PREDICTING ACADEMIC PERFORMANCE: EXECUTIVE FUNCTIONS, METACOGNITION, STUDY STRATEGIES, AND SELF-EFFICACY.

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Abstract

The current study investigated the prediction of academic performance of 32 female college students as measured by observed study behaviors and test scores in a mock study session. The predictors of interest were: executive functions, academic self-efficacy, self-reported study strategies, and metacognitive skills. Unexpectedly, executive functions, self-efficacy and self-reported study strategies did not predict academic performance, nor did the two measures of academic performance (test score and observed study behaviors) correlate with each other. However, hierarchical regression analysis demonstrated that the metacognitive skill of procedural knowledge and the study strategy of time management predicted 39% of the variance in test performance; whereas, the metacognitive skills of planning and information management predicted 22% of the variance in observed study behaviors. This study attempted to move beyond self-report measures to assess academic performance in a mock situation and, in general, self-reported metacognitive skills were most important in predicting individual differences in the female students' performance. However, questions remain with regard to why the observed study behaviors did not correlate with the test performance and why other characteristics, such as executive functions and self-efficacy, were not predictive.

Predicting Academic Performance: Executive Functions, Metacognition, Study Strategies, and Self-Efficacy

There are many variables that contribute to various patterns of performance in school. According to Centra and Potter (1980), there has been much interest in the study of a range of variables in order to determine which are most important in facilitating academic performance. It is not only general intelligence that students bring to a class that impacts their academic performance. A number of variables involved in academic performance have been investigated, and many authors have examined (a) motivational variables, such as self-efficacy (Bandura, 1997); (b) cognitive variables like executive functions and metacognitive strategies (Best, Miller, & Naglieri); and (c) behavioral variables, such as study strategies (Purdue & Hattie, 1999). In fact, these variables related to academic performance individually, also could, in combination, be even more predictive of academic performance. In turn, an underdanding of these predictive relationships could lead to the emergence of several educational implications in regard to classroom practices.

In research examining the influences on academic performance, the construct of academic performance has been measured by the use of several techniques. Students' grade point average (GPA) is the most common index used by researchers to assess academic performance (Chen, 2000; Nguyen, Allen, & Fraccastoro, 2005; Said & Welsh, 2011). In addition, typically, this measure of academic performance is based on self-report (Nonis & Hudson, 2010; Nguyen et al.). In some studies of academic achievement, test scores have been used for certain academic subjects (Taylor, Schatschneider, Barry, & Owens, 1996; Waber, Gerber, Turcios, Wagne, & Forben, 2006) to represent academic performance. For the current study, academic performance represents the outcome variable; therefore, it is problematic to rely on self-report to assess it. Also, for the current study, the use of GPA has little meaning, since the participants' GPA represents only one semester of college. Thus, an actual test session and observed study behaviors (OSB) were selected to assess students' academic performance, that is, to examine students' academic performance in a setting that attempted to mimic reality and to avoid self-report measures.

Executive Functions and Academic Performance

According to Welsh and Pennington (1988), "executive function is defined as the ability to maintain an appropriate problem-solving set for attainment of a future goal." The authors included the components of: "a) an intention to inhibit a response or to defer it to a later more appropriate time; b) a strategic plan of action sequences;

and c) a mental representation of the task, including the relevant stimulus information encoded in memory and the desired future goal-state" (pp. 201-202). Also, Cooper-Kahn and Diezal (2009) defined executive functions as “a set of processes that all have to do with managing oneself and one’s resources in order to achieve a goal. It is an umbrella term for the neurologically-based skills involving mental control and self-regulation” (p. 1). According to Cooper-Kahn and Dietzal, different researchers and practitioners have their own favorite lists of executive functions**,** although the overall concept is basically the same. The list proposed by Gioia, Isquith, Guy, and Lauren (Roth, Isquith & Gioia, 2005) was adopted for use in the current study, and it includes the executive function components of: (a) inhibition, (b) shift, (c) emotional control, (d) initiation, (e) working memory, (f) planning/ organization, (g) organization of materials, and (h) task monitoring.

