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AN EXAMINATION OF THE CONCEPTUAL RELATIONS AMONG EXECUTIVE FUNCTIONING, METACOGNITION, AND SELF-REGULATED LEARNING

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ABSTRACT

The current study aimed to examine and clarify the conceptual relations among executive functioning, metacognition, and self-regulated learning. One hundred and seventeen undergraduate students enrolled in an educational psychology course completed direct and indirect measures of executive functioning, metacognition, and self-regulated learning. A mediation model specifying the relationships among the regulatory constructs was proposed and supported. In multiple linear regression analyses, executive functioning predicted metacognition ($R^2 = .20$) and self-regulated learning ($R^2 = .29$). Direct measures of inhibition and shifting accounted for a significant amount of the variance in metacognition ($\Delta R^2 = .07$) and self-regulated learning ($\Delta R^2 = .06$) beyond an indirect measure of executive functioning. Separate mediation analyses indicated the role of metacognition in mediating the relationship between executive functioning and self-regulated learning ($\beta = .16$, $p < .001$; 95% CI = [0.08, 0.27]) as well as between specific executive functions and self-regulated learning ($\beta = .12$, $p < .05$; 95% CI = [0.03, 0.21]), with large effect sizes obtained in both analyses ($R^2 = .40$ and .32, respectively). Obtained findings extend prior research conceptualizing the relations among the regulatory constructs and situate and specify executive functions as key processes, mediated by metacognition, that facilitate self-regulated learning.

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Chapter 1

Introduction

There exists considerable interest in regulatory constructs as they relate to learning and academic functioning. Self-regulated learning research has dominated the literature for many years, with self-regulated learning viewed as processes that facilitate the acquisition of academic skills, the setting and planning of goals and tasks, the deployment of strategies, and the ability to self-monitor progress and goal completion (Zimmerman, 2008; Cleary, Callan, & Zimmerman, 2012). A concurrent interest has developed in executive functions as processes that facilitate the coordination of cognition and support the development of academic skills (Anderson, Anderson, Jacobs, & Smith, 2008; Molfese et al., 2010; Sesma, Mahone, Levine, Eason, & Cutting, 2009). Because of the shared focus on the regulation of cognition (Baddeley, 1996; Brown, 1978; Flavell, 1979), researchers noted conceptual similarities among the constructs of executive functioning, metacognition, and self-regulated learning. Such research has provided evidence of significant relations among the regulatory constructs (Effeney, Carroll, & Bahr, 2013; Garner, 2009; Hofmann, Schmeichel, & Baddeley, 2012).

A brief comparison of definitional elements among the constructs of executive functioning, metacognition, and self-regulated learning reveals commonality across definitions of and specific processes included in the constructs. For example, executive functions are described as processes that allow for the control and coordination of cognition, with frameworks of executive functions including, as examples, planning, flexibility, and monitoring, while metacognition is often couched in terms of regulation of cognition, also including the processes of planning and monitoring (Anderson et al., 2008; Molfese et al., 2010; Brown, 1978). This overlap has been noted by several researchers with concern for construct clarity and a need for a disentangling of the conceptual boundaries among the regulatory constructs (Garner, 2009; Effeney et al., 2013).

However, despite considerable interest in these constructs that inform learners' regulation, a lack of conceptual clarity remains among executive functioning, metacognition, and self-regulated learning (Dinsmore, Alexander, & Loughlin, 2008; Effeney et al., 2013; Garner, 2009). The lack of clear understanding of how executive functioning is related to metacognition and self-regulated learning risks blurring the conceptual boundaries among the regulatory constructs and also has important implications for the measurement of and interventions put into place to facilitate self-regulated learning outcomes.

The main goal of the current study was to critically evaluate executive functioning, metacognition, and self-regulated learning in an attempt to provide a more integrative framework of the conceptual relations among regulatory constructs. A second goal of the current study was to provide an explication of how executive functions inform self-regulated learning. Toward these goals, an examination of the conceptual relations among executive functioning, metacognition, and self-regulated learning was conducted utilizing a series of direct and indirect measures of the regulatory constructs. Specifically, the study utilized a measure of executive functioning as well as measures of the executive functions of inhibition and shifting, and specified the role executive functions may play in self-regulated learning.

Executive Functioning

Recently, increasing interest in executive functioning has led to a focus on the contribution of executive functions to student learning and achievement (Molfese et al., 2010). Executive functions describe neurocognitive processes that control and coordinate cognition and guide behavior that is goal-directed (Barkley, 1997; Denckla, 2007; Garner, 2009; Meltzer, Pollica, & Barzillai, 2007; Salthouse, 2005). Theoretical and empirical support for executive functioning draws on information processing theory, neuropsychological research, as well as Baddeley's multicomponent model of working memory (Anderson et al., 2008; Baddeley, 1996; Barkley, 1997; Denckla, 1995; Miyake et al., 2000). While different conceptualizations of executive functioning exist, there is commonality in key features of executive functions as being associated with the ability to set goals, inhibit maladaptive thought or behavior, persist toward a task or goal in the face of distraction or alternative task options, shift mental sets, and engage in future-oriented behavior (Anderson et al., 2008; Barkley, 1997; Garner, 2009; Molfese et al., 2010).

In a latent variable analysis, Miyake and colleagues (2000) examined the separability and utility of three core executive functions contributing to an executive function taxonomy: shifting/cognitive flexibility, updating, and inhibition. The authors noted that the three executive functions were distinguishable but were moderately correlated, and contributed significantly, yet differentially, to performance on more complex cognitive tasks measuring planning ability, working memory, and the ability to shift mental sets (Miyake et al., 2000). The authors also noted that, despite their separability, these three executive functions appeared to share an underlying commonality, and reported indication of "common mechanisms across different executive functions" (p. 88). They concluded, however, that the source of the commonality was not yet known. The findings are important in evaluating the potential for executive functions to contribute significantly to self-regulated learning as independent but interactive processes that share commonality in a complex contribution to regulatory outcomes.

The study of executive functions as processes that facilitate cognition has resulted in the application of executive function research to several important areas, including the study of academic skill acquisition and development, understanding deficits in attentional functioning, and the selection and use of strategies to facilitate the attainment of learning and related goals (Diamond & Lee, 2011; Hofmann, Schmeichel, & Baddeley, 2012). For example, researchers have identified important contributions of executive functions to key academic skills, including word reading (Christopher et al., 2012), reading comprehension (Locascio, Mahone, Eason, & Cutting, 2010; Sesma et al., 2009), literacy skills (Altemeier, Abbott, & Berninger, 2008), and writing ability (Altemeier et al., 2008). Specific findings have also linked deficits with reading comprehension to specific inhibitory difficulties (Borella, Carretti, Pelegrina, 2010) and improvement in inhibition and shifting to important literacy outcomes (Altemeier et al., 2008). Such findings highlight the multifaceted role of executive functioning in facilitating academic skill development and functioning.

Executive functions have traditionally been measured in accordance with two formats: direct, task-based measures (e.g., Stroop task, Stop-signal task, Antisaccade task, Tower of Hanoi/Tower of London; Anderson et al., 2008; Delis, Kaplan, & Kramer, 2001; Miyake et al., 2000) that emphasize performance on a specific task to measure specific executive *functions*; or indirect, self-report measures designed to tap a global estimate of executive *functioning* (Barkley, 1997; Gioia, Isquith, Guy, & Kenworthy, 2004). Thus, existing measures underscore either a process-oriented approach to measuring specific executive functions or a retrospective rating of executive functioning. Prior research has suggested the utility of using both direct and indirect measures in predicting academic outcomes and separately accounting for variance in academic functioning (Fuhs, Farran, & Nesbitt, 2015).

Despite the existence of alternative measurement formats in the form of direct measures, the literature is populated with studies relying on self-report or Likert-based measures to capture specific executive functions (Barkley, 2012; Dawson & Guare, 2010; Effeney et al., 2013; Garner, 2009). There is also variability in the manner in which executive functioning is assessed among indirect measures, with some self-report measures including metacognitive processes or distinct scales tapping metacognition (Dawson & Guare, 2010; Gioia et al., 2004) and others that do not include scales measuring such metacognitive processes (Spinella, 2005; as cited in Garner, 2009).

This variability across measures of executive functioning is reflective of the blurred conceptual boundaries between executive functioning and metacognition, and highlights subtle but important differences in conceptualizations of executive and metacognitive processes contributing to learners’ regulation. These differences have important implications for the accurate measurement of executive functioning and metacognition as independent constructs (Effeney et al., 2013). Thus, a clear explication of these differences is likely to be helpful in informing a clear understanding of the role and boundaries of each in facilitating self-regulated learning.

Metacognition

Metacognition has traditionally been defined based on its components: knowledge of cognition and regulation of cognition (Sperling, Howard, Staley, & DuBois, 2004). Knowledge of cognition reflects knowledge of one’s own learning processes, and incorporates declarative (i.e., knowing what), procedural (i.e., knowing how), and conditional (i.e., knowing when) knowledge of cognition (Brown, 1978; Flavell, 1979). As Sperling and colleagues indicated, there is substantial evidence indicating that individuals vary in their knowledge of cognition (2004). Regulation of cognition encompasses the controlling of one's cognitive processes, including processes such as predicting, checking, and monitoring, as examples (Brown, 1978). Taken together, knowledge and regulation of cognition contribute to the ability of a learner, guided by metacognitive knowledge and regulatory ability, to employ strategies aimed at effectively meeting learning goals and solving problems (Winne, 1996).

Despite the shared importance of knowledge of cognition and regulation of cognition as contributors to metacognition, in facilitating learners' use of strategies to attain learning outcomes, the relationship between knowledge of cognition and regulation of cognition is not fully understood. Schraw and Dennison (1994) found evidence suggesting that knowledge of cognition may precede regulation of cognition. Specifically, learners with high knowledge of cognition were found to demonstrate greater regulation of cognition (Schraw & Dennison, 1994; Sperling et al., 2004). Similarly, Schraw (1994) reported that individuals with higher knowledge of cognition were better able to monitor their performance.

Metacognition has been assessed extensively and is typically measured by the use of either more indirect (i.e., self-report) measures of metacognition (Fortunato, Hecht, Tittle, & Alvarez, 1991; Pintrich & De Groot, 1990; Pintrich, Smith, Garcia, & McKeachie, 1993; Schraw, 1994; Schraw & Dennison, 1994) or by the calculation of more direct (i.e., index) measures of metacognitive monitoring (Huff & Nietfeld, 2009; Schraw, 2009; Winne & Perry, 2000). Despite the existence of differing measurement formats of metacognition, research examining the relations among these different measures has typically found a lack of a strong relationship between the measures (Sperling et al., 2004; Winne & Perry, 2000). These findings highlight the importance of utilizing both indirect and direct measures of metacognition in examining learners' ability to monitor and regulate their own learning (e.g., Huff & Nietfeld, 2009; Schraw, 1994; Winne, 2000).

An early and influential framework of metacognitive monitoring specified the interaction of metacognitive monitoring and metacognitive control occurring during the acquisition, retention, and retrieval of information (Bjork, Dunlosky, & Kornell, 2013; Nelson & Narens, 1990). The temporal nature of metacognitive monitoring reflects the continual appraisal of learning to facilitate decision making about learning, such as including information that should be studied, the accuracy of retrieved information, and whether procedures used to facilitate learning and studying are effective (Bjork et al., 2013). Judgments occurring at the acquisition phase of learning include ease-of-learning judgments (EOL) and judgments of learning (JOL); judgments occurring during the retention phase include feeling-of-knowing judgments (FOK); and judgments occurring during the retrieval phase include source-monitoring judgments and confidence in retrieved answers (Bjork et al., 2013; Dunlosky & Lipko, 2007).

While there are variations in approaches to measuring metacognitive monitoring, absolute accuracy and bias are measures that have garnered considerable empirical support (Huff & Nietfeld, 2009; Schraw, 2009; Sperling et al., 2004). Absolute accuracy provides a measure of the precision of a judgment that is made by a learner on a specific performance on a task (Schraw, 2009). Specifically, the index provides a measure of the absolute difference between a learner's confidence score and actual performance. Smaller scores are indicative of higher accuracy based on smaller deviations between the confidence judgment and actual performance. The mean absolute accuracy score is calculated by taking the sum of the item-level squared deviations and dividing by the number of items (Schraw, 2009). Bias describes the extent of under- or over-confidence made in a given confidence judgment, expressed as an index indicating the direction and magnitude of the discrepancy between judgment and performance (Schraw, 2009). Accurate metacognitive monitoring is a crucial process that facilitates the adjustment of effort to attain goals and learning outcomes, contingent upon accuracy of perceived performance, through the allocation of cognitive resources and strategies (Huff & Nietfeld, 2009; Winne, 1996).

