining the item content, pattern matrix and scale reliabilities as mentioned above, the six-factor solution with 22 items was determined to be the most interpretable, which included most of the cognitive and self-regulation strategies that were expected. However, there were differences between how biology students perceive strategies and sub-strategies and findings from previous studies with students who work on non-science writing tasks (Kaplan, Lichtinger, & Gorodetsky, 2009; Malpique & Veiga-Simão, 2014).

Evidence Based on Relationships with Other Variables

Discriminant validity. To examine discriminant validity, a third principal axis factor analysis was conducted using responses on the Cognitive and Self-Regulation Strategies instrument and the Biology Writing Self-Efficacy measure. The purpose of this exploratory factor analysis was to investigate whether items from the instrument loaded on factors distinct from the self-efficacy variable. Correlations among the factors measured by these two instruments were also examined.

According to the pattern matrix, seven factors were extracted from these two instruments, accounting for 64% of total variance. The first factor consisted of items from the Biology Writing Self-Efficacy instrument. The remaining items loaded on six individual factors of corresponded to the cognitive and self-regulation writing strategies found in the previous section. See Appendix I for the pattern matrix of 22-Item instrument with biology self-efficacy items.

The Pearson correlations shows that biology writing self-efficacy was significantly and positively related to self-regulation ($r = 0.156$), planning ($r = 0.291$), drafting ($r = 0.098$) and evaluation of writing mechanics ($r = 0.268$), but was not related to revisions based on peer ($r = 0.017$) or TAs ($r = 0.049$) feedback. Overall, biology writing self-efficacy has a low to moderate association (rs = 0.017 – 0.291) with the cognitive and self-regulation strategies. Specifically, biology writing for self-efficacy had the weakest significant relationship with drafting ($r = 0.098$) and the strongest with planning ($r = 0.291$). Overall, the findings established discriminant validity evidence for the Cognitive and Self-Regulated Writing Strategies instrument. See Table 3 for correlations between biology writing self-efficacy and writing and self-regulation strategies.

Criterion validity. Table 3 shows that grades on the final lab assignment were significantly and weakly related to biology writing self-efficacy ($r = .139$, $p<0.05$), revisions based on TA feedback ($r = .134$, $p<0.05$), drafting ($r = .162$, $p<0.05$), and evaluation of writing mechanics ($r = .110$, $p<0.05$). These results suggested that higher grades on final lab reports are positively associated with students' perceptions on their abilities to write biology, making revisions based on TAs feedback, conducting multiple drafting and making corrections to their style and grammar errors. Writing performances on final lab reports were not statistically significantly associated with use of self-regulation strategies, making revisions based on peer feedback, and planning. A one-way ANOVA was conducted to determine if final lab report grades was different based on sections students enrolled in. Final lab report grades were statically significantly different across sections, F (37,401) = 2.356, P<0.05. Tukey post hoc analysis revealed that differences in writing performances occurs across multiple sections, and the mean difference ranged from 2.5 to 3 points in the lab report grades.

A stepwise multiple linear regression analysis was conducted to test the relationships between strategies for writing biology lab reports and writing performances. Specifically, the analysis would determine if the addition of cognitive and self-regulation strategies obtained from the factor analysis improved the prediction of final lab report performances over and above effects of lab section and biology writing self-efficacy. Table 5 reports the stepwise regression analysis of predicting final lab report grades. Step 1 included the control variables, and together they significantly account for variance in final lab report grades, R^2 = 0.198, F (38, 394) = 2.556, p<0.05. That is, the lab sections and biology writing self-efficacy explained around 19.8% of the variance in writing performance on final lab reports.

Step 2 entered the cognitive and self-regulation strategies extracted from the internal structure analysis and the addition of strategies led to a statistically significant increase in variance explained in final lab report grades, R^2 change = 0.040, F change (6,388) = 3.365, p>0.05. That is, after controlling for variance in sections and biology writing self-efficacy, the cognitive and self-regulation strategies significantly contributed to explaining differences in final lab report performances. Overall, the full regression model results in an R^2 of .237, and accounted for 23.7% of the variance in lab report grades. Among the six strategies, only revision based on TA feedback (β = .136, p<0.05) and drafting (β = .123, p<0.05) was significantly and positively predictive of performances. These findings provides predictive validity evidence for the instrument.

Table 3
Correlation Matrix.

	1	2	3	4	5	6	7	8
1. LRG	1							
2. BWSE	0.139**	1						
3. SR	0.008	0.156**	1					
4. RPF	-0.018	0.017	0.250**	1				
5. RTAF	0.134**	0.049	0.256**	0.336**	1			
6. D	0.162**	0.098*	0.314**	0.334**	0.474**	1		
7. P	0.120	0.291**	0.503**	0.205**	0.222**	0.312**	1	
8. EWM	0.110*	0.268**	0.253**	0.209**	0.170**	0.281**	0.300**	1

Notes: LRG = Lab Report Grades, SR = Self-Regulation Strategies, RPF = Revision Based on Peer Feedback, RTAF = Revision Based on TA Feedback, D = Drafting, P = Planning, EWM = Evaluation of Writing Mechanics. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 4

Stepwise Regression Analysis on Predictors of Final Lab Report Performances

	Step 1		Step 2	
Variable	B (SE)	β	B (SE)	β
Self-Efficacy	.016(.005)**	.144**	.014(.006)*	.126*
Self-Regulation			-.145(.142)	-.059
Revisions Based on Peer Feedback			-.137(.082)	-.086
Revisions Based on TA Feedback			.193(.082)*	.136*
Planning			-.130 (.155)	-.049
Drafting			.218(.099)*	.123*
Evaluation of Biology Writing Mechanics			.225(.154)	.075
R^2	.198**		.237**	
F	2.556**		2.746**	
R^2 change			.040**	
F for change in R^2			3.365**	

*p<0.05. **p<0.01.