There is now substantial evidence that executive functions have a vital role in the learning process. Taylor et al. (1996) demonstrated that reading and spelling skills were predicted by inhibition for a sample of students, who were 6-14 years of age. Espy, McDiarmid, Cwik, Stalets, and Senn (2004) found that inhibition, and to a lesser extent, working memory predicted concurrent emerging math skills; however, flexibility did not correlate with math skills. Once the covariates (e.g., age, vocabulary, mother’s education, and other executive functions) were entered into the model, only inhibition predicted math achievement and explained 12% of the unique variance. Waber et al. (2006) found higher correlations between executive functions and reading/writing achievement than between executive functions and math achievement. It must be mentioned that the focus of nearly all of these studies was on 9-12 year old students and that, in this age group, executive functions seemed to be more powerfully associated with reading/ writing achievement. Van der Sluis, Jong, and Van (2007) found that working memory predicted reading/writing achievement more strongly and uniquely than math achievement.

In another study, Blair and Razza (2007) sought to predict concurrent and longitudinal math skills, phonemic awareness, and letter knowledge in 3-5 year old students. Inhibition proved to be more strongly correlated with math skills than with phonemic awareness and letter knowledge. McClelland, Cameron, Connor, Farris, Jewkes, and Morrison (2007) measured the relationship between inhibition and vocabulary, literacy, and mathematics achievement in a large sample of prekindergarten students. Two measurements were taken: at the beginning and end of prekindergarten. Children’s inhibition capacities were used to predict performance on these three academic skills. The results showed that inhibition was more strongly associated with math skills than with vocabulary and literacy. Brock, Rimm-Kaufman, Nathanson, and Grimm (2009) examined the contribution of hot and cool executive functions to academic achievement (i.e., reading and mathematics) in a sample of kindergarten students**.** The cool cognitive aspects of executive function are more associated with the dorsolateral regions of the prefrontal cortex, and the hot affective aspects are more associated with the ventral and medial regions (Zelazo & Miller, 2002). They found that math achievement was predicted uniquely by cool executive functions (i.e., two inhibition tasks). Finally, St. Clair-Thompson and Gathercole (2006) found that working memory was more strongly associated with school achievement than was inhibition. The strongest association was observed between working memory and reading/ writing achievement.

There is much less research that reports the association between executive functions and academic achievement in adolescents and college students; thus, the current study is an attempt to fill this gap. Mercer (2005) found that the contribution of executive function to written expression was nonsignificant, and the manipulation, which was designed to examine the role of executive function in written expression by reduction of the organizational demands of the writing task, did not have its predicted effect for a sample of college students. Harder (2006) examined the relation between executive function and written expression with two groups of undergraduate students. Group 1 consisted of 31 students diagnosed with ADHD, and Group 2 consisted of 27 control students. Harder found that the measure of inhibition made a statistically significant contribution to the prediction of Writing Mechanics. Chang (2008) found significant differences in academic performance between college students with ADHD and without ADHD; moreover, there was a significant difference between the two groups on the measures of executive functions of**:** (a) inhibition, (b) shifting, (c) self-monitor, (d) initiation, (e) working memory, (f) planning/organization, (g) task monitor, and (h) organization of materials.

In summary, the executive function that exhibits the strongest association with various patterns of academic performance is inhibition; also**,** to a lesser extent, the executive function of working memory is a significant predictor of academic performance. Most studies (Blair & Razza, 2007; McClelland et al., 2007; Taylor et al., 1996) in this area were focused on samples drawn from the elementary school grades, except for the Chang (2008), Harder (2006), and Mercer (2005) studies**,** which were focused on college students. However, the focus of the Change and Harder studies was on clinically diagnosed ADHD college students, not typical college students. Thus, the current study fills this need in the literature, because typical college students comprised the sample. In addition to executive functions, perceived academic self-efficacy is a motivational variable that could be important for academic performance.

Self-Efficacy and Academic Performance

Bandura (1997) stated that self-efficacy perceptions refer to "beliefs in one's capabilities to organize and execute the courses of action required producing given attainments" (p. 3). Bandura proposed that individuals, who perceive themselves as capable, tend to attempt and successfully execute tasks or activities. Also, self-efficacy beliefs have been found to be related to the academic achievement of both men and women. In a meta-analysis of self-efficacy research studies, which were published between 1977 and 1988, Multon, Brown, and Lent (1991) found a positive relationship between efficacy beliefs and academic achievement. In Graham and Weiner's (1996) review of motivational research, their findings were similar to those of Multon et al., that is, the presence of self-efficacy predicted academic performance more consistently than any other motivational constructs. Based on their longitudinal findings, Bandura, Caprara, Barbaranelli, Gerbino, and Pastorelli (2003) reported that there was a decline in students' self-regulatory efficacy from junior to senior high school, but those who experienced the lowest decline in self-regulatory efficacy had the higher grades and the greater chance of remaining in school. In sum, the presence of high perceived self-regulatory efficacy contributed positively to students' junior high grades. In contrast, Carroll, Houghton, Wood, Unsworth, and Hattie (2009) defined social self-efficacy as the willingness to initiate behavior in social situations. The abilities to establish friendships, form sustainable peer relationships, receive positive peer praise, and be socially acceptable are all important characteristics for success in school.