Self-Regulated Learning

Self-regulation is characterized by thoughts and behaviors that are monitored and adapted in a cyclical fashion that facilitate the use of strategies and the attainment of goals (Effeney et al., 2013; Zimmerman, 1989). The application of self-regulation specific to the academic context has led to a focus on self-regulated learning (Cleary, 2006; Winne, 1996; Zimmerman, 1989), and is exemplified by students who are “metacognitively, motivationally, and behaviorally active participants in their own learning process” (Zimmerman, 2008, p. 167). A learner’s ability to regulate his or her own learning is facilitated by the effective use of specific strategies to facilitate the attainment of goals. Zimmerman describes self-regulated learning strategies as actions or processes that facilitate the acquisition of information or the development of skills that hinge upon agency, purpose, and perceptions of the learner (1989). Examples of such strategies include seeking information, organizing information, and using memory aids (Cleary, 2006; Garner, 2009; Zimmerman, 1989, 2008).

A learner's use of self-regulated learning strategies is applied to a given learning context and can vary based on a host of influences, including level of knowledge in a given academic or content area and level of metacognitive skill (Zimmerman, 1989). As noted by Winne and Perry (2000), self-regulated learning exhibits both aptitude- and event-like characteristics. Zimmerman summarizes the dynamic nature of self-regulated learning by describing it as varying in degree, rather than as existing as an absolute state, and depending on social and physical context (1989). Thus, the effective use of strategies is expected to be impacted by important cognitive and situational factors.

Central to the effective regulation of learning is the ability of the learner to monitor his or her own performance, appraise performance relative to goals and standards, and evaluate the successful attainment of those goals and standards. The use of these regulatory processes draws on the importance of metacognition in guiding self-regulated learning, whereby learners are able to monitor progress toward tasks and goals as a means of successively refining their use of strategies to ensure successful completion (Effeney et al., 2013; Winne, 1996). Such metacognitive monitoring also facilitates metacognitive control over the use of specific strategies to guide behavior toward task or goal completion (Winne, 1996).

Models of and Common Elements Among Regulatory Constructs

Zimmerman's model of self-regulated learning has been heavily incorporated into classroom and instructional practice (Zimmerman, 2008). The model draws considerable theoretical support from social cognitive theory, emphasizing the roles of the self, behavior, and environment as determinants in the regulation of learning (Puustinen & Pulkkinen, 2001; Zimmerman, 2000). Zimmerman emphasizes a dynamic nature to regulation, where self-regulation is defined as “thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals” (2000, p. 14). Three overarching phases are emphasized: forethought, highlighting task analytic and self-motivational process; performance, highlighting self-control and self-observational processes; and self-reflection, highlighting self-judgment and self-reaction processes (Zimmerman, 2008). The model, overall, is characterized as being both motivation-and strategy-oriented, with a shared focus on the intersection of self-efficacy and goal setting in the attainment of learning outcomes (Puustinen & Pulkkinen, 2001).

Another prominent model of self-regulated learning is Winne’s model of self-regulated learning (Winne, 1996). Winne’s model draws on more heterogeneous theoretical support (Puustinen & Pulkkinen, 2001), and emphasizes the use of metacognition in guiding behavior through enabling the use of cognitive tactics and strategies when engaged in a learning task (Winne, 1996; Winne & Perry, 2000). The model has been described as emphasizing a metacognition and a strategy orientation, highlighting the use of metacognitive monitoring to inform the use of strategy at each phase of the model (Puustinen & Pulkkinen, 2001). It also delineates self-regulation as an event – a transient state situated within a larger series of states over time – as well as an aptitude (Winne & Perry, 2000; Puustinen & Pulkkinen, 2001).

The shared focus on cognitive, metacognitive, and motivational factors, the emphasis on a cyclical, dynamic, and adaptive process of regulation, and the contextual or event-like nature of regulation all contribute to the ability of self-regulated learning to inform the attainment of goals, academic skill acquisition, and learning outcomes. Despite specific or overarching orientations with respect to motivational, cognitive, or metacognitive processes, each of the models delineates a shared contribution among cognitive, metacognitive, and motivational processes. This is important, as each of these processes plays an integral role in research that impact the implementation of intervention and instruction aimed at improving self-regulatory functioning among learners. Importantly, however, the emphasis on cognitive and metacognitive processes in models of self-regulated learning affords the potential for an examination of which specific processes are likely to inform self-regulated learning. This examination draws on research that established relationships among executive functioning, metacognition, and self-regulated learning as regulatory constructs that interact based on a shared emphasis on cognitive (i.e., executive) and metacognitive processes.

Conceptualizing the Relations Among Regulatory Constructs

In an examination of the conceptual relations among executive functions and self-regulated learning, Garner (2009) reported evidence of moderate relations between self-report measures of executive functioning and self-regulated learning. Executive functioning significantly predicted metacognitive strategy use as well as effort regulation and supported and contributed to the variability in self-regulated learning processes (Garner, 2009). Similarly, self-regulated learning processes were noted as implicating, although not fully relying on, executive functions. The findings highlighted the multifaceted nature of self-regulated learning as well as the variability among processes that interact to contribute to self-regulated learning. The findings also highlighted the role of effort regulation in drawing on the effective application of executive functions in facilitating self-regulatory outcomes (Garner, 2009).

In a similar study, Effeney and colleagues (2013) examined relationships between self-regulated learning and executive functioning in a sample of adolescent males. The study also utilized self-report measures of executive functioning and found evidence of strong correlations between the measures. The authors noted particularly strong associations in areas of executive functioning and self-regulated learning associated with metacognitive processes (Effeney et al., 2013). The authors drew on the work of Dinsmore, Alexander, and Loughlin (2008), and highlighted the associations as evidence that metacognition occupies a conceptual middle ground between executive functioning and self-regulated learning. Dinsmore and colleagues proposed a conceptual core that binds the constructs of metacognition and self-regulated learning, which reflects an emphasis on a learner's efforts and ability to monitor thoughts and actions and to act in a manner that affords the learner with the ability to control them (2008).

Despite evidence of significant relations among the regulatory constructs of executive functioning, metacognition, and self-regulated learning, a persistent theme permeating each of the studies reviewed is a reliance on the use of self-report measures to capture executive functioning. Such a reliance rests on an assumption of a trait-like nature of executive functioning and further risks a lack of precision in measuring specific executive processes that have the potential to inform self-regulated learning outcomes, both of which contribute to an overarching concern about and need to effectively and accurately measure the dynamic nature of regulatory processes (Dinsmore et al., 2008).

The joint importance of the executive functions of inhibition and shifting are also implicated in the ability of individuals to adjust strategy use and abandon strategies that are ineffective while selecting those that are likely to be more effective (Garner, 2009; Hofmann et al., 2012). In an examination of executive functions and self-regulated learning, Hofmann and colleagues (2012) articulated several connections between executive functions and self-regulated learning, and suggested the specific role of the executive functions of inhibition and task-switching/shifting as supporting key mechanisms that facilitate self-regulated learning. In delineating these connections, Hofmann and colleagues asserted that impairment in self-regulatory outcomes "can be explained via state reductions in executive functions as the underlying conceptual mechanism" (p. 177; 2012). As the authors suggest, behavioral inhibition, or the ability to inhibit or override a prepotent response, has the potential to interfere with the completion of goals in favor of responses that are supportive of goal completion. Similarly, the ability to shift flexibly between approaches to completing a task or accomplishing a goal as well as between several goals is supported as a regulatory mechanism served by task switching or shifting ability (Hofmann et al., 2012).

Taken together, these findings invoke an important role of executive functions in supporting self-regulated learning. Central to this relationship is the role of metacognition and metacognitive processes, with prior research suggesting metacognition may facilitate the relationship between executive functioning and self-regulated learning. Despite evidence of conceptual relations among the constructs, little, if any, research has specified the nature of the relationship between executive functioning and self-regulated learning. Such an examination is thus likely to clarify an understanding of how executive functions inform self-regulated learning. A clear explication of the role executive functions play in facilitating self-regulated learning also holds potential for disentangling the conceptual boundaries among the regulatory constructs.

The Current Study

The current study aimed to examine and clarify the conceptual relations among executive functioning, metacognition, and self-regulated learning, with intent to provide empirical support for a framework delineating the relations among these regulatory constructs. In supporting this aim, the following research questions guided the current study:

Research Question 1. What are the relations among direct and indirect measures of executive functioning, metacognition, and self-regulated learning?

Research Question 2. Does executive functioning, as measured by direct and indirect measures, predict metacognition and self-regulated learning?

Research Question 3. Does metacognition affect the relationship between executive functioning and self-regulated learning?

Based in part on prior research, it was expected that executive functioning would be significantly related with both metacognition and self-regulated learning. It was also expected that executive functioning would significantly predict metacognition and self-regulated learning. It was further expected that the inclusion of direct measures of inhibition and shifting would add precision to the measurement of executive functions and would account for additional variance in self-regulated learning over and above that accounted for by an indirect measure of executive functioning.

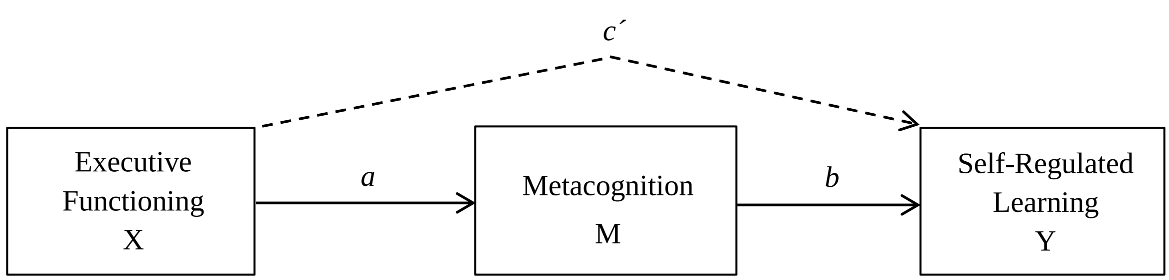

Figure 1. Hypothesized model for metacognition mediating the relationship between executive functioning and self-regulated learning.

Based on research supporting the connections between executive functions and self-regulated learning (Garner, 2009; Hofmann et al., 2012) and implicating metacognitive processes as occupying a conceptual middle ground (Effeney et al., 2013), metacognition was expected to play a mediating role in the relationship between executive functioning and self-regulated learning.

Figure 1 depicts the hypothesized conceptual model for metacognition mediating the relationship between executive functioning and self-regulated learning. Separate mediation analyses were conducted to examine the role of an indirect measure of executive functioning as well as direct measures of executive functions in accounting for self-regulated learning. Based on the established relationship between executive functioning and self-regulated learning, it was expected that the effect of executive functioning on self-regulated learning would be partially transmitted by metacognition with executive functioning measured by both direct and indirect measures.

Chapter 2

Method

Design

The measures in this cross-sectional study were randomly and individually administered. In addressing the second research question, measures of executive functions were utilized as the independent variables in the regression analyses. Measures of metacognition and self-regulated learning were utilized as dependent measures in the multiple linear regression models. In addressing the third research question, measures of executive functions were used as the independent variables in the mediation analyses. In the first mediation analysis, an indirect measure of executive functioning was used; in the second mediation analysis, direct measures of inhibition and shifting were used as the independent variables. A measure of metacognition was used as the mediator variable, and a measure of self-regulated learning was used as the dependent variable.

Participants

One hundred and nineteen undergraduate students participated in and completed the study. Institutional Review Board approval (IRB #: 00001440) was obtained prior to data collection. Implied consent was obtained from all participants. Data from 2 participants contained greater than 10% missing values (15.91% and 13.64%); these data were excluded from the analyses. This resulted in a final sample size of 117. Participants included 18 males (15.4%) and 98 females (83.8%); one participant (0.9%) did not indicate gender information (see Appendix K for the demographic questionnaire). Participants were recruited for participation in the study through their enrollment in an undergraduate educational psychology course at a large, Mid-Atlantic research university (see Appendix A for the recruitment statement). All participants were at least 18 years of age; the majority of participants (94.1%; *n* = 110) were between the ages of 18 and 21, while the remaining (2.7%; *n* = 3) were between the ages of 24 and 32. Four participants (3.4%) did not disclose age information. Of the participants, 56.4% (*n* = 66) were first-year students, 34.2% (*n* = 40) were second-year students, 6.0% (*n* = 7) were third-year students, and 3.4% (*n* = 4) were fourth-year students.