Chapter 5

Discussion

The primary purpose of this study was to develop an instrument to measure writing and self-regulation strategies employed by biology students when composing lab reports. Potentially, this instrument can be used to identify strategies that undergraduate students may or may not be using to assist their lab report writing processes. Information on which strategies are crucial for explaining lab report performances was also derived from this investigation.

Initial psychometric properties and validity evidence was gathered to examine the interpretation and use of this instrument. In general, validity evidence was shown to be positive as demonstrated by evidence for test content, evidence for internal structure, and evidence for relationships with other variables. Throughout the validation process, a series of modifications and reductions of the items was conducted to refine the alignment between items and constructs of interest. The final instrument consisted of 22 items that measures six strategies for lab report writing that can be interpreted as: self-regulation strategies, planning, drafting, revisions based on peer feedback, revisions based on TA feedback, and evaluation of writing mechanics. Furthermore, this study extends on past research in which it analyzed the relationships among cognitive and self-regulation strategies for lab report writing, and how they influence self-efficacy and writing performances in the biology domain.

Evidence Based on Content

Given that undergraduate biology students are the intended audience for this instrument, it is important to control for students' interpretations of the item content to obtain proper responses on which strategies they employ for lab report writing. Instruments that have appropriate formatting and wording for undergraduates will help exclude extraneous and unwanted influences to the responses, such as lack of knowledge or misunderstanding of a word in the items. Thus, validity evidence based on content came from experts' judgements on the connections between the overall design of the items and the strategies hypothesized to be measured. The experts suggested that not all undergraduates are familiar with or share the same understanding of advanced terminologies such as "analyzing". Therefore, revisions were mainly made to items rated as difficult to comprehend or has an overly complicated format for undergraduates. After a series of modifications and reductions of items, the content of the instrument had adequate ease of comprehension, appropriateness of format, and represents cognitive and self-regulation strategies specific to composing biology lab reports.

Evidence Based on Internal Structure

The remaining 28 items with good content representativeness were administered to a large group of undergraduate biology students to examine its internal structure. Exploratory factory analysis procedures produced a six-factor solution, with 22 items on the final version of the instrument. Five out of the six factors had moderate to very good internal consistencies.

The self-regulation factor consisted of items measuring goal setting, progress monitoring and reflection for lab report writing. Biology students who score high on this factor can be expected to exhibit regulatory thoughts, such as thinking about which writing strategies were helpful and whether students have sufficient content knowledge for completing the lab report (Harris et al., 2011; Zimmerman & Risemberg, 1997). In contrast to the four separate regulation strategies that the instrument was initially expected to measure, the factor loadings show that these items explain more variance together rather than as separate constructs. Zimmerman and Reisemberg (1997) described self-regulation of writing as a cyclical and complex system that involves interdependent processes. Specifically, proficient writers often use regulation strategies in conjunction with each other while composing. For instance, reflecting upon the past lab report writing process can involve setting goals for future writing tasks. Therefore, it can be expected that distinct self-regulation procedures might converge onto a single factor that represents an overall control and monitoring of one's thoughts and behaviors during writing.

Interestingly, items for task management did not load on any constructs. These items were mainly designed to measure whether students think about the amount of time and effort they will need to invest in writing the final lab report. Compare with goal setting, progress monitoring and reflection, the items for task management were more centered around controlling behavioral aspects of writing a lab report. Whereas items on progress monitoring for instance, were more focused the thought processes underlying the regulation of writing experience. Although the behavioral and cognitive aspects of self-regulated writing are both crucial to examine, the common link among the self-regulation strategies measured in this study appears to be more covert and cognitive, rather than overt and behavioral.

EFA results further showed that the original review factor was split into three finer grain strategies. These cognitive writing strategies represented whether students make revisions based on peer feedback or TA feedback, and whether students check to see if they followed the writing guideline, correct their spelling or grammar errors. Students average use of revisions based on peer (mean = 2.82) or TA (mean = 2.87) feedback was the lowest among the six strategies. A possible reason for the least popularity of these strategies might be that students do not ask for feedback unless they were instructed to by the professor. In the case of this study, the course instructor and TAs might have only suggested students to seek feedback from others, but it was not required. Another reason is that asking feedback on lab reports from peers or TAs might not be a commonly used strategy for novice writers. This study showed that undergraduate students were more familiar with evaluating writing mechanics because they reported the most usage of this strategy (mean = 4.57).

Previous research on proficient science writers indicated that reviewing a piece of writing also involves making revisions based on others feedback and checking writing mechanics, such as proofreading to correct style and grammatical problems (Yore, Florence, Pearson, & Weaver, 2006; Yore et al., 2004, 2002). Expert science writers perceived reviewing as a multi-stepped and iterative process that incorporates different types of revision strategies. Strategies that experts reported using shared similar functions as the ones biology undergraduates reported in this study. However, expert science writers heavily focused on employing all aspects of reviewing and described reviewing as one of the most important strategies for writing, which was not reflected so much by the undergraduates. Although students in this study frequently corrected and checked mechanical errors during revisions, they were least likely to ask others for feedback. These findings show that undergraduate students, like expert writers, are knowledge about different types of strategies. However, unlike experts, they do not use some of the more effective aspects of reviewing as frequently as the experts would recommend.