In sum, most studies (Bandura et al., 2003; Graham & Weiner, 1996; Multon et al.1991) on this topic showed that students' perception of self-efficacy was associated with their academic performance; however, the direction of casual relationship, that is, to determine which one causes the other, has not been addressed yet in the literature. The direction of cause and effect could go either way between self-efficacy and academic achievement. Students, who perform better in a certain academic task, are more likely to gain high self-efficacy for the next academic task and vise versa. In fact, individual differences in the execution of study strategies could be a third variable that is responsible for the observed association between self-efficacy and academic performance (i.e., it is correlated with each of these and creates a correlation between the two). Thus, in addition to executive functions and academic self-efficacy, students' study strategies have been discussed in the literature in the context of its relationship with academic performance.

Study Strategies and Academic Performance

Study strategies are systematic plans that improve the encoding of information and task performance. Use of study strategies improves performance in the task at hand and can generalize beyond the learning context (Zimmerman & Schunk, 1989). Wells (1993) found that the study strategy of time management was a significant predictor of GPA for a sample of undergraduate students. Purdue and Hattie (1999) analyzed 52 studies about the outcomes of the relationships between study strategies and academic performance, and they concluded that, when students learn effective study behaviors and incorporate them into a meaningful approach to learning, they achieve positive academic outcomes.

In current educational practice, students are learning increasingly complex literacy practices in order to navigate increasingly complex technologies; therefore, they develop a range of study strategies that vary by the type and usefulness of the task (Moje, 2002). Gee (2000) cautioned that lower income teens see the use~~s~~ of literacy differently than do upper middle-class teens, who are immersed in a more academic world and, therefore, the lower-income adolescents may not be able to apply the study strategies that are needed.

An unexpected relationship between study habits and academic performance was found by Nonis and Hudson (2010). They reported that study habit scheduling demonstrated a negative relationship with GPA for a sample of undergraduate students and implied that students who waited until the last minute to study or work on their projects performed better than those students who used a more consistent approach in the short term.

In spite of a few contradictory findings, such as the Nonis and Hudson (2010) results, a student's study strategy is an important factor that is involved in academic performance. Therefore, the goal of educational practices and teaching methods should be to assist students to adopt various patterns of effective study strategies. It is worthwhile to distinguish between the two study strategies or approaches that are addressed in the current study: metacognitive skills and study strategies. In the current study, study strategies are viewed as study or learning habits that students adopt in order to accomplish their academic tasks. For the purposes of the current project, study strategies represent overt or behavioral strategies; whereas, metacognitive skills represent deep cognitive processes, which include self-regulation and students**'** perception/ monitoring of their practices within academic tasks. It is possible, that contradictory findings in the literature may be able to be resolved if researchers distinguish between the overt behavioral techniques and covert metacognitive processes that are both involved in what are referred to as study strategies.

Metacognition and Academic Performance

The metacognitive strategies that students adopt represent their cognitive engagement while they are involved in academic activities. Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). Dunslosky and Thiede (1998) viewed metacognition as the higher-order mental processes involved in learning that include making plans for learning. The importance of adapting one's cognitive strategies to task demands has been the focus of several self-regulations models. Biggs (1985) proposed that, for effective learning, students must be aware of task requirements and be able to exert control over the cognitive processes used to meet these requirements. Meta-learning, according to Biggs, occurs when the student uses his or her cognitive strategies to accomplish the task requirements. Likewise, Winne and Hadwin's study (1998, as cited in Abd-El-Fattah, 2011) of self-regulated learning included four basic stages: (a) task definition, (b) goal setting and planning, (c) enactment, and (d) adaptation. Winne and Hadwin suggested that the learner: (a) develops a perception of what the task is and the available resources, (b) constructs a plan to address the task, (c) adapts study strategies, and (d) makes changes to his or her cognitive structure depending on perception of performance.