With respect to ethnicity, 89.7% (*n* = 105) of participants identified themselves as White/Caucasian, 2.6% (*n* = 3) as Black/African American, 5.1% (*n* = 6) as Asian, and 2.6% (*n* = 3) as Hispanic. In terms of language ability, 19.7% (*n* = 23) of the participants indicated speaking a language other than English. Of the participants speaking languages other than English (*n* = 23), 83.6% (*n* = 19) characterized their degree of ability with the English language as fluent, 13.0% (*n* = 3) as advanced, and 4.4% (*n* = 1) as intermediate. With respect to intended major, the majority of the participants indicated an intended major of one of the following: childhood and early adolescent education (38.46%; *n* = 45), secondary education (19.66%; *n* = 23), communication sciences and disorders (18.80%; *n* = 22), or special education (4.27%; *n* = 5). The mean self-reported GPA was 3.40 (*SD* = 0.35).

Materials and Measures

All participants completed: 1) measures of executive functioning, consisting of the Executive Skills Questionnaire (Dawson & Guare, 2010), the category and verbal fluency tasks (adapted from Swanson, 2011), and the plus-minus task (adapted from Miyake et al., 2000); 2) measures of metacognition, consisting of the Motivated Strategies for Learning Questionnaire, Metacognitive Self-Regulation subscale (MSLQ; Pintrich & De Groot, 1990), the Strategic Problem Solving Inventory (Fortunato et al., 1991), and absolute accuracy and bias as measures of metacognitive monitoring; and 3) a measure of self-regulated learning, consisting of the Self-Regulation Strategy Inventory – Self-Report (SRSI-SR; Cleary, 2006).

Executive Functioning

Indirect executive functioning measure. The Executive Skills Questionnaire (Dawson & Guare, 2010; see Appendix B) was administered as an indirect measure of executive functioning. The 33-item questionnaire measured reported response inhibition, emotional control, task initiation, organization, flexibility, goal-directed persistence, working memory, sustained attention, planning/ prioritization, time management, and metacognition. The questionnaire was adapted for use with college-age individuals. Example items included: "*I easily adjust to changes in plans and routines*" (included in the Flexibility scale), "*I think before I speak*" (included in the Response Inhibition scale), and "*When I have a lot to do, I can easily focus on the most important things*" (included in the Planning scale). An examination of the use of the ESQ in this college-aged sample indicated high reliability (α = .89). A composite score for the ESQ was utilized as a measure of global executive functioning. The scale was previously used in school settings to facilitate the implementation of interventions aimed at improving students' executive function skills (Dawson & Guare, 2010).

Direct executive function measures. The category and verbal fluency tasks (Swanson, 2011; see Appendix C) were used as a measure of inhibition. The tasks consisted of two sections. The first section provided participants with a category (i.e., animals) and asked them to generate as many things as they could that fell within that category. The second section provided participants with a letter (i.e., B) and asked them to generate as many words as they could that began with that letter. Participant responses were restricted to these parameters to activate inhibition. The number of items generated was calculated for each condition; the average number of generated items across task conditions was used as a measure of inhibition. The measure has been used in prior research examining the contribution of executive functioning to problem-solving ability (Swanson, 2011).

The plus-minus task (adapted from Miyake et al., 2000; see Appendix D) was used as a measure of shifting. The task, used by Miyake and colleagues (2000) as a measure of shifting ability, was found to contribute to performance on a widely-used measure of planning and cognitive flexibility (i.e., Wisconsin Card Sorting Test). The task consisted of three lists of two-digit numbers, each with 20 two-digit randomized, nonrepeating numbers per list. For the first list, participants were instructed to add 3 to each number while recording their answers. For the second list, participants were instructed to subtract 3 to each number while recording their answers. For the third list, participants were instructed to alternate between adding and subtracting 3 as quickly and accurately as possible to and from each number (i.e., adding 3 to the first two-digit number, subtracting 3 from the second two-digit number, etc.). Response times were recorded for each list completion. Performance on the alternating condition was utilized as a measure of shifting. Shifting scores were converted to standard scores and transformed so that higher scores indicated higher performance.

Metacognition and Metacognitive Monitoring

Metacognition measures. The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & De Groot, 1990; see Appendix F) was administered with reference to the undergraduate educational psychology course from which the participants were recruited. The widely-used questionnaire consists of 81 items, with subscales that are able to be used and interpreted separately (Pintrich, Smith, Garcia, & McKeachie, 1993). An example item is "*I ask myself questions to make sure I know the material I've been studying*" (included in the

Learning Strategies scale) (Pintrich & De Groot, 1990). Each item was rated on a 7-point Likert scale (1 – Not at all true of me to 7 – Very true of me). For the current study, the metacognitive self-regulation scale (MS-R) was used as a measure of metacognition based on Pintrich and colleagues' conceptualization of the scale as focused on the control and self-regulation aspects of metacognition as well as the metacognitive processes of planning, monitoring, and regulating (Pintrich et al., 1991). The MS-R scale has demonstrated relatively high reliability and wide use in the literature (Bartels & Magun-Jackson, 2009; Garner, 2009; Pintrich et al., 1993).

The Strategic Problem Solving Inventory (Fortunato et al., 1991; see Appendix G) was used as a measure of metacognition that taps temporal aspects of metacognition while problem solving. The inventory consists of 21 items, each of which was rated on a 7-point Likert scale (1 – Not at all true of me to 7 – Very true of me), that asked participants to rate their behaviors while engaged with a problem scenario before, during, and after the problem. Example items include "*I tried to put the problem into my own words*", "*I checked my work step by step as I worked the problem*", and "*I thought about a different way to solve the problem*". An examination of the use of the Strategic Problem Solving Inventory in the current college-age sample indicated relatively high reliability ($\alpha = .89$).

Metacognitive monitoring measures. The calculation of metacognitive monitoring was anchored around the administration of an assessment text with accompanying multiple-choice test items. The text was a 1,112 word, 11-paragraph passage (see Appendix I) on standardized test scores. The sections of the text described standardized tests, measures of central tendency, measures of variability, the normal distribution, raw scores, percentiles, *z*-scores, *T*-scores, and stanines. The text was presented electronically on a single page with typical section headings. After reading the text, participants completed 20 multiple-choice items assessing recognition and comprehension of the text content (see Appendix J). The items, designed based on Bloom's taxonomy (Bloom, Hastings, & Madaus, 1971), were incorporated in prior research (Lan & Sperling, 2008). Items were classified into one of three levels: knowledge-level items; application-level items; and analysis-, synthesis-, evaluation-level items (i.e., ASE-level items). The primary purpose of the text and accompanying multiple-choice items was to provide a mechanism for calculating direct measures of metacognitive monitoring.

Participants were asked to record confidence judgments for each of the assessment text multiple-choice items. Confidence judgments were recorded on a scale from 0 (0% confident; left side of scale) to 100 (100% confident; right side of scale) by marking the point on the scale that represented their perceived level of confidence in responding to and correctly answering the question (Huff & Nietfeld, 2009). Metacognitive monitoring was measured through the calculation of calibration accuracy and calibration bias. Calibration accuracy was obtained by taking the absolute value of the difference between the confidence judgment provided following completion of each item (i.e., 0 to 100) and the actual performance on each item (i.e., 1 for correct and 0 for correct responses). Each absolute value was summed across all problem items and then divided by the total number of problems to yield the calibration accuracy index (Huff & Nietfeld, 2009; Schraw, 2009). Calibration bias was obtained by taking the signed difference between the average confidence judgment and actual performance on each item to yield a measure of bias (i.e., overconfidence and underconfidence in confidence ratings (Huff & Nietfeld, 2009; Schraw, 2009). Calibration accuracy and bias have been used in prior studies examining the relations between metacognitive monitoring and self-report measures of metacognition (Schraw, 1994) as well as the ability of strategy instruction to improve metacognitive monitoring (Huff & Nietfeld, 2009).

Self-Regulated Learning

The 28-item Self-Regulation Strategy Inventory – Self-Report (SRSI-SR; Cleary, 2006; see Appendix H) was administered as a measure of self-regulated learning and the use of specific self-regulation strategies. Each item was rated on a 7-point Likert scale (1 – Never to 7 – Always). The inventory consists of three factors: managing environment and behavior, seeking and learning information, and maladaptive regulatory behavior. Example items include "*I think about how best to study before I begin studying*" (included in the Managing Environment and Behavior scale), "*I ask my teacher questions when I do not understand something*" (included in the Seeking and Learning Information scale), and "*I try to forget about the topics that I have trouble learning*" (included in the Maladaptive Regulatory Behavior scale). Originally developed for administration in the context of science learning, select items were adapted slightly, with references to science classes removed, to allow for domain-general administration. A prior examination of the use of the SRSI-SR indicated high reliability ($\alpha = .92$), with estimates of subscale reliability ranging from .72 to .88 (Cleary, 2006). The reliability for the current sample was also high ($\alpha = .89$).

Procedure

Data collection occurred in the fall of 2014 during a 3-week period. All measures were administered individually via an electronic survey software program. Median total study completion time was approximately 75 minutes. Participants were administered all assessments in accordance with the appropriate administration procedures for each instrument. All measures were administered in randomized order to control for potential order and fatigue effects.

Chapter 3

Results

Missing data analyses were conducted to examine the extent of missing data and inform the imputation of missing values. Missing value analyses revealed: 2 cases with 8.33% missing (11 values); 2 cases with 6.82% missing (9 values); 1 case with 5.30% missing (7 values); 1 case with 2.27% missing (3 values); 2 cases with 1.52% missing (2 values); and 13 cases with .76% missing (1 value) data. Across all participants, a total of 67 missing values were obtained of 15,444 total possible values. This resulted in a total missing value percentage of 0.43%.

Because a nominal amount of data were missing, single imputation based on a randomized hot-deck imputation procedure for missing data was utilized (Andridge & Little, 2010; Cheema, 2014). Imputed values were selected based on randomly selected cases with similar age, ethnicity, class standing, and GPA characteristics. In cases where there were limited donor cases from which to impute (e.g., based on limited representation of ethnicity for like cases), all eligible donors were used. Across all cases for which there were missing values, an average of 10 eligible donor cases were available with similar age, ethnicity, class standing, and GPA information to conduct the imputations.

Equivalence of Participants on Regulatory Functioning

A multivariate analysis of variance (MANOVA) examining gender, ethnicity, and class standing was conducted for scores of executive functioning (ESQ; inhibition and shifting), metacognition (MSLQ – MS-R; calibration accuracy; calibration bias), and self-regulated learning (SRSI) to ensure equivalence of regulatory functioning in the sample. Executive functioning, metacognition, and self-regulated learning did not differ by gender

(Wilks's Λ = 0.84, *F* (12, 192) = 1.51, $p > .05$), ethnicity (Wilks's Λ = 0.79, *F* (18, 272.01) = 1.34, $p > .05$), or class standing (Wilks's Λ = 0.79, *F* (18, 272.01) = 1.34, $p > .05$).

As expected, tests of between-subjects effects were not significant ($p > .05$). There were no significant interactions between gender and ethnicity (Wilks's Λ = 0.96, *F* (6, 96) = 0.76, $p > .05$), gender and class standing (Wilks's Λ = 0.83, *F* (18, 272.01) = 1.07, $p > .05$), and ethnicity and class standing (Wilks's Λ = 0.75, *F* (18, 272.01) = 1.62, $p > .05$) for the scores on measures of executive functioning, metacognition and metacognitive monitoring, and self-regulated learning. The results supported the use of the measures in equitably measuring each of the regulatory constructs in the sample.

Preliminary Data Analysis

Descriptive and reliability statistics for indirect measures of regulatory functioning included in the multiple linear regression and mediation analyses are included in Table 1. Cronbach's alpha was used as an estimate of reliability for each of the indirect measures; acceptable reliability coefficients were obtained for all measures. All of the measures had relatively low skewness and kurtosis statistics ($Z < 1.96$), indicating normality among each of the scale-level distributions.