The remaining two strategies reflected by this study are drafting and planning. Although several original planning items were deleted due to low factor loadings, most of these items were fairly stable and highly correlated with the planning factor. The mean usage of planning was 3.904, and this was the second most frequently used strategy after evaluation of writing mechanics. The Planning strategy reflected whether students create a plan for writing a lab report by thinking about the topic, audience, purpose and specific parts of the lab report structure. The Drafting strategy reflected whether students use multiple draft and revise the draft before turning in the lab report. The mean usage of a drafting strategy was 3.421. These results shows that based on the internal structure of the instrument, planning and drafting strategies can be both adequately measured using the corresponding items.

Evidence Based on Relationship with Other Variables

Evidence for the instrument's association with other variables was provided by examining relationships among the six cognitive and self-regulation strategies, biology writing self-efficacy and lab report writing performances. Discriminant validity findings were consistent with previous frameworks on writing and self-regulation, in which strategic processes for biology writing and regulation are conceptually and empirically distinct from students' perceptions of their competence in biology writing (Baldwin, et al., 1999; Brunstein & Glaser, 2011; Macarthur et al., 2014). A principal axis factoring analysis showed that the six strategies for lab report writing loaded on separate factors from biology writing self-efficacy. In addition, biology writing self-efficacy had a low to moderate association ($r = 0.017 – 0.291$) with the writing and self-regulation strategies.

The correlation results further indicated that self-efficacy in biology lab report writing is not linearly associated with higher use of all types of cognitive and regulatory strategies across writing genres. Instead, individual differences in writing self-efficacy contributes to the preference and use of certain strategies. Specifically, biology writing self-efficacy had the strongest significant and positive association with planning (r = 0.291), and the weakest with drafting (r = 0.098). This shows that students who perceive themselves possessing high confidence in their ability to write good lab reports are most likely to consider aspects of the lab report, such as the topic, audience, writing guidelines, and then make a plan for generating ideas and subsequent writing. On the other hand, those with high self-efficacy are less likely to engage in writing multiple drafts of the lab report compared with other regulation strategies.

Biology writing self-efficacy was significantly associated with evaluation of writing mechanics and self-regulation. It could be possible that confident students did not engage in lots of drafting was due to increase checking for mechanical errors and high quality regulatory processes that guided their writing. Further research is needed to explore the direction of influences between motivational and regulatory processes during lab report writing.

Previous studies situated in the general academic domains consistently suggests that employing strategies for writing results in better writing quality (K. R. Harris et al., 2011; Hidi & Boscolo, 2006; MacArthur et al., 2014). This study narrowed the scope of analysis to examine whether cognitive and self-regulation strategies are predictive of writing performances in biology lab reports. This study showed that the six cognitive and self-regulation strategies emerged from the factor analysis significantly explained additional variance in final lab report qualities at the end of the semester, over and above variance accounted by sections and biology writing self-efficacy. In addition, consistent with previous studies situated in non-science contexts (Brunstein & Glaser, 2011; Hidi & Boscolo, 2006; Pajares, 2003), students sense of efficacy in biology writing was significantly predictive of lab report performances. That is, biology students who are more confident in their abilities to write in the biology domain are more likely to receive higher grades on their lab reports. Thus, criterion validity evidence for the cognitive and self-regulated writing instrument was provided from these analyses.

Across the six strategies, only drafting and revisions based on TA feedback had significant and independent contributions to lab report writing grades. Drafting and revision strategies have been found to be critical procedures for promoting writing performances across a variety of tasks (Brunstein & Glaser, 2011; MacArthur et al., 2014; Tracy, Reid, & Graham, 2009). As for writing biology lab reports, college students perceived that these strategies were particularly influential to the quality of scientific descriptions of biology lab experiments.

Evaluation of writing mechanics, planning and drafting were the most used strategies by college students for composing their lab reports. Whereas making revisions based on TA feedback was one of the least used strategies. However, there is a disconnection between the strategies that students most frequently used and the quality of the writing outcomes. The regression analysis showed that students who were spending more time on checking their spelling, grammar, whether they following the rubric, and planning how to write the lab report, did not translate to better lab report grades. On the contrary, descriptive results showed that students were least likely to ask their TA for feedback, but those who did received higher grades on their lab reports.

There are two possibilities to explain this pattern. First, it could be that only drafting and revision strategies are essential to composing good biology lab reports college, and unfortunately, most of these students are not allocating their time and effort to these beneficial strategies. However, this is unlikely due to the wide range of strategies that expert science writers have reported using for scientific writing (Yore et al., 2004, 1999). The expert science writers expressed that planning and regulatory strategies are also necessary for obtaining high quality writing. Many indicated that good science writing requires managing of multiple strategies, and high self-regulation throughout the long periods of time engaged in the composition process (Yore et al., 2004).