Entwistle and Entwistle (2003) investigated university students' adaptation of their cognitive strategies. They concluded that the students in their sample adapted their study strategies based on their perceptions of what the instructor expected to see in a test. Furthermore, Pintrich (2000) suggested that students: (a) develop perceptions of the task demands, (b) engage in metacognitive monitoring, (c) select and implement cognitive strategies that are appropriate for the task demands, and (d) evaluate task performance while they reflect on the effectiveness of the cognitive strategies. Pintrich proposed that these somewhat diverse strategies of self-regulated learning represented an interaction between personal factors and learning situations such as: (a) task demands, (b) the coordination of goal setting and metacognition, (c) the use of cognitive learning strategies, and (d) self-reflection. Zulkiply et al. (2000) examined the relationship between students' academic performance and each of the five components of metacognitive regulation, namely: (a) planning, (b) information management strategies, (c) comprehension monitoring, (d) debugging strategies, and (e) evaluation for their sample of students, who attended a private secondary school. The findings revealed a significant positive relationship between these students' academic performance and metacognitive awareness in terms of three components: (a) planning, (b) evaluation, and (c) debugging strategies.

Thus, except for the Zulkiply et al. (2000) study, the studies discussed earlier were based on different subcomponents of metacognition than the subcomponents that were examined in the current study**.** Even Zulkiply et al. used only five of the eight subcomponents of the Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994). Also, the sole indicator of academic performance in the Zulkiply et al research was the students' self-reported GPA. Therefore, the current study expands on past research on metacognition and academic achievement, in that, the researcher examined all eight components of the MAI in the context of their individual and joint associations with academic performance for college students as measured by test score and OSB.

Purpose and Research Questions

In the studies discussed earlier, the researchers examined the degree to which study strategies, executive functions, self-efficacy, and metacognitive skills individually predicted academic performance. However, this author has not found a published study in which all of these variables were examined in regard to their association with academic performance in college students. In addition, in most of the studies reviewed, the researchers examined only a few components of each of the constructs. This, in turn, makes the current study unique, because the correlations between multiple aspects of executive functions, study strategies, and metacognitive skills and academic performance were examined. Moreover, in contrast to past research, the current author sought to examine students' perceived overall academic self-efficacy, as opposed to a specific focus on their academic self-efficacy in a particular academic subject (e.g., math). Another novel approach utilized in this study is that overt or behavioral study strategies, as well as more covert, deep-level cognitive strategies in the form of metacognition were examined to represent two categories of study strategies associated with academic performance. Finally, the findings from this study contribute to the literature by utilizing the observation of actual study behaviors and academic performance in a mock study situation, as opposed to the typical self-reports that are characteristic of this research area.

The main purpose of this study is to investigate the associations between five constructs: executive functions, self-efficacy, study strategies, metacognitive skills, and academic performance as measured by the OSB and test score of female college students. The college where the study was conducted has a high proportion of female students (62%), and because this was a new area of inquiry, it was advisable to remove one source of variability, gender, and focus on female students only. The research questions which guided this study were:

1. Are academic performance scores (i.e., test score and OSB) associated with students' self-reports of everyday executive functions skills?

2. Are academic performance scores associated with students' self-reports of academic self-efficacy?

3. Are academic performance scores associated with students' self-reports of their use of three study strategies: (a) determination of priority, (b) time management, and (c) procrastination?

4. Are academic performance scores associated with students' self-reports of their use of metacognitive awareness skills?

5. What is the combination of variables that predicts the most variance in the two measures of academic performance?

Method

Participants

The participants in this study were 32 female college students of traditional college age (M = 18.6; SD =.76). The participants were recruited from Introductory Psychology courses at a mid-sized state university in the Rocky Mountain region of the United States. The students were offered partial class credit as compensation for participation. Participation was voluntary and confidential, and informed consent was obtained according to an institutional review board (IRB) approved protocol.

Procedures

All testing was conducted in group sessions of two to four participants each. For each session, research surveys of metacognitive awareness, executive function, study strategies, and self-efficacy were administered. In addition, a mock study was conducted, which was based on reading a section from a college textbook, a study session, and a test on the reading material.