Table 1

Descriptive Statistics for Indirect Measures of Regulatory Functioning

Measure	*M*	*Mdn*	*SD*	Range	Number of Items	α
ESQ Composite	110.84	110.00	14.93	89.00	33	.89
MSLQ – MS-R	54.84	55.00	9.20	49.00	12	.77
SPSI Composite	90.77	91.00	18.97	94.00	21	.89
SRSI Composite	141.79	143.00	19.61	86.00	28	.89

Note. ESQ = Executive Skills Questionnaire, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire, Metacognitive Self-Regulation Scale; SRSI = Self-Regulation Strategy Inventory, SPSI = Strategic Problem Solving Inventory.

Descriptive statistics for direct measures of executive functions included in the multiple linear regression and mediation analyses are included in Table 2. Cronbach's alpha was used as an estimate of reliability for the measure of inhibition based on the category and verbal fluency scores, yielding adequate reliability (α = .61). An estimate of reliability could not be calculated for the measure of shifting because there was one response time for the shifting condition.

Table 2

Descriptive Statistics for Direct Measures of Executive Functions and Metacognition

Measure	M	Mdn	SD	Range
Inhibition	18.87	18.50	4.10	24.50
Category Fluency	18.89	19.00	4.80	27.00
Verbal Fluency	18.85	19.00	4.88	28.00
Shifting	73.16	70.00	22.49	131.03
Calibration Accuracy	0.36	0.36	0.07	.36
Calibration Bias	-0.04	-0.03	0.17	.84

Note. The category fluency and verbal fluency were averaged to yield the inhibition measure.

What Are the Relations Among Executive Functioning, Metacognition, and Self-Regulated Learning?

Correlations obtained among the composite scores for the ESQ, the MSLQ – MS-R, the SPSI, and the SRSI are displayed in Table 3. In general, the correlations obtained provided evidence of significant relations among executive functioning, metacognition, and self-regulated learning. Moderate, significant correlations were obtained between the ESQ and the MSLQ – MS-R and SRSI, supporting executive functioning as significantly related with but independent from the regulatory constructs of metacognition and self-regulated learning. A strong correlation was obtained between the MSLQ – MS-R and the SRSI, supporting a strong relationship between metacognition and self-regulated learning.

The SPSI demonstrated a moderate relationship with the MSLQ – MS-R , a correlation that was slightly lower than expected given that both instruments served as measures of metacognition. Similarly, the SPSI demonstrated a weak to moderate relationship with the SRSI and a nonsignificant relationship with the ESQ. These findings are interpreted in light of the fact that the SPSI purported to measure temporal aspects of metacognition with respect to problem solving before, during, and after problem solving. It may be that the specificity of this temporal measurement focus was such that the scores obtained on the other indirect measures were more global in nature relative to the temporally-specified measurement of the SPSI.

Table 3

Correlations Among Composite Scores for Measures of Executive Functioning, Metacognition, and Self-Regulated Learning

Measure	1	2	3	4
1. ESQ Composite	-			
2. MSLQ – MS-R	.36**	-		
3. SPSI Composite	.13	.32**	-	
4. SRSI Composite	.47**	.56**	.23*	-

Note. ESQ = Executive Skills Questionnaire, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire, Metacognitive Self-Regulation Scale, SPSI = Strategic Problem Solving Inventory, SRSI = Self-Regulation Strategy Inventory.
*$p < .05$. **$p < .01$. ***$p < .001$.

Correlations obtained among direct measures of executive functions and composite scores for the ESQ, the MSLQ – MS-R, the SPSI, and the SRSI are displayed in Table 4. Significant correlations were obtained between the direct measures of executive functions and the indirect measures of metacognition and self-regulated learning. Significant correlations were obtained between the category fluency task, contributing to the measure of inhibition, and scores obtained on the MSLQ – MS-R, the SPSI, and the SRSI.

The correlation obtained between the composite measure of inhibition and the MSLQ was also significant, which indicated a significant relationship between performance on an inhibition task and metacognition. Similarly, the correlation obtained between the measure of inhibition and the SRSI was significant, and supported a significant relationship between inhibition and self-regulated learning. The low and nonsignificant correlations obtained between the direct and indirect executive function measures mirrored prior findings in the literature (Barkley, 2012; Cuperus, Vugs, Scheper, & Hendriks, 2014) and further highlighted the multifaceted nature of executive functioning and the need to measure executive functioning by use of both direct and indirect measures.

Table 4

Correlations Among Direct Measures of Executive Functions and Composite Scores for Indirect Measures of Executive Functioning, Metacognition, and Self-Regulated Learning

Measure	Shifting	Inhibition	Category Fluency	Verbal Fluency
ESQ Composite	.02	.02	.05	-.08
MSLQ – MS-R	.10	.21*	.23*	.13
SPSI Composite	.09	.15	.19*	.06
SRSI Composite	-.04	.23*	.26**	.12

Note. ESQ = Executive Skills Questionnaire, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire – Metacognitive Self-Regulation Scale, SPSI = Strategic Problem Solving Inventory, SRSI = Self-Regulation Strategy Inventory. The category fluency and verbal fluency were averaged to yield the inhibition measure.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

To examine the relations among measures of metacognitive monitoring and indirect measures of metacognition and self-regulated learning, correlations were calculated among the measures. The correlational analyses, presented in Table 5, also facilitated the selection of the mediating variable for the mediation analyses. Absolute accuracy was significantly but negatively related with bias, indicating that, as participants' overconfidence decreased, absolute accuracy increased. In other words, participants' precision of item-level confidence judgments relative to performance on the test items increased as their overconfidence in performance decreased. Such findings are consistent with the finding that, when confidence is high and performance is low, overconfidence occurs (Schraw, 2009).

Table 5

Correlations Among Measures of Metacognitive Monitoring and Composite Scores for Indirect Measures of Metacognition and Self-Regulated Learning

Measure	1	2	3	4	5
1. Calibration Accuracy	-				
2. Calibration Index	-.24**	-			
3. MSLQ – MS-R	-.05	.14	-		
4. SPSI Composite	-.13	.35**	.32**	-	
5. SRSI Composite	-.17	.16	.56**	.23*	-

Note. MSLQ – MS-R = Motivated Strategies for Learning Questionnaire – Metacognitive Self-Regulation Scale, SRSI = Self-Regulation Strategy Inventory.
**p* < .05. ***p* < .01. ****p* < .001.

Calibration bias was significantly related with reported metacognition on the SPSI, but was not significantly related with scores obtained on the MSLQ – MS-R or the SRSI. Absolute accuracy was negatively but not significantly related with scores on the MSLQ – MS-R, the SPSI, or the SRSI, indicating a lack of correspondence between the direct measure of metacognitive monitoring and indirect measures of metacognition and self-regulated learning. Such findings of a lack of a significant relationship between monitoring accuracy and self-report measures of metacognition are consistent with those noted in the literature (Schraw & Dennison, 1994; Winne & Perry, 2000).

Calibration bias and accuracy, as more direct measures of metacognition, appeared inconsistent in their measurement of metacognition based on differences in magnitude and direction of the obtained correlations with indirect measures of metacognition. This, combined with the finding of a negative relationship between absolute accuracy and bias as a function of overconfidence, resulted in the selection of the MSLQ – MS-R scale as the most appropriate measure of metacognition to serve as the mediating variable in subsequent mediation analyses.

Does Executive Functioning, as Measured by Direct and Indirect Measures, Predict Metacognition and Self-Regulated Learning?

Multiple linear regression analyses are displayed in Table 6. The composite score obtained from the ESQ was used as an indirect measure of executive functioning, while measures of inhibition and shifting were used as direct measures of executive functions. Outcome variables for both analyses consisted of the MSLQ – MS-R and SRSI scores. Hierarchical regression analysis was utilized to examine separately the impact of the indirect measure of executive functioning and direct measures of executive functions on metacognition and self-regulated learning. Collinearity statistics, including tolerance and variance inflation factor estimates, were within normal limits and ranged from .90 to 1.00 and 1.00 to 1.11 respectively, with none of the condition index values exceeding the normal limit (i.e., < 30).

Student GPA was entered into each regression model in preliminary analyses to evaluate whether obtained findings were a function of academic achievement. GPA was not a significant predictor of metacognition, $\beta = .09$, $t\ (113) = 0.98$, $p > .05$, or of self-regulated learning, $\beta = .08$, $t\ (113) = 1.00$, $p > .05$, in either model, suggesting that academic achievement was not a significant predictor of regulatory functioning in the sample. As a result, GPA was removed from the final regression models to improve the estimates of the retained regression coefficients in the models.

Executive functioning, as measured by both direct and indirect measures, significantly predicted metacognition, as measured by the MSLQ – MS-R, $F\ (3, 113) = 9.49$,

$p < .001$, $R^2 = .20$. The effect size obtained indicated a medium effect, with the model accounting for 20% of the variance in the metacognition scores. Each measure of executive functioning, including the ESQ, $\beta = .36$, t (113) = 4.27, $p < .001$, inhibition, $\beta = .27$, t (113) = 3.08, $p < .01$, and shifting, $\beta = .18$, t (113) = 1.99, $p < .05$, significantly predicted metacognition as measured by the MSLQ – M-SR. As expected, an examination of the change in R^2 revealed a significant increase in the amount of variance accounted for by the model including the direct measures of executive functioning over and beyond that accounted for by the model containing only the indirect measure of executive functioning, F (2,113) = 5.25, $p = .01$, $\Delta R^2 = .07$. The findings supported the inclusion of the direct measures of executive functions in the regression model.

Table 6

Summary of Multiple Linear Regression Analyses for Executive Functioning Predicting Composite Scores of Metacognition and Self-Regulated Learning

	MSLQ – M-SR		SRSI Composite	
Variable	B (β)	95% CI	B (β)	95% CI
ESQ	0.22(0.36)***	[0.12, 0.32]	0.63(0.48)***	[0.42, 0.83]
Inhibition	0.62(0.27)**	[0.22, 1.01]	1.27(0.27)**	[0.47, 2.07]
Shifting	0.10(0.18)*	[0.01, 0.20]	0.11(0.09)	[-0.09, 0.32]
R^2	.20		.29	
Adj. R^2	.18		.27	
F	9.49***		15.06***	
p	< .001		< .001	

Note. ESQ = Executive Skills Questionnaire, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire – Metacognitive Self-Regulation Scale, SRSI = Self-Regulation Strategy Inventory.
*$p < .05$. **$p < .01$. ***$p < .001$.

Executive functioning, as measured by direct and indirect measures, also significantly predicted self-regulated learning, F (3, 113) = 15.06, $p < .001$, $R^2 = .29$. The effect size obtained indicated a large effect, with the model accounting for 29% of the variance in self-regulated learning scores. The indirect measure of executive functioning, $\beta = .48$, t (113) =

5.99, $p < .001$, as well as the measure of inhibition, $\beta = .27$, t (113) = 3.14, $p < .01$, significantly predicted self-regulatory functioning on the SRSI. Shifting was not a significant predictor of self-regulated learning in the model, $\beta = .09$, t (113) = 1.07, $p > .05$. An examination of the change in R^2 revealed a significant increase in the amount of variance accounted for by the model that contained the direct measure of inhibition over and above that accounted for by the model containing only the indirect measure of executive functioning, F (2,113) = 4.94, $p < .01$, $\Delta R^2 = .06$.

The findings again supported the inclusion of a direct measure of executive function in the regression model. In both models, the addition of direct measures of executive functions accounted for additional variance (6% and 7%, respectively) in metacognition and self-regulated learning over and above the inclusion of an indirect measure of global executive functioning. Taken together, the findings implicated an important role of specific executive functions in accounting for variance in metacognition and self-regulated learning beyond commonly included indirect measures of executive functioning.

Does Metacognition Affect the Relationship Between Executive Functioning and Self-Regulated Learning?

Separate mediation analyses were conducted to examine the mediating effect of metacognition on executive functioning as measured by both indirect and direct measures. Mediation analyses were conducted utilizing PROCESS as the computational procedure in SPSS (Hayes, 2012). In the first mediation analysis, scores from the ESQ were used as a measure of executive functioning (Dawson & Guare, 2010). In the second mediation analysis, scores obtained from the measures of inhibition and shifting were used as a composite direct measure of executive functions. Scores from the MSLQ – M-SR scale were used as a measure of metacognition that served as the mediator variable (Pintrich & De Groot, 1990). Scores on the SRSI were used as a measure of self-regulated learning (Cleary, 2006).