Second, college biology students might be inappropriately and ineffectively using the strategies that were not predictive of lab report performances (e.g. planning and self-regulation). The biology course explored in this study did not include a full component of writing instruction or strategy instruction for how to compose good lab reports. Students received a detailed guideline on what was expected to be written in each section of the lab report, but there was no instruction on how to effectively and efficiently write lab reports. It is difficult to assess whether students had accurate knowledge of strategies such as self-regulating and how were they using them.

Strategy instruction in the writing domain has yet to target discipline specific tasks such as biology lab reports. Successful instruction frameworks like Self-Regulated Strategy Development (SRSD) and it's alternative models have only been targeting elementary to secondary classrooms and domain general writing tasks (e.g. expository writing, argumentative writing) (Graham & Harris, 2006a; K. R. Harris et al., 2011; MacArthur et al., 2014). Results from this study shows that without systematic strategy instruction or guidance for how to write biology lab reports, college students only regard drafting and revision strategies as essential to lab report performances. Further research is needed on how students use cognitive and self-regulation strategies, and how to best instruct those who don't use these strategies for composing lab reports.

Limitations and Areas for Future Research

There are several limitations to this study. First, the differences in lab report grades across sections might have been influenced by either student characteristics or inconsistency in TA grading. For instance, some of the sections might have had a higher concentration of students with a certain biology major (e.g. ecology), and their prior experience in biology lab report writing could be different from another section with students from a different major (e.g. neuroscience). Also, the 22 TAs did not undergo systematic training in how to score the final lab reports. The only instructional training that they were given was a detailed lab report rubric and guidelines. It is unclear how much did the student and TA factors influenced the final lab report performances. Future studies that involves large number of students in multiple sections with different TAs should be cautious about how the raters were trained and individual differences among students across each section.

Second, evidence based on relationship with other variables was only analyzed by using biology writing self-efficacy and lab report writing performances. Strategies for writing and self-regulation have been shown to be linked to various constructs such as writing interest and task value (Hidi & Boscolo, 2006). Students who employ various strategies to help them write better lab reports could also be students who perceive the task as important or aligns with their interest in the biology content. Additional evidence to support the relationships writing and self-regulation strategies have with other variables should be explored by future research.

Third, the cognitive and self-regulation strategies measured might not capture a full view of all important strategies students use to write lab reports. This is mainly because the items were constructed from non-biology literature. Due to the lack of studies in biology writing or lab report writing, there were only a few strategies for lab report writing described in existing literature. In addition, a qualitative method such as using open ended responses or a think-aloud procedure might provide a fuller range of strategies that students typically use for lab report writing. More studies should be conducted on examining strategies unique to biology that was not included in this study.

Conclusions

The cognitive and self-regulation strategies instrument developed and validated in this study adds to existing research on examining the strategic processes underlying writing biology lab reports in two critical ways. First, it provided a better understanding of the strategies that are employed by college biology students. Specifically, the final 22 items were interpreted to measure six different strategies, including self-regulation, planning, drafting, revisions based on peer feedback, revision based on TA feedback, and evaluation of writing mechanics. Second, this study provides initial evidence for reliability and validity of a self-report strategies instrument for lab report writing. Furthermore, drafting and revisions based on TA feedback appear to be most associated with final lab report performances. Science faculty and researchers may benefit from this instrument by examining changes in strategic and regulatory processes of college students when composing lab reports, which can potentially inform strategy instruction for science writing.

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Appendix A
Cognitive and Self-Regulated Writing Strategies Instrument for Biology Lab Report (Initial 32 Items)

Instructions to Students: The following items asks about the cognitive and self-regulation strategies you would use for writing a biology lab report. There are no right or wrong answers. Use the scale from <u>not at all true of me</u> (1) to <u>very true of me</u> (7) to rate how accurate each statement describes you.

Cognitive Strategies

<u>Planning</u>

P1. For writing a biology lab report, I would make a writing plan by analyzing the topic
P2. For writing a biology lab report, I would make a writing plan by analyzing the audience
P3. For writing a biology lab report, I would make a writing plan by analyzing the purpose of the assignment
P4. For writing a biology lab report, I would make a writing plan by analyzing the genre elements
P5. For writing a biology lab report, I would make a writing plan by analyzing the overall requirements
P6. For writing a biology lab report, I would use free style writing (-)
P7. For writing a biology lab report, I would write down random ideas that comes to mind (-)

<u>Drafting</u>

D8. For writing a biology lab report, I would use the plan and draft sentences of the main ideas
D9. For writing a biology lab report, I would use the plan and draft supporting details of the main ideas
D10. For writing a biology lab report, I would write one draft of my lab report and hand it in (-)
D11. For writing a biology lab report, I would write multiple drafts

<u>Review</u>

REV12. For writing a biology lab report, I would evaluate my drafts
REV13. For writing a biology lab report, I would ask a peer to review my drafts
REV14. For writing a biology lab report, I would ask the TA to review my drafts
REV15. For writing a biology lab report, I would revise the drafts based on given feedback
REV16. For writing a biology lab report, I would hand in the final draft without revision (-)

Self-Regulation Strategies

<u>Goal Setting</u>

GS17. For writing a biology lab report, I would set personal goals (e.g. I want to get an A on this assignment)
GS18. For writing a biology lab report, I would set short term goals
GS19. For writing a biology lab report, I would set long term goals

<u>Task Management</u>

TM20. I would manage my time for writing a biology lab report
TM21. I would manage the location where I write a biology lab report