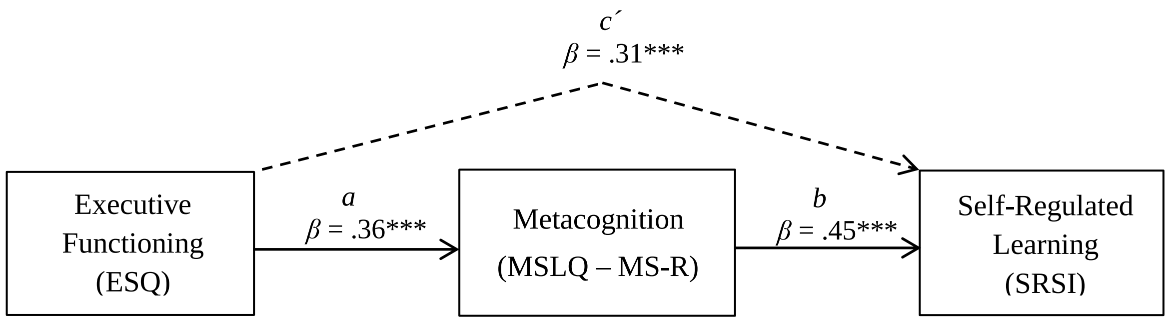

Figure 2. Obtained model for metacognition mediating the relationship between executive functioning and self-regulated learning.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Figure 2 displays the obtained statistical model for the first mediation analysis with metacognition mediating the relationship between executive functioning and self-regulated learning. The obtained model supported the hypothesized conceptual model in explaining how metacognition affects the relationship between executive functioning and self-regulated learning. Correlations obtained among measures of executive functioning, metacognition, and self-regulated learning used in the mediation analysis are included in Table 7. The mediation analysis results are displayed in Table 8. Scores from each of the measures were standardized on a *z*-score scale prior to analysis.

Executive functioning and metacognition accounted for a significant amount of the variance in self-regulated learning, F (2, 114) = 38.01, $p < .001$, $R^2 = .40$. The effect size obtained indicated a large effect, with the model accounting for 40% of the variance in self-regulated learning scores. A comparison of the change in R^2 revealed a significant increase in the amount of variance explained by the regression model containing the mediator compared with the model excluding the mediator, *F* (1,114) = 35.36, $p < .001$, $\Delta R^2 = .18$, supporting the inclusion of metacognition as the mediating variable.

Table 7

Correlations Among Measures of Executive Functioning, Metacognition, and Self-Regulated Learning Included in the Mediation Analysis

Measure	1	2	3
1. ESQ Composite	-		
2. MSLQ – MS-R	.36**	-	
3. SRSI Composite	.47**	.56**	-

Note. ESQ = Executive Skills Questionnaire, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire, Metacognitive Self-Regulation Scale, SRSI = Self-Regulation Strategy Inventory.
*$p < .05$. **$p < .01$. ***$p < .001$.

A decomposition of the associations among executive functioning, metacognition, and self-regulated learning revealed significance across all paths (i.e., paths *a*, *b*, and *c´*). As expected, scores on the ESQ were associated with scores on the MSLQ – M-SR scale when the ESQ was entered independently in the model (path *a*, X → M), $\beta = .36$, $t = 5.75$, $p < .001$, $SE = .09$. Scores on the MSLQ – M-SR scale were associated with scores on the SRSI (path *b*, M → Y, X), $\beta = .45$, $t = 5.80$, $p < .001$, $SE = .08$. The direct effect of executive functioning on self-regulated learning was statistically significant (path *c´*, X → Y, M), $\beta = .31$, $t = 4.02$, $p < .001$, $SE = .08$, supporting the hypothesized effect and indicating that the effect of executive functioning on self-regulated learning was partially transmitted by metacognition.

The indirect effect (*ab*), $\beta = .16$, $SE = .05$, of executive functioning on self-regulated learning through metacognition was evaluated by way of the Sobel test and the calculation of a bootstrap confidence interval (Hayes, 2012; MacKinnon, Fairchild, & Fritz, 2007; Sobel, 1986). The indirect effect was found to be statistically significant, $Z = 3.34$, $p < .001$, $R^2 = .14$. A bias-corrected bootstrap confidence interval for the indirect effect was calculated using 10,000 bootstrap samples (Hayes, 2012). An examination of the confidence interval for the indirect effect indicated that the interval did not contain zero (95% CI = [0.08, 0.27]). The confidence interval corroborated the findings of the Sobel test indicating significance of the indirect effect.

Table 8

Mediation Analysis of the Effect of Executive Functioning on Self-Regulated Learning by Metacognition

Model	Estimate		*SE*	*p*	95% CI *LL*	95% CI *UL*
Model without mediator						
ESQ→SRSI (*c*)	.47		.08	< .001	.31	.64
$R^2 Y,X$		.22				
Adj. R^2		.21				
F		33.05		< .001		
Model with mediator						
ESQ→M-SR (*a*)	.36		.09	< .001	.18	.53
M-SR→SRSI (*b*)	.45		.08	< .001	.29	.60
ESQ→SRSI (*c´*)	.31		.08	< .001	.16	.47
Indirect Effect (*ab*)	.16		.05	< .001	.09	.27
$R^2 Y,MX$		.40				
Adj. R^2		.39				
F		38.01		< .001		
ΔR^2		.18		< .001		

Note. $R^2 Y,X$ is the proportion of variance in *Y* explained by *X*. $R^2 Y,MX$ is the proportion of variance in *Y* explained by *X* and *M*. LL = lower limit; UL = upper limit; Confidence intervals reflect limits of unstandardized coefficients. ESQ = Executive Skills Questionnaire; SRSI = Self-Regulation Strategy Inventory; M-SR = Metacognitive Self-Regulation.

Figure 3 displays the obtained statistical model for the second mediation analysis with metacognition mediating the relationship between the executive functions of inhibition and shifting and self-regulated learning. The obtained model again supported the hypothesized model in explaining how metacognition affects the relationship between executive functions and self-regulated learning.

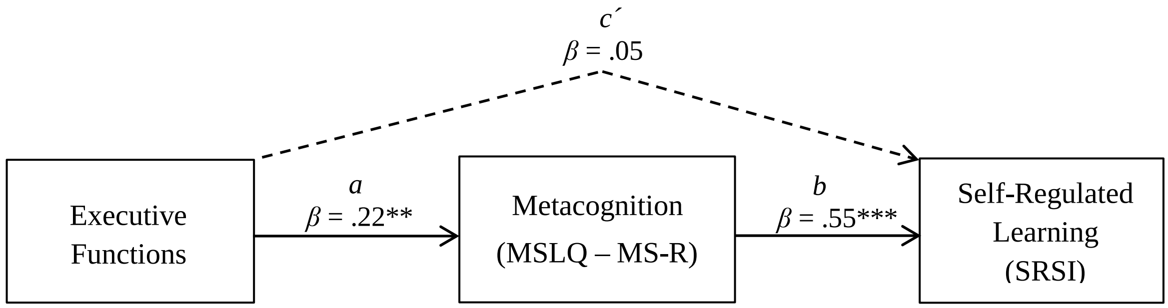

Figure 3. Obtained model for metacognition mediating the relationship between executive functions and self-regulated learning.
*$p < .05$. **$p < .01$. ***$p < .001$.

Correlations obtained among the measures of executive functions, metacognition, and self-regulated learning used in the mediation analysis are included in Table 9. The mediation analysis results are displayed in Table 10. Scores from each of the measures were again standardized on a *z*-score scale prior to analysis. Scores for the measures of inhibition and shifting were standardized and then summed to yield a composite executive function score. A similar scoring method has been used in prior research to derive a composite direct executive function score (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014).

Table 9

Correlations Among Measures of Executive Functions, Metacognition, and Self-Regulated Learning Included in the Mediation Analysis

Measure	1	2	3
1. Executive Functions	-		
2. MSLQ – MS-R	.26**	-	
3. SRSI Composite	.20*	.56**	-

Note. Executive Functions = Inhibition and Shifting Composite Score, MSLQ – MS-R = Motivated Strategies for Learning Questionnaire, Metacognitive Self-Regulation Scale, SRSI = Self-Regulation Strategy Inventory.
*$p < .05$. **$p < .01$. ***$p < .001$.

Executive functions and metacognition accounted for a significant amount of the variance in self-regulated learning, F (2, 114) = 26.64, $p < .001$, $R^2 = .32$. The effect size obtained again indicated a large effect, with the model accounting for 32% of the variance in self-regulated learning scores. A comparison of the change in R^2 revealed a significant increase in the amount of variance explained by the regression model containing the mediator compared with the model excluding the mediator, F (1,114) = 46.40, $p < .001$, $\Delta R^2 = .28$.

Table 10

Mediation Analysis of the Effect of Executive Functions on Self-Regulated Learning by Metacognition

Model	Estimate	*SE*	*p*	95% CI *LL*	95% CI *UL*
Model without mediator					
EFs→SRSI (*c*)	.18	.08	< .05	.02	.33
$R^2_{Y,X}$	.04				
Adj. R^2	.03				
F	4.93		< .05		
Model with mediator					
EFs→M-SR (*a*)	.22	.08	< .01	.07	.38
M-SR→SRSI (*b*)	.55	.08	< .001	.39	.70
EFs→SRSI (*c*´)	.05	.07	.44	-.08	.19
Indirect Effect (*ab*)	.12	.05	< .05	.04	.22
$R^2_{Y,MX}$	.32				
Adj. R^2	.31				
F	26.64		< .001		
ΔR^2	.28		< .001		

Note. $R^2_{Y,X}$ is the proportion of variance in *Y* explained by *X*. $R^2_{Y,MX}$ is the proportion of variance in Y explained by X and M. LL = lower limit; UL = upper limit; Confidence intervals reflect limits of unstandardized coefficients. EFs = Executive Functions; SRSI = Self-Regulation Strategy Inventory; M-SR = Metacognitive Self-Regulation.

As expected, scores on the composite measure of inhibition and shifting were associated with scores on the MSLQ – M-SR scale when the executive function scores were entered independently in the model (path *a*, X → M), $\beta = .22$, $t = 2.88$, $p < .01$, $SE = .08$. Scores on the MSLQ – M-SR scale were associated with scores on the SRSI (path *b*, M → Y, X), $\beta = .55$, $t = 6.81$, $p < .001$, $SE = .07$. The direct effect of executive functions on self-regulated learning, however, was not statistically significant (path *c*´, X → Y, M), $\beta = .05$, $t = 0.77$, $p = .44$, $SE = .07$, indicating that the effect of executive functions on self-regulated learning was transmitted fully by metacognition.

The indirect effect (*ab*), $\beta = .12$, $SE = .05$, of executive functioning on self-regulated learning through metacognition was found to be statistically significant, $Z = 2.63$, $p = .01$, $R^2 = .04$. A bias-corrected bootstrap confidence interval using 10,000 bootstrap samples (Hayes, 2012) indicated that the interval did not contain zero (95% CI = [0.03, 0.21]), corroborating the findings of the significance of the indirect effect.

Split-Sample Cross-Validation and Cross-Validated $\hat{R}^2$ for the Mediation Regression Model

A split-sample cross-validation procedure was employed to evaluate the replicability of the predictors included in the mediation regression model. The sample ($n = 117$) was randomly split into two halves ($n = 59$ and $n = 58$, respectively). A regression equation was obtained for the split sample ($n = 59$) and applied to the cross-validation sample ($n = 58$) to obtain predicted values for the outcome variable (i.e., SRSI scores) based on the two predictors (i.e., ESQ scores and MSLQ – MS-R scores) included in the model, $F(2, 56) = 18.18$, $p < .001$, $R^2 = .39$. Predicted scores on the SRSI in the cross-validation sample were then correlated with the obtained SSRI scores in the same sample to provide evidence of the robustness of the predictors in the regression model. The obtained correlation, $r(56) = .58$, $p < .001$, provided evidence for the replicability of the regression model predictors to other samples.

The cross-validated $\hat{R}^2$ was then calculated for the entire sample as an estimate of the variance accounted for in self-regulated learning by the predictors used in the study if applied to another sample. The obtained value, $\hat{R}^2 = .35$ ($N = 117$), indicated that, if the sample regression weights were applied to the population or another sample in the population, the predictors would account for approximately 35% of the variance in self-regulated learning

(Cohen, Cohen, West, & Aiken, 2003). The results provided support for the replicability of the predictors in the regression models in accounting for variance in self-regulated learning.