TM22. I would manage how much effort I use for writing a biology lab report
TM23. I would manage my emotions and motivations for writing a biology lab report
TM24. I would write whenever and wherever I want for writing a biology lab report (-)

Progress Monitoring
PM25. For writing a biology lab report, I would monitor my progress while I write by asking "do I have sufficient content knowledge for the assignment?"
PM26. For writing a biology lab report, I would monitor my progress while I write by asking "am I using strategies to help me write?"
PM27. For writing a biology lab report, I would monitor my progress while I write by asking "are the strategies helping me to improve my writing?"
PM28. For writing a biology lab report, I would write without asking myself any questions about the writing process

Reflection
REF29. After writing a biology lab report, I would reflect and consider which strategies were helpful
REF30. After writing a biology lab report, I would reflect and consider what I learned about the lab report assignment
REF31. After writing a biology lab report, I would reflect and consider what goals to set for the next assignment
REF32. After writing a biology lab report, I would not think about how was the writing process (-)

Appendix B

Sample of Expert Judgement Form for One Item

Instructions for the instrument when administered to students: The following items asks about the cognitive and self-regulation strategies you would use for writing a biology lab report. There are no right or wrong answers. Use the scale from not at all true of me (1) to very true of me (7) to rate how accurate each statement best describes you.

Cognitive Strategies Items

Planning

1. For writing a biology lab report, I would make a writing plan by analyzing the topic

Please rate the ease of comprehension for this item

1 Very hard to understand	2	3	4	5 Very easy to understand

How appropriate is the format and wording of this item for measuring planning?

1 Very inappropriate	2	3	4	5 Very appropriate

How well does the content of this item reflect student's use of planning?

1 Does not reflect at all	2	3	4	5 Accurately reflects this strategy

If you were to modify the item, please write the modifications you would suggest:

Appendix C

Biology Self-Efficacy Writing Scale

Items adopted from Baldwin, J. A., Ebert-May, D., & Burns, D. J. (1999). The development of a college biology self-efficacy instrument for non-majors. *Science Education*, *83*(4), 397–408.

Instructions: The following questions are statements about your confidence in writing and critiquing biology lab reports. There are no right or wrong answers. For each question, please rate on the following scale: 0 (not confident at all) to 100 (completely confident).

1. How confident are you that you could critique a laboratory report written by another student?

2. How confident are you that you could write an introduction to a lab report?

3. How confident are you that you could read the procedures for an experiment and feel sure about conducting the experiment on your own?

4. How confident are you that you could write the methods section of a lab report (i.e. describe the experiment procedures)?

5. How confident are you that you could write up the results to a lab report?

6. How confident are you that you could write the conclusions to a lab report?

7. How confident are you that you could tutor another student on how to write a lab report?

Appendix D

Descriptive Statistics of Expert Ratings and Revisions Made to Initial Items

Initial Items	**Avg Ease of Comp**	**Avg Content**	**Avg Format**	**Avg Overall Rating**	**Revisions Based on Ratings (Initial R stands for "Revised Item on New Version of the Instrument")**
P1. For writing a biology lab report, I would make a writing plan by analyzing the topic	2.67	4.00	3.00	3.22	Reworded into: RP1. When writing my biology lab report, I think about the topic and then create a plan for my writing
P2. For writing a biology lab report, I would make a writing plan by analyzing the audience	3.00	3.33	3.00	3.11	Reworded into: RP2. When writing my biology lab report, I think about my audience and create a plan for my writing
P3. For writing a biology lab report, I would make a writing plan by analyzing the purpose of the assignment	3.33	4.00	3.33	3.55	Reworded into: RP3. I think about the purpose of the assignment and then create a plan for my writing
P4. For writing a biology lab report, I would make a writing plan by analyzing the genre elements	1.67	1.67	1.67	1.67	Reworded into: RP4. When writing my biology lab report, I think about the parts of a lab report and then create a plan for my writing
P5. For writing a biology lab report, I would make a writing plan by analyzing the overall requirements	3.33	4.33	3.33	3.66	Reworded into: RP5. When writing my biology lab report, I think about the guidelines given and then create a plan for my writing
P6. For writing a biology lab report, I would use free style writing (-)	2.67	3.00	2.33	2.67	Deleted
P7. For writing a biology lab report, I would write down random ideas that comes to mind (-)	4.67	3.67	2.67	3.67	Reworded into: RP6. When writing my biology lab report, I write down whatever comes to my mind (-)
D8. For writing a biology lab report, I would use the plan and draft sentences of the main ideas	3.367	4.67	4.00	4.01	Merged with D9 and reworded into: RD8. When writing my biology lab report, I follow a plan when writing the draft
D9. For writing a biology lab report, I would use the plan and draft supporting details of the main ideas	4.00	4.33	4.00	4.11	See above
D10. For writing a biology lab report, I would write one draft of my lab report and hand it in (-)	4.67	4.33	3.67	4.22	Reworded into: RD7. When writing my biology lab report, I write one draft then hand it in (-)

D11. For writing a biology lab report, I would write multiple drafts	4.67	4.67	4.33	4.57	Reworded into: RD9. When writing my biology lab report, I write multiple drafts before I hand in my lab report
REV12. For writing a biology lab report, I would evaluate my drafts	4.67	4.67	4.33	4.56	Moved to Drafting and reworded into: RD10. When writing my biology lab report, I often revise or rewrite the draft of my lab report before I turn it in
REV13. For writing a biology lab report, I would ask a peer to review my drafts	4.33	4.67	4.33	4.44	Split into two items and reworded into: RREV13. Before I hand in my biology lab report, I ask a peer to review the organization of ides in my lab report RREV14. Before I hand in my biology lab report, I ask a peer to proof read my lab report for spelling and grammar errors
REV14. For writing a biology lab report, I would ask the TA to review my drafts	4.33	4.67	4.33	4.44	Split into two items and reworded into: RREV15. Before I hand in my biology lab report, I ask a TA to review the organization of ideas in my lab report RREV16. Before I hand in my biology lab report, I ask a TA to proof read my lab report for spelling and grammar errors
REV15. For writing a biology lab report, I would revise the drafts based on given feedback	3.67	4.00	3.67	3.78	Split into two items and reworded into: RREV17. Before I hand in my biology lab report, I revise the lab report based on feedback I got from my peers RREV18. Before I hand in my biology lab report, I revise the lab report based on feedback I got from a TA
REV16. For writing a biology lab report, I would hand in the final draft without revision (-)	3.67	3.33	3.33	3.44	Deleted and replaced with new items: RREV11. Before I hand in my biology lab report, I check to make sure I followed the writing guidelines RREV12. Before I hand in my biology lab report, I proof read for spelling and grammar errors
GS17. For writing a biology lab report, I would set personal goals (e.g. I want to get an A on this assignment)	4.00	4.67	4.33	4.33	Deleted and replaced with new item: RGS 19. Before I begin writing my lab report, I set a goal for the grade I would like to get on this assignment
GS18. For writing a biology lab report, I would set short term goals	4.33	4.00	3.33	3.89	Deleted and replaced with new item: RGS 20. Before I begin writing my lab report, I set a goal to learn as much as I can while working on this lab report

GS19. For writing a biology lab report, I would set long term goals	4.33	3.33	3.00	3.55	Deleted
TM20. I would manage my time for writing a biology lab report	4.33	3.33	2.67	3.44	Reworded into: RTM21. When I decide how to work on the lab report, I think about how much time I need to finish it
TM21. I would manage the location where I write a biology lab report	3.33	4.67	3.67	3.89	Deleted
TM22. I would manage how much effort I use for writing a biology lab report	3.67	3.67	4.00	3.78	Reworded into: RTM22. When I decide how to work on the lab report, I think the result of my lab report is related to how hard I work on it
TM23. I would manage my emotions and motivations for writing a biology lab report	3.67	4.00	3.00	3.56	Deleted
TM24. I would write whenever and wherever I want for writing a biology lab report (-)	3.67	4.33	3.33	3.78	Deleted
PM25. For writing a biology lab report, I would monitor my progress while I write by asking “do I have sufficient content knowledge for the assignment?”	3.67	4.67	3.67	4.00	Reworded into: RPM23. While I write my biology lab report, I ask myself if I have sufficient content knowledge for the assignment.
PM26. For writing a biology lab report, I would monitor my progress while I write by asking “am I using strategies to help me write?”	4.00	4.33	4.00	4.11	Merged with PM27, and reworded into: RPM24. While I write my biology lab report, I ask myself if I am using good writing strategies
PM27. For writing a biology lab report, I would monitor my progress while I write by asking “are the strategies helping me to improve my writing?”	4.00	4.33	4.00	4.11	See above
PM28. For writing a biology lab report, I would write without asking myself any questions about the writing process (-)	4.00	4.33	4.00	4.11	Reworded into: RPM25. While I write my biology lab report, I do not ask myself are the writing strategies helping me to improve my writing (-)
REF29. After writing a biology lab report, I would reflect and consider which strategies were helpful	4.33	4.67	4.33	4.44	Reworded into: RREF26. After I get my lab report grade, I think about which writing strategies that I used were helpful

REF30. After writing a biology lab report, I would reflect and consider what I learned about the lab report assignment	4.33	4.00	4.33	4.22	Reworded into: RREF27. After I get my lab report grade, I think about how much I learned from writing the lab report
REF31. After writing a biology lab report, I would reflect and consider what goals to set for the next assignment	4.67	4.67	4.33	4.56	Reworded into: RREF28. After I get my lab report grade, I think about my goals for the next report
REF32. After writing a biology lab report, I would not think about how was the writing process (-)	4.00	4.33	4.00	4.11	Deleted

Appendix E

Full List of Revised Items After Expert Judgement Feedback (28 Items)

The following items asks about the cognitive and self-regulation strategies you would use for writing a biology lab report. There are no right or wrong answers. Use the scale from not at all true of me (1) to very true of me (7) to rate how accurate each statement best describes you.