Chapter 4

Discussion

The primary purpose of the current study was to examine and clarify the conceptual relations among executive functioning, metacognition, and self-regulated learning. A secondary aim of the study was to explicate how self-regulated learning is informed by executive functions. Prior research has noted significant relations among executive functioning and metacognition (Effeney et al., 2013) and executive functioning and self-regulated learning (Effeney et al., 2013; Garner, 2009). However, prior research has rested on the use of indirect measures of executive functioning and has not evaluated how executive functions inform self-regulated learning, providing an incomplete picture of the framework of regulatory constructs.

Moderate correlations among executive functioning, metacognition, and self-regulated learning were obtained, supporting executive functioning as significantly related with but independent from the regulatory constructs of metacognition and self-regulated learning. Executive functioning significantly predicted and accounted for variance in metacognition and self-regulated learning. With respect to metacognition, an indirect measure of global executive functioning as well as direct measures of inhibition and shifting ability predicted metacognition. The addition of direct measures of executive functions accounted for a significant amount of the variance in metacognition beyond the inclusion of an indirect measure.

Executive functioning was also a significant predictor of reported self-regulated learning. As with metacognition, an indirect measure of global executive functioning as well as a direct measure of inhibition predicted self-regulated learning. However, the direct measure of shifting ability was not a significant predictor in the model. Despite this finding, the addition of the direct measure of inhibition accounted for a significant amount of additional variance in self-regulated learning.

Taken together, the findings supported the inclusion of direct as well as indirect measures of executive functioning in the analyses, and also supported the role of specific executive functions in explaining self-regulated learning. Such findings replicate and extend prior research demonstrating the ability of executive functioning to predict self-regulated learning (Effeney et al., 2013; Garner, 2009) but also implicate the importance of examining the role of the specific executive functions of inhibition and shifting in accounting for learners' regulation.

Inhibition and shifting are described as core executive functions (Barkley, 2012; Denckla, 2007; Meltzer et al., 2007; Miyake et al., 2000) suggested in the performance of complex cognitive functioning and linked with a host of academic skills and achievement areas (Altemeier et al., 2008; Borella et al., 2010; Christopher et al., 2012; Locascio et al., 2010; Sesma et al., 2009). The current findings support the interrelated role of these executive functions as independent but important processes that demonstrate a shared contribution in contributing to learners' regulation. The findings also demonstrate the multifaceted and multidimensional nature of executive functioning as a regulatory construct that has both global (i.e., unitary) and specific (i.e., diverse) elements (Miyake et al., 2000).

The hypothesis that metacognition would mediate the relationship between executive functioning and self-regulated learning was supported. Metacognition partially transmitted the effect of executive functioning on self-regulated learning when an indirect measure of executive functioning was used; this finding draws on prior research that has demonstrated a direct relationship between executive functioning and self-regulated learning when indirect measures of the regulatory constructs were used (Effeney et al., 2013; Garner, 2009; Hofmann et al., 2012). With an indirect measure of executive functioning employed, the mediation regression model accounted for a significant amount of the variance in self-regulatory functioning. Interestingly, the effect of executive functions on self-regulated learning was transmitted fully by metacognition when the executive functions of inhibition and shifting were entered in the mediation model. Together, the findings across mediation analyses demonstrated large effects that suggest and support an important role of executive functions in influencing self-regulated learning through metacognitive processes.

Limitations

The current study utilized an undergraduate student sample of convenience that was predominantly female. As a result, the composition of the sample has the potential to limit the generalizability of the obtained findings. In addition, as a preliminary step in explicating how executive functions relate with and inform self-regulated learning, one measure was used to represent the constructs of metacognition and self-regulated learning. The underlying logic of this determination was to provide clear, straightforward evidence, using one indicator per construct, of the relational processes among the constructs. Future research would likely benefit from the inclusion of alternative measures of metacognition and self-regulated learning in further specifying the relations among the regulatory constructs.

Finally, the current study demonstrated the ability of inhibition and shifting as empirically-supported executive functions to inform self-regulated learning (Miyake et al., 2000). However, the potential exists for other executive functions, supported by the literature as contributing to self-regulated learning outcomes, to account for additional variance in self-regulated learning. Future research may also benefit from the incorporation of additional executive functions in mediational analyses that evaluate the effect of such processes in accounting for self-regulated learning.

Implications and Future Research

The findings of the current study clarify the nature of the relationship between executive functioning and self-regulated learning by delineating how executive functioning informs metacognition and how metacognition in turn informs self-regulated learning. The findings also add clarity to the measurement of key regulatory constructs with the incorporation of direct or task-based measures of performance on executive functions. Executive functions are therefore situated and specified as processes that work to facilitate self-regulated learning and the use of strategies guided by metacognition that support the attainment of goals and learning outcomes (Winne, 1996; Winne, 2000; Zimmerman, 2008). In other words, executive functioning and metacognition appear to share commonality in contributing to self-regulated learning, with executive functions serving as specific but related cognitive processes mediated by metacognition that facilitate the flexible use of learning strategies to facilitate the attainment of learning goals (Garner, 2009; Zimmerman, 1989).

The findings also have potential to improve the understanding of the regulation of cognition component of metacognition (Sperling et al., 2004). When measured at the process or function level, metacognition transmits fully the effect of inhibition and shifting on self-regulated learning. However, when executive functioning is measured at a more global level, a direct effect remains on self-regulated learning. This suggests that, as processes, the executive functions of inhibition and shifting may facilitate the regulation of cognition of learners, and that such an effect is transmitted directly by metacognitive processes that coordinate the regulation of cognition. This finding adds clarity to the understanding of the processes that may play a contributing role to learners' regulation of cognition. Prior research has suggested that knowledge of cognition is related with and may precede regulation of cognition (Schraw, 1994; Sperling et al., 2004). The current study adds to this understanding by implicating specific processes at a finer grain size that contribute to learners' regulation of cognition. Thus, metacognition is again supported as a key contributing variable to self-regulated learning; however, executive functioning contributes significantly to self-regulated learning in a way that isn't captured by metacognition alone.

Overall, this work provided initial support for a regulatory framework that orders and situates self-regulated learning as the superordinate or overarching regulatory construct, with executive functions serving as specific facilitative regulatory processes. In this framework, metacognition and metacognitive processes function as mediating processes that facilitate self-regulated learning. Such a framework also positions executive functions as processes that are incorporated in and inform the cyclical and dynamic nature of self-regulation (Zimmerman, 2008). These points highlight the assertion by Hofmann, Schmeichel, and Baddeley (2012) that reductions in executive functions may explain and account for situational risk factors associated with temporary impairments in self-regulation and imply the need for measurement of executive functions to better understand self-regulated learning outcomes. These points also shed light on the potential for impairment in self-regulatory functioning to be explained by temporary reductions in executive functions such as inhibition and shifting (Hofmann et al., 2012). Areas of research that examine the conditions that lead to such reductions in functioning are likely to further illuminate and specify the impact of executive functions on self-regulated learning.

Based on the delineation of the regulatory framework, at least two important areas of future research are suggested by the findings of the current study. Despite the large amount of variance accounted for in self-regulated learning by the mediating effect of metacognition on executive functioning ($R^2 = .40$) and the executive functions of inhibition and shifting ($R^2 = .32$), additional variance in self-regulated learning is left unexplained. Garner (2009) articulates an important difference in cognitive processes that contribute to the flexible use of metacognitive and self-regulatory learning strategies and motivational processes that contribute to the sustained and deliberate use of such strategies. Given the importance of motivation and motivational processes as determinants of self-regulated learning (Winne, 1996), examination of the impact of such motivational processes contributing to the sustained used of strategies and anchored to a specific learning area would likely further specify the regulatory framework among executive functions, metacognition, and self-regulated learning (Garner, 2009; Hofmann et al., 2012).

The findings also have important implications for the role of and relation between executive functioning and working memory in contributing to regulatory outcomes. Attempts to integrate executive functions and working memory have led to differences in conceptualizations of the relations between the two construct areas (Barkley, 2012; Dawson & Guare, 2010; Gioia et al., 2004; Molfese et al., 2010). In line with Miyake and colleagues' (2000) findings supporting executive functions as separable but related processes that share an underlying commonality, it is possible that executive functions contribute to the role and function of the central executive as component processes within working memory (Baddeley, 1996). Such a conceptualization would support Baddeley's emphasis on the control functions of working memory, and would specify the central executive as a set of unified and multiple executive functions that contribute to more complex cognitive functioning, including the use of such strategies to facilitate regulation and attain learning goals and outcomes (1996). Additional research is needed to explicate and specify the role and relation of executive functions and working memory in contributing to self-regulated learning.

References

Altemeier, L. E., Abbott, R. D., Berninger, V. W. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology, 30*(5), 588-606. DOI: 10.1080/13803390701562818

Anderson, V., Anderson, P. J., Jacobs, R., & Smith, M. S. (2008). Development and assessment of executive function: From preschool to adolescence. In V. Anderson, R. Jacobs, & P. J. Anderson (Eds.), *Executive Functions and the Frontal Lobes*, (123-154). New York, NY: Taylor & Francis Group, LLC.

Andridge, R. R. & Little, R. J. A. (2010). A review of hot deck imputation for survey non-response. *International Statistical Review, 78*(1), 40-64.

Baddeley, A. D. (1996). Exploring the central executive. *Quarterly Journal of Experimental Psychology*, *49A*, 5–28.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*, 65-94.

Barkley, R. A. (2012). *Barkley Deficits in Executive Functioning Scale – Children and Adolescents.* New York: NY: The Guilford Press.

Bartels, J. M. & Magun-Jackson, S. (2009). Approach‐avoidance motivation and metacognitive self-regulation: The role of need for achievement and fear of failure. *Learning and Individual Differences,19*(4), 459-463.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning, beliefs, and techniques, and illusions. *Annual Review of Psychology, 64*, 417-444.

Bloom, B. S., Hastings, J. T., Madaus, G. F. (1971). *Handbook on formative and summative evaluation of student learning*. New York: McGraw-Hill.

Borella, E., Carretti, B., Pelegrina, S. (2010). The specific role of inhibition in reading comprehension in good and poor comprehenders. *Journal of Learning Disabilities, 43*(6), 541-52. DOI: 10.1177/0022219410371676

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. *Advances in Instructional Psychology, 1*, 77–165.

Cheema, J. R. (2014). A review of missing data handling methods in educational research. *Review of Educational Research, 84*(4), 487-508. DOI: 10.3102/0034654314532697.

Christopher, M. E., Miyake, A., Keenan, J. M., Pennington, B., DeFries, J. C., Wadsworth, S. J., Willcutt, E., & Olson, R. K. (2012). Predicting word reading and comprehension with executive function and speed measures across development: A latent variable analysis. *Journal of Experimental Psychology: General, 141*(3), 470-488. DOI: 10.1037/a0027375

Cleary, T. J. (2006). The development and validation of the Self-Regulation Strategy Inventory – Self-Report. *Journal of School Psychology, 44*, 307-322.

Cleary, T. J., Callan, G. L., & Zimmerman, B. J. (2012). Assessing self-regulation as a cyclical, context-specific phenomenon: Overview and analysis of SRL microanalytic protocols. *Education Research International, 2012*, 1-19.

Cohen, J., Cohen P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/ correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Cuperus, J., Vugs, B., Scheper, A., & Hendriks, M. (2014). Executive function behaviours in children with specific language impairment (SLI). *International Journal of Developmental Disabilities, 60*(3), 132-143.

Dawson, P. & Guare, R. (2010). *Executive skills in children and adolescents: A practical guide to assessment and intervention* (2nd ed.). New York, NY: The Guilford Press.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *The Delis-Kaplan Executive Function System: Examiner's Manual.* San Antonio: The Psychological Corporation.

Denckla, M. B. (1995). A theory and model of executive function: A neuropsychological perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 263–278). Baltimore: Brooks.

Denckla, M. B. (2007). Executive function: Binding together the definitions of attention-deficit/hyperactivity disorder and learning disabilities. In L. Meltzer (Ed.), *Executive Function in Education* (5-18). New York, NY: The Guildford Press.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*, 959 – 964.

Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review, 20,* 391-409.

Dunlosky, J. & Lipko A. R. (2007). Metacomprehension: A brief history and how to improve its accuracy. *Current Directions in Psychological Science, 16*, 228–232.