Cognitive Strategies

Planning

RP1. When writing my biology lab report, I think about the topic and then create a plan for my writing

RP2. When writing my biology lab report, I think about my audience and create a plan for my writing

RP3. When writing my biology lab report, I think about the purpose of the assignment and then create a plan for my writing

RP4. When writing my biology lab report, I think about the parts of a lab report and then create a plan for my writing

RP5. When writing my biology lab report, I think about the guidelines given and then create a plan for my writing

RP6. When writing my biology lab report, I write down whatever comes to my mind (-)

Drafting

RD7. When writing my biology lab report, I write one draft then hand it in (-)

RD8. When writing my biology lab report, I follow a plan when writing the draft

RD9. When writing my biology lab report, I write multiple drafts before I hand in my lab report

RD10. When writing my biology lab report, I often revise or rewrite the draft of my lab report before I turn it in

Review

RREV11. Before I hand in my biology lab report, I check to make sure I followed the writing guidelines

RREV12. Before I hand in my biology lab report, I proof read for spelling and grammar errors

RREV13. Before I hand in my biology lab report, I ask a peer to review the organization of ides in my lab report

RREV14. Before I hand in my biology lab report, I ask a peer to proof read my lab report for spelling and grammar errors

RREV15. Before I hand in my biology lab report, I ask a TA to review the organization of ideas in my lab report

RREV16. Before I hand in my biology lab report, I ask a TA to proof read my lab report for spelling and grammar errors

RREV17. Before I hand in my biology lab report, I revise the lab report based on feedback I got from my peers

RREV18. Before I hand in my biology lab report, I revise the lab report based on feedback I got from a TA

Self-Regulation Strategies

Goal setting

RGS 19. Before I begin writing my lab report, I set a goal for the grade I would like to get on this assignment

RGS 20. Before I begin writing my lab report, I set a goal to learn as much as I can while working on this lab report

Task management

RTM21. When I decide how to work on the lab report, I think about how much time I need to finish it

RTM22. I think the result of my lab report is related to how hard I work on it

Progress monitor

RPM23. While I write my biology lab report, I ask myself if I have sufficient content knowledge for the assignment.

RPM24. While I write my biology lab report, I ask myself if I am using good writing strategies

RPM25. While I write my biology lab report, I do not ask myself are the writing strategies helping me to improve my writing (-)

Reflection

RREF26. After I get my lab report grade, I think about which writing strategies that I used were helpful

RREF27. After I get my lab report grade, I think about how much I learned from writing the lab report

RREF28. After I get my lab report grade, I think about my goals for the next report

Note: R stands for “Revised Item”

Appendix F

Pattern Matrix of EFA Results for 28-Item Instrument

	Factor						
	1	2	3	4	5	6	7
RGS20	**.895**	.068	-.036	-.059	-.037	-.074	-.030
RREF27	**.755**	-.011	.014	-.068	-.007	-.159	.180
RREF26	**.537**	.066	-.013	.064	.005	-.152	.288
RREF28	**.534**	-.013	-.006	.058	.035	.001	-.019
RGS19	.497	-.058	.067	-.070	-.039	.299	-.115
RREV14	-.057	**.963**	-.047	.023	.016	-.001	.005
RREV13	.013	**.871**	.014	-.054	-.020	.068	-.042
RREV17	.117	**.700**	.072	.038	-.022	.014	-.082
RREV15	-.053	-.029	**1.015**	-.005	-.013	-.004	.052
RREV16	.018	.000	**.778**	-.022	-.017	-.053	.057
RREV18	.007	.067	**.696**	.033	.061	.051	-.087
RP3	-.020	-.035	.011	**.696**	.064	-.138	.025
RP1	-.112	.048	-.022	**.675**	.036	.011	.138
RP4	.012	-.038	-.002	**.635**	-.098	.123	-.057
RP5	.063	-.016	-.019	.520	-.081	.183	-.345
RP2	.085	.113	.061	**.426**	.028	-.139	.124
RD7 (-)	-.093	-.010	-.022	-.018	**.887**	-.035	.007
RD9	.056	-.007	.049	.026	**.828**	-.043	-.055
RD10	.107	-.004	.047	-.032	**.496**	.252	-.038
RREV11	-.054	-.004	.076	.022	-.076	**.630**	.025
RREV12	-.160	.125	-.047	-.126	.001	**.628**	.272
RD8	.093	.005	.047	.136	.130	.248	.090
RTM22	.231	-.016	-.061	.104	.086	.232	.113
RTM21	.191	-.023	-.080	.088	.038	.227	.149
RP6 (-)	-.034	.001	-.108	.053	.114	.157	-.094
RPM24	.143	-.093	.047	.091	-.059	.111	**.581**
RPM25 (-)	.106	-.027	.007	-.074	-.004	.032	**.367**
RPM23	.219	-.029	-.023	.106	-.044	.193	**.363**

Note: Item loadings are sorted by size.

Appendix G
Full List of Items for the Cognitive and Self-Regulation Strategies Instrument for Biology Lab Report Writing (22 items)

<u>Self-Regulation Strategies</u>

RREF27. After I get my lab report grade, I think about how much I learned from writing the lab report

RREF26. After I get my lab report grade, I think about which writing strategies that I used were helpful

RGS20. Before I begin writing my lab report, I set a goal to learn as much as I can while working on this lab report

RPM24. While I write my biology lab report, I ask myself if I am using good writing strategies

RREF28. After I get my lab report grade, I think about my goals for the next report

RPM23. While I write my biology lab report, I ask myself if I have sufficient content knowledge for the assignment.