Effeney, G., Carroll, A., & Bahr, N. (2013). Self-regulated learning and executive function: Exploring the relationships in a sample of adolescent males. *Educational Psychology: An International Journal of Experimental Educational Psychology*, *33*(7), 773-796.

Fitzpatrick, C., McKinnon, R. D., Blair, C. B., & Willoughby, M. T. (2014). Do preschool executive function skills explain the school readiness gap between advantaged and disadvantaged children? *Learning and Instruction*, *30*, 25-31. http://dx.doi.org/10.1016/j.learninstruc.2013.11.003

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906-911.

Fortunato, I., Hecht, D., Tittle, C. K., & Alvarez, L. (1991). Metacognition and problem solving. *Arithmetic Teacher*, *39*(4), 38-40.

Fuhs, M. W., Farran, D. C., Nesbitt, K. T. (2015). Prekindergarten children's executive functioning skills and achievement gains: The utility of direct assessments and teacher ratings. *Journal of Educational Psychology, 107*(1), 207-221. DOI: 10.1037/a0037366

Garner, J. K. (2009). Conceptualizing the relations between executive functions and self-regulated learning. *The Journal of Psychology, 143*(4), 405-426.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2004). *The Behavior Rating Inventory of Executive Function.* Lutz, FL: Psychological Association Resources.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling [White paper]. Retrieved from http://www.afhayes.com/ public/process2012.pdf.

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*(3), 174-180.

Huff, J. D. & Nietfeld, J. L. (2009). Using strategy instruction and confidence judgments to improve metacognitive monitoring. *Metacognition Learning, 4*, 161-176.

Lan, Y. L. & Sperling, R. A. (2008). Effectiveness of notetaking, self-questioning and summarizing strategies on learning from diagrams. (Unpublished Thesis). The Pennsylvania State University, University Park, PA.

Locascio, G., Mahone, E.M., Eason, S. H., & Cutting, L. E. (2010). Executive dysfunction among children with reading comprehension deficits. *Journal of Learning Disabilities, 43*(5), 441-454. DOI: 10.1177/0022219409355476

Meltzer, L., Pollica, L. S., & Barzillai, M. (2007). Executive function in the classroom: Embedding strategy instruction into daily teaching practices. In L. Meltzer (Ed.), *Executive Function in Education* (5-18). New York, NY: The Guildford Press.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.

Molfese, V. J., Molfese, P. J., Molfese, D. L., Rudasill, K. M., Armstrong, N., & Starkey, G. (2010). Executive function skills of 6-8 year olds: Brain and behavioral evidence and implications for school achievement. *Contemporary Educational Psychology, 35*, 116-125.

Nelson, T.O. & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation*, Vol. 26 (pp. 125–173). New York: Academic Press.

Pintrich, P. R. & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33-40.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).* Ann Arbor: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

Pintrich, P. R., Smith, D. A. F., Garcia, T., McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53*, 801-813.

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

Salthouse, T. A. (2005). Relations between cognitive abilities and measures of executive functioning. *Neuropsychology, 19*(4), 532-545.

Schraw, G. (1994). The effect of metacognitive knowledge on local and global monitoring. *Contemporary Educational Psychology*, *19*, 143–154.

Schraw, G. (2009). A conceptual analysis of five measures of metacognitive monitoring. *Metacognition Learning, 4*, 33-45.

Schraw, G., & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*, 460–475.

Sesma, H. W., Mahone, E. M., Levine, T., Eason, S. H., & Cutting, L. E. (2009). The contribution of executive skills to reading comprehension. *Child Neuropsychology, 15*, 232-246. DOI: 10.1080/09297040802220029

Sobel, M. E. (1986). New results on indirect effects and their standard errors in covariance structure models. *Sociological Methodology, 16*, 159-186.

Sperling, R. A., Howard, B. C., Staley, R., & DuBois, N. (2004). Metacognition and self-regulated learning constructs. *Educational Research and Evaluation: An International Journal on Theory and Practice, 10*(2), 117-139.

Spinella, M. (2005). Self-rated executive function: Development of the Executive Function Index. *International Journal of Neuroscience, 115*, 649–667.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.

Swanson, H. L. (2011). Working memory, attention, and mathematical problem solving: A longitudinal study of elementary school children. *Journal of Educational Psychology, 103*(4), 821-837.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences, 8*(4), 327-353.

Winne, P. H. & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (532-564). Burlington, MA: Elsevier Academic Press.

Yan, Y. L. & Sperling, R. A. (2008). *Effectiveness of notetaking, self-questioning, and summarizing strategies on learning from diagrams*. (Unpublished master's thesis). The Pennsylvania State University, University Park, PA.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*, 329-339.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166-183.

Appendix A

Recruitment Statement

EDPSY 010/014

The researchers will describe the study and recruit volunteers in person in EDPSY 010/014 using the following recruitment statement:

I am here to recruit participants for a research study that examines how learners regulate and monitor their own learning. This research is being conducted by faculty member(s) and a graduate student from the Educational Psychology Department at Penn State and is being conducted for research purposes only. The study will be conducted online and should take 60 to 90 minutes to complete. You must be 18 years or older to participate in this study. If you agree to participate, you will be asked to complete a demographic inventory, solve problems, complete several questionnaires, read a text, answer questions about the text, and answer several questions that assess your thinking.

The study should take no more than 90 minutes to complete. You may receive extra credit to equal approximately 2% of the total points available in your course for your participation. You may also request to complete an article review instead of participating in the study to earn equivalent extra credit points. The review will be collected from a member of the research team who is not your instructor.

A list of participants will be provided to your instructor at the conclusion of the data collection at the end of the semester so that extra credit can be awarded. None of your responses to the study will be linked with your ID for the purposes of obtaining extra credit. If you have questions about the study you may contact D. Jake Follmer (djf244@psu.edu).

Appendix B

Executive Skills Questionnaire (Dawson & Guare, 2010)

Strongly disagree   Disagree   Neutral   Agree   Strongly agree

1. I don’t jump to conclusions
2. I think before I speak.
3. I don’t take action without having all the facts.
4. I have a good memory for facts, dates, and details.
5. I am very good at remembering the things I have committed to do.
6. I seldom need reminders to complete tasks
7. My emotions seldom get in the way when performing on the job.
8. Little things do not affect me emotionally or distract me from the task at hand.
9. I can defer my personal feelings until after a task has been completed
10. No matter what the task, I believe in getting started as soon as possible.
11. Procrastination is usually not a problem for me.
12. I seldom leave tasks to the last minute
13. I find it easy to stay focused on my work.
14. Once I start an assignment, I work diligently until it’s completed.
15. Even when interrupted, I find it easy to get back and complete the job at hand.
16. When I plan out my day, I identify priorities and stick to them
17. When I have a lot to do, I can easily focus on the most important things .
18. I typically break big tasks down into subtasks and timelines.
19. I am an organized person.
20. It is natural for me to keep my work area neat and organized.
21. I am good at maintaining systems for organizing my work.
22. At the end of the day, I’ve usually finished what I set out to do.
23. I am good at estimating how long it takes to do something.
24. I am usually on time for appointments and activities.
25. I take unexpected events in stride.
26. I easily adjust to changes in plans and priorities.
27. I consider myself to be flexible and adaptive to change.
28. I routinely evaluate my performance and devise methods for personal improvement.
29. I am able to step back from a situation in order to make objective decisions.
30. I “read” situations well and can adjust my behavior based on the reactions of others.
31. I think of myself as being driven to meet my goals.
32. I easily give up immediate pleasures to work on long-term goals.
33. I believe in setting and achieving high levels of performance.

Appendix C

Category and Verbal Fluency Tasks (Swanson, 2011)

In this section, you will be given a category and will be asked to generate as many things as you can that fall within that category. You will have 60 seconds to complete this task, at which time the survey will advance to the next page.

When you are ready to start the task, click to the next page. Time will begin automatically.

List as many animals as you can in one minute.

In this section, you will be given a letter and will be asked to generate as many words as you can that begin with that letter. You will have 60 seconds to complete this task, at which time the survey will advance to the next page.

When you are ready to start the task, click to the next page. Time will begin automatically.

List as many words as you can that begin with the letter *B*.

Appendix D

Plus-Minus Task (Miyake et al., 2000)

You will be presented with three sets of two-digit numbers. For the first set, you are to add 3 to every number as quickly as you can, entering the calculated number into the form box to the right of the number. For the second set, you are to subtract 3 from every number as quickly as you can, entering the calculated number into the form box to the right of the number. For the third set, you are to alternate between adding and subtracting 3 (i.e., add 3 to the first number, subtract 3 from the second number, etc.) from every number in the set.

Complete each section as quickly as you can. When you are ready to begin, click to the next page.

Set 1.
Add 3

49
80
22
99
16
46
76
41
74
36
59
37
27
58
73
29
15
85
17
64

Set 2.

Subtract 3

75
36
67

64
98
59
77
36
79
33
20
42
30
79
88
42
85
53
11
47

Set 3.

Alternate (add, subtract, add, subtract, etc.)

47
74
16
14
51
33
62
81
20
11
72
60
91
14
78
27
21
24
93
17

Appendix E

Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich &De Groot, 1990)

Part B. Learning Strategies

The following questions ask about your learning strategies and study skills for this class. Again, there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible. Use the same scale to answer the remaining questions. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1 2 3 4 5 6 7; *Not at all true of me – Very true of me*

32. When I study the readings for this course, I outline the material to help me organize my thoughts.
33. During class time I often miss important points because I’m thinking of other things.
34. When studying for this course, I often try to explain the material to a classmate or friend.
35. I usually study in a place where I can concentrate on my course work.
36. When reading for this course, I make up questions to help focus my reading.
37. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.
38. I often find myself questioning things I hear or read in this course to decide if I find them convincing.
39. When I study for this class, I practice saying the material to myself over and over.
40. Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.
41. When I become confused about something I’m reading for this class, I go back and try to figure it out.
42. When I study for this course, I go through the readings and my class notes and try to find the most important ideas.
43. I make good use of my study time for this course.
44. If course readings are difficult to understand, I change the way I read the material.
45. I try to work with other students from this class to complete the course assignments.
46. When studying for this course, I read my class notes and the course readings over and over again.
47. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.
48. I work hard to do well in this class even if I don’t like what we are doing.
49. I make simple charts, diagrams, or tables to help me organize course material.
50. When studying for this course, I often set aside time to discuss course material with a group of students from the class.
51. I treat the course material as a starting point and try to develop my own ideas about it.
52. I find it hard to stick to a study schedule.
53. When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.

54. Before I study new course material thoroughly, I often skim it to see how it is organized.
55. I ask myself questions to make sure I understand the material I have been studying in this class.
56. I try to change the way I study in order to fit the course requirements and the instructor's teaching style.
57. I often find that I have been reading for this class but don't know what it was all about.
58. I ask the instructor to clarify concepts I don't understand well.
59. I memorize key words to remind me of important concepts in this class.
60. When course work is difficult, I either give up or only study the easy parts.
61. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.
62. I try to relate ideas in this subject to those in other courses whenever possible.
63. When I study for this course, I go over my class notes and make an outline of important concepts.
64. When reading for this class, I try to relate the material to what I already know.
65. I have a regular place set aside for studying.
66. I try to play around with ideas of my own related to what I am learning in this course.
67. When I study for this course, I write brief summaries of the main ideas from the readings and my class notes.
68. When I can't understand the material in this course, I ask another student in this class for help.
69. I try to understand the material in this class by making connections between the readings and the concepts from the lectures.
70. I make sure that I keep up with the weekly readings and assignments for this course.
71. Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.
72. I make lists of important items for this course and memorize the lists.
73. I attend this class regularly.
74. Even when course materials are dull and uninteresting, I manage to keep working until I finish.
75. I try to identify students in this class whom I can ask for help if necessary.
76. When studying for this course I try to determine which concepts I don't understand well.
77. I often find that I don't spend very much time on this course because of other activities. (reverse coded)
78. When I study for this class, I set goals for myself in order to direct my activities in each study period.
79. If I get confused taking notes in class, I make sure I sort it out afterwards.
80. I rarely find time to review my notes or readings before an exam.
81. I try to apply ideas from course readings in other class activities such as lecture and discussion.

Appendix F

Strategic Problem Solving Inventory (Fortunato, Hecht, Tittle, &Alvarez, 1991)

Before you began to solve a problem, what did you do?
1. I read the problem more than once.
2. I think to myself, "Do I understand what the problem is asking me?"
3. I try to put the problem into my own words.
4. I try to remember if I had worked a problem like this before.
5. I think about what information I needed to solve the problem.
6. I ask myself, "Is there information in the problem that I don't need?"

As you worked the problems, what did you do?
7. I think about all the steps as I work problems.
8. I look back at problems after I do a step.
9. I stop and rethink a step I had already done.
10. I check my work step by step as I worked the problem.
11. If do something wrong, I redo my step(s).

After you finished working the problems, what did you do?
12. I look back to see if I did the correct procedures.
13. I check to see if my calculations were correct.
14. I go back and checked my work again.
15. I look back at the problem to see if my answer made sense.
16. I think about a different way to solve the problem.

Did you use any of these ways of working?
17. I draw a picture to help me understand the problem
18. I "guess and check."
19. I pick out the operations I need to do the problem.
20. I feel confused and could not decide what to do.
21. I write down important information.

Appendix G

Self-Regulation Strategy Inventory – Self-Report (SRSI-SR; Cleary, 2006)

A. Managing environment and behavior
1. I make sure no one disturbs me when I study.
8. I make a schedule to help me organize my study time.
28. I finish all of my studying before I play video games or with my friends.
2. I try to study in a quiet place.
27. I think about how best to study before I begin studying.
16. I try to study in a place that has no distractions (e.g., noise, people talking).
7. I quiz myself to see how much I am learning during studying.
6. I study hard even when there are more fun things to do at home.
24. I tell myself to keep trying when I can't learn a topic or idea.
9. I use binders or folders to organize my science study materials.
21. I tell myself exactly what I want to accomplish during studying.
25. I carefully organize my study materials so I don't lose them.

B. Seeking and learning information
17. I ask my teacher questions when I do not understand something.
14. I try to see how my notes from science class relates to things I already know.
18. I make pictures or drawings to help me learn science concepts.
22. I look over my homework assignments if I don't understand something.
3. I think about the types of questions that might be on a test.
4. I ask my science teacher about the topics that will be on upcoming tests.
5. I rely on my science class notes to study.
15. I try to identify the format of upcoming science tests.

C. Maladaptive regulatory behavior
20. I forget to bring home my science materials when I need to study.
11. I avoid going to extra-help sessions in science.
10. I lose important science dittos or materials.
19. I give up or quit when I do not understand something.
26. I let my friends interrupt me when I am studying.
23. I avoid asking questions in class about things I don't understand.
12. I wait to the last minute to study for science tests.
13. I try to forget about the topics that I have trouble learning.

Appendix H

The Text of Standardized Test Scores

Standardized Test Scores
A ***standardized test*** is a test, an assessment, or an evaluation instrument that a large sample of students take under uniform conditions and are scored according to uniform procedures. Some typical examples of these tests are the Scholastic Aptitude Test (SAT), and the California Achievement Test (CAT). Most students have taken these types of tests.

Central Tendency
To interpret ***standardized test*** scores, basic statistics and knowledge of ***central tendency*** and ***normal distribution*** are necessary. The three most commonly used central tendency measures are the ***mode***, ***mean***, and ***median***. The ***mode*** is defined as the most frequently occurring in the distribution. A distribution may have two or more modes. The ***median*** is the score which marks the middle point. Therefore, half of the students have scores below this point and the other half have scores above it. Most of us have learned from high school that the ***mean*** is the average. We also learned that the average is obtained by adding all the scores in the group and dividing the sum by the number of students in the group. Among the measures of central tendency, the mean is the most commonly reported.

Standard Deviation
In addition to central tendency, the ***variance*** or ***standard deviation*** is calculated for every test. The variance is calculated through a series of steps. Given a frequency distribution, we first calculate the ***mean***. Second, the mean is subtracted from each of the individual scores. The result is then squared to eliminate negative numbers. These numbers are then totaled. Next, the sum is divided by the total number of students and the result is the value of ***variance***. The ***standard deviation*** is the square root of the ***variance.*** Usually, the standard deviation is denoted by **σ** and the variance is denoted by **σ2**. The purpose of standard deviation is to provide a measure of how spread out the scores are in a given distribution. The mean and standard deviation together provide a simple and efficient description of a distribution.

Normal Distribution
Because standardized tests are administered to large numbers of students, the resulting distribution of scores approximates a ***normal distribution***, also known as a ***normal curve***, or a ***bell-shaped curve***. The characteristics of a normal distribution include a symmetric distribution with the mean, median, and mode as the same value in the center. If these measures of central tendency are not the same, the resulting distribution is considered asymmetric, or skewed.

Raw Scores
A ***raw score*** is the most basic score. A raw score simply represents the number of items answered correctly by a student. For example, a student who received a 39 on a 52-item test, receives a raw score of 39. Because raw scores do not provide the ability to compare across tests, measures of relative position, such as ***percentiles, stanines,*** and ***standard scores*** such as ***z-scores*** or ***T-scores*** are more often used when interpreting standardized tests.

Percentiles
Percentiles (also called ***percentile ranks*** or ***percentile scores***) are also reported for standardized tests. A student's ***percentile*** indicates the % of students whose raw scores are below that student in the norm group.

_z_-Scores

The most convenient standardized testing scoring system is the z-score**.** The ***z-score*** is the number of standard deviations a student's raw score is from the ***mean*** of the norm group. That is, the z-score of a student is the student's deviation score expressed in units of standard deviation. If the z-score is positive, it indicates a score above the mean; if the z-score is negative, it indicates a score below the mean. Note that the mean of a *z*-score is always 0 and the standard deviation of a z-score is always 1. The possible z-scores range between -3 and 3. For example, given an exam for a class in which the mean score is 40 and the standard deviation is 5. If Alice's raw score is 44, Alice's z-score is (44 – 40) / 5= 0.8. After all students' raw scores for this class are converted to z-scores, the mean z-score will be 0 and standard deviation of the distribution will be 1.

When the raw scores are normally distributed, we can convert z-scores to ***percentiles scores***. That is, given a z-score, we can find what proportion of the students in this group fall below this z-score. For example, a student with a z-score of 0 would be in the 50th percentile; a student with a z-score of 1 would be in the 84th (= 50th + 34th) percentile; a student with a z-score of 2 would be in the 98th (= 50th + 34th + 14th) percentile; while a student with a z-score of -1 would be in the 16th (= 50th - 34th) percentile; a student with a z-score of -2 would be in the 2nd (= 50th - 34th -14th) percentile. Therefore, Alice's z-score of 0.8 would place her around the 79th percentile.

_T_-Scores

Another popular standardized testing score is the T-score. The ***T-score*** is similar to the z-score. The T-score has a mean of *50*, however, instead of 0 as with the z-score, and a standard deviation of 10 instead of 1 as with the z-score. If a T-score is over 50, it indicates the score is above the mean; if a T-score is under 50, it indicates a score is below the mean. For example, Alice scores 0.8 standard deviations above the mean on a test; thus, her z-score is 0.8. After transforming her z-score to a T-score, she gets a T-score of (10*0.8) + 50 = 58. Any given score can be interpreted as either a z-score or a T-score. For example, a T-score of 50 equals a z-score of 0; a T-score of 60 equals a z-score of 1; a T-score of 40 equals a z-score of -1; and so forth.

Stanines

While percentile ranks provide a single score, another type of standardized test score that is often reported is the ***stanine***, or ***standard nine***. This indicates a range of scores. There are nine stanines. Stanine 5 is in the middle of the normal distribution and includes all scores within one-fourth of a standard deviation both above and below the mean. Representing scores below the mean, ***stanines*** 4, 3**,** and 2 are each one-half of a standard deviation in width. Similarly, ***stanines*** 6, 7, and 8 are one-half a standard deviation in width above the mean. For example, stanine 5 represents a ***z-score*** between -.25 and +.25; stanine 6 represents a z-score between +.25 and +.75; and so forth. ***Stanines*** 1 and 9 cover the rest of the lower tail and upper tail respectively. Stanine scores also used to provide a broad measure of test performance.

Appendix I

Assessment Text Multiple-Choice Items

1. A score at -1 standard deviation represents a percentile rank of approximately
2%.
16%.
34%.
68%.

2. The mode of the distribution below is:
1, 2, 4, 4, 4, 5, 5, 6, 6, 8, 9
2.
4.
5.
6.

3. David received a raw score of 56. Given a mean of 50, a median of 50, a standard deviation of 4, what is David's T-score?
35
55
65
75

4. According to the text you read, what is one commonly cited concern of standardized achievement tests?
Student scores on the tests sometimes indicate that they know more than they actually do.
A focus on standardized testing sometimes decreases innovative teaching.
Material covered in the tests sometimes corresponds to one particular text book series.
Teachers and administrators don't know what will be tested so students are unprepared.

5. The range of the following distribution is: 1, 2, 4, 4, 5, 5, 5, 6, 6, 8, 9
4.
6.
8.
10.

6. A small standard deviation indicates that
there are a small number of data points.
the median score is relatively small.
there are a number of missing data points.
the variance in scores is small.

7. Allie was so excited her son scored a 100 on the Wechsler Intelligence Scale for Children. Which of the following is an appropriate conclusion regarding her son's score?
His z-score is 0.
He is below average.

He is in the 4th stanine.
His percentile score is 85.

8. Scores of individuals taking a standardized test are compared to the scores of a group of individuals similar in age, grade level, and background who have taken the same test. This group of individuals used for comparison is called
a grade equivalent group.
a norming group.
a peer group.
an ability group.

9. The median of the distribution below is: 7, 7, 7, 11, 12, 13, 14, 17, 18
7.
11.
12.
14.

10. Angie is in the eighth grade. On a standardized test, she scored at the tenth grade level on a vocabulary subtest. What is the best interpretation of her score?
Angie is at the 80th percentile rank of eighth graders for vocabulary.
Angie's vocabulary is similar to that of the average tenth grader taking that test.
Angie's score is about two standard deviations above the average vocabulary score for eighth graders.
Angie scores better on vocabulary than in other content areas.

11. The purpose of a norming group is to describe specifically what content students know and don't know.
provide information for decisions about advancement to the next grade.
describe student performance in terms of specific criteria.
allow educators to compare the progress of their students with others.

12. George needs to calculate a measure of variation for an achievement score. Which measure should he use?
standard deviation
standard score
mean
stanine score

13. Adam, the TA, found the standard deviation for a set of test scores to be 4. His professor asked for the variance. What is the variance of the sample?
2.
4.
8.
16.

14. In a distribution with a mean of 28 and a standard deviation of 2, almost all of the scores fall between
22-24.
18-38.
22-30.
26-38.

15. Given a mean of 15 and a median of 22 what can we say about the distribution of scores?
It is a negatively skewed distribution.
It is a positively skewed distribution.
We can't determine its distribution.
It is normally distributed.

16. Jordan's score on a standardized test of mathematical aptitude was at the 85th percentile. Which of the following best interprets this score?
Jordan got 85% of the test items correct.
Jordan's rank in the class is about 15th.
15% of all the students taking this test scored higher than Jordan.
For any given test item, Jordan's chances of answering it correctly are 8.5 out of 10.

17. Given a person with a z-score of 0 on a norm-referenced assessment, what can we conclude regarding her performance? Compared to the norm group,
the person performed poorly.
the person performed at the mean.
the person performed above average.
the person performed at the 34th percentile.

18. Ellen scored in the 72nd percentile on a standardized exam. What is her approximate z-score?
-2.0
-1.5
.5
1.5

19. The mean of the distribution below is: 1, 2, 4, 4, 5, 5, 5, 6, 6, 8, 9
2.
4.
5.
6.

20. On a test with a mean of 50 and a standard deviation of 10, the percentile score of a person who scores a 40 is approximately
2.
16.
34.
50.

Appendix J

Demographic Questionnaire

How old are you?

____

What is your gender?
- Male
- Female
- Other/Prefer not to say

Which of the following describes you?
- American Indian/Alaskan Native
- Black/African American
- Asian
- Native Hawaiian or Other Pacific Islander
- White/Caucasian
- Hispanic
- Indian/South Asian
- Other/Please specify:

Please indicate your class standing:
- First-year student
- Second-year student
- Third-year student
- Fourth-year student
- Fifth year and beyond

Please list your current GPA:

____

Please indicate your intended major(s):

____

Do you speak languages other than English?
- Yes
- No

Please list all the languages you speak, starting with your first language.

____

How would you characterize your degree of ability with the English language?
- Beginning
- Intermediate
- Advanced
- Fluent