RPM25 (-) While I write my biology lab report, I do not ask myself are the writing strategies helping me to improve my writing (-)

<u>Revision Based on Peer Feedback</u>

RREV13. Before I hand in my biology lab report, I ask a peer to review the organization of ides in my lab report

RREV14. Before I hand in my biology lab report, I ask a peer to proof read my lab report for spelling and grammar errors

RREV17. Before I hand in my biology lab report, I revise the lab report based on feedback I got from my peers

<u>Revision Based on TA feedback</u>

RREV15. Before I hand in my biology lab report, I ask a TA to review the organization of ideas in my lab report

RREV16. Before I hand in my biology lab report, I ask a TA to proof read my lab report for spelling and grammar errors

RREV18. Before I hand in my biology lab report, I revise the lab report based on feedback I got from a TA

<u>Drafting</u>

RD7. When writing my biology lab report, I write one draft then hand it in (-)

RD9. When writing my biology lab report, I write multiple drafts before I hand in my lab report

RD10. When writing my biology lab report, I often revise or rewrite the draft of my lab report before I turn it in

<u>Planning</u>

RP1. When writing my biology lab report, I think about the topic and then create a plan for my writing

RP2. When writing my biology lab report, I think about my audience and create a plan for my writing
RP3. When writing my biology lab report, I think about the purpose of the assignment and then create a plan for my writing
RP4. When writing my biology lab report, I think about the parts of a lab report and then create a plan for my writing

Evaluation of Writing Mechanics

RREV11. Before I hand in my biology lab report, I check to make sure I followed the writing guidelines
RREV12. Before I hand in my biology lab report, I proof read for spelling and grammar errors

Appendix H
Pattern Matrix of EFA Results for the 22-Item Instrument (Final Version)

	Factor					
	1	2	3	4	5	6
RREF27	**.888**	-.031	.048	-.037	-.142	-.036
RREF26	**.772**	.053	-.047	.032	-.012	-.062
RGS20	**.708**	.064	.060	-.090	.020	-.037
RPM24	**.511**	-.079	-.075	.081	.139	.070
RREF28	**.474**	-.022	.063	-.019	.068	.036
RPM23	**.421**	-.027	-.072	.022	.188	.147
RPM25 (r)	**.346**	-.016	-.063	.074	-.044	.007
RREV14	-.032	**.964**	-.066	.035	.004	-.025
RREV13	-.011	**.872**	.017	-.019	-.063	.054
RREV17	.044	**.695**	.094	-.042	.056	.004
RREV15	-.025	-.026	**.993**	.009	-.003	-.009
RREV16	.055	-.005	**.777**	-.013	-.044	-.012
RREV18	-.067	.067	**.700**	.061	.052	.024
RD7 (r)	-.032	-.012	-.040	**.931**	-.046	-.068
RD9	.044	-.003	.088	**.753**	.016	-.014
RD10	.060	.000	.086	**.478**	.032	.171
RP1	-.059	.045	-.049	.020	**.778**	-.014
RP3	.012	-.051	.018	.023	**.655**	-.070
RP4	.001	-.052	.018	-.094	**.584**	.080
RP2	.158	.107	.048	.015	**.419**	-.085
RREV11	-.028	-.048	.092	-.091	.009	**.728**
RREV12	.025	.108	-.111	.083	-.050	**.582**

Note: Item loadings are sorted by size.

Appendix I
Pattern Matrix of 22-Item Instrument with Biology Self-Efficacy Items

	Factor						
	1	2	3	4	5	6	7
BWSE7	**.843**	.053	.003	.033	-.006	.001	-.055
BWSE 5	**.808**	-.066	.041	-.006	-.015	-.009	.026
BWSE 6	**.791**	-.038	.014	-.003	-.023	.055	-.030
BWSE 4	**.783**	.043	.021	.015	-.062	-.097	.128
BWSE 2	**.732**	-.100	-.041	.008	.034	.022	.179
BWSE 3	**.676**	.087	-.028	-.073	.094	-.053	-.055
BWSE 1	**.662**	-.003	-.047	-.024	.002	.120	-.104
RREF27	.074	**.880**	-.025	.043	-.017	-.131	-.101
RREF26	-.030	**.756**	.062	-.052	.025	-.009	-.018
RGS20	.076	**.699**	.070	.055	-.067	.022	-.082
RPM24	-.071	**.531**	-.095	-.050	.038	.097	.200
RREF28	-.092	**.490**	-.022	.054	-.016	.100	.015
RPM23	-.063	**.436**	-.037	-.055	.004	.183	.206
RPM25 (r)	.008	**.343**	-.015	-.055	.052	-.078	.080
RREV14	.001	-.031	**.954**	-.074	.037	.001	.002
RREV13	-.010	-.006	**.871**	.012	-.012	-.048	.039
RREV17	-.018	.042	**.689**	.102	-.042	.061	.027
RREV15	-.003	-.025	-.033	**1.000**	.005	-.018	.002
RREV16	-.022	.065	-.003	**.772**	-.015	-.061	-.003
RREV18	-.021	-.067	.061	**.710**	.052	.056	.029
RD7 (r)	-.011	-.034	-.005	-.043	**.894**	-.051	-.025
RD9	.025	.035	-.001	.066	**.792**	.028	-.049
RD10	.017	.054	.001	.091	**.471**	.049	.164
RP1	-.068	-.043	.046	-.057	.019	**.768**	.031
RP3	.051	.022	-.050	.007	.036	**.654**	-.102
RP4	.040	.017	-.044	.013	-.109	**.550**	.107
RP2	.101	.139	.115	.030	.047	**.428**	-.137
RREV12	.021	.057	.092	-.060	.049	-.080	**.648**
RREV11	.049	.011	-.027	.112	-.066	.076	**.513**

Note: SE = Biology Writing Self-Efficacy