The entire test session was administered as follows. First, the participants were administered the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A; Roth, Isquith, & Gioia, 2005). When they finished, they were given 30 minutes to study six pages on the topic of social cognition from the textbook currently used in the Introductory Psychology course. This topic was scheduled to be covered at the end of the same semester, so none of the participants had studied this section at the time of the study. While the participants studied, the research assistants observed the participants' study behaviors (e.g., use of highlighter, study guide sheet, sticky notes, paper, pens, dictionary, and index cards), and the research assistants recorded the use of these materials on a checklist (e.g., two observers per participant to assess interrater reliability). After their study of the six pages, the participants completed a checklist in which they were asked to identify the study strategies that they used to study the topic; this was the same checklist completed by the two observers. Next, the participants were administered the: (a)

Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994); (b) academic self-efficacy measure from the Multidimensional Scales of Perceived Self-Efficacy (MPSES; Bandura, 1989); and (c) College Study Skills Inventory (CSSI; Probst, 2010). Finally, the participants were administered a multiple-choice test that covered the six pages of social cognition material they read and studied earlier in the test session. The entire test session took approximately 1 hour, 20 minutes.

Instruments

Behavior Rating Inventory of Executive Function (BRIEF)-Adult Version (EF). This scale was developed by Roth et al. (2005). It is a brief self-report scale which is used to measure difficulties with the following executive functions: (a) inhibit, (b) shift, (c) emotional control, (d) self-monitor, (e) initiate, (f) working memory, (g) plan/organize, (h) task monitor, and (i) organization of materials. In addition to the subscales, the measure yields data for the: (a) Behavioral Regulation Index, (b) Metacognition Index, and (c) Global Executive Composite. The internal consistency for the scale is moderate to high; the alpha coefficients range from .73-.90. The BRIEF was used in this study to measure students' executive functions, and the focus was on the individual subscales.

Metacognitive Awareness Inventory. (MAI; Schraw & Dennison, 1994). The MAI is a 52 item inventory used to measure students' metacognitive awareness, and it was developed by Schraw and Dennison (1994). The items are classified into eight subcomponents: (a) monitoring, (b) planning, (c) procedural knowledge, (d) declarative knowledge, (e) evaluation, (f) debugging strategies, (g) information management strategies, and (h) conditional knowledge. These subcomponents are subsumed under two broader categories: knowledge of cognition and regulation of cognition. The internal consistency for the scales ranged from .88**-**.93.

Bandura's (1989) Multidimensional Scales of Perceived Self-Efficacy (MSPSE).
Bandura's (1989) MSPSE is a 57 item self-report measure with nine subscales. The MSPSE scales were developed in response to the theoretical and applied importance of the self-efficacy construct. In Bandura's (1986) social cognitive theory of perceived self-efficacy**,** he specified the origins and structure of efficacy beliefs. Items on the scales were tailored to academic domains of functioning. The internal consistency reliability of the academic self-efficacy scale has been reported as r = .74 for a college aged sample (Choi, Fequa, & Griffin, 2001).

College Study Skills Inventory (CSSI). Developed by Probst (2010), the College Study Skills Inventory (CSSI) is a diagnostic prescriptive inventory used to assess a student's application of the study skills required to excel in college level courses. The reliability for the entire scale was computed as r = .95 (Said & Welsh, 2011). The inventory is used to measure the subcomponents of study strategies: (a) goal setting, (b) time management, (c) determining priorities, (d) procrastination, (e) perseverance, (f) test taking, (g) test preparation, (h) recall, (i) retention, (j) comprehension skills, (k) cognitive mapping and outline, and (l) vocabulary skills. Only three subscales (i.e., time management, determining priority, and procrastination) were used in this study, since Said and Welsh found that these three had the strongest correlations with the other predictor variables.

Materials for Mock Study and Test Session

Text material on social cognition. For ease of access and convenience, this author selected six pages from the textbook (Wood, Wood, & Boyd, 2011) of the introductory psychology course to use for mock study session. The topics addressed in these pages were: (a) impression management, (b) attribution, and (c) attraction. Again, the students participating in this study had not yet covered this material in their introductory psychology course.

Test on social cognition material. This researcher designed a test to evaluate the participants' knowledge of the social cognition content in the six pages from the introductory psychology textbook. It was a multiple-choice test and consisted of 20 questions. The test covered several domains in social cognition (e.g., impression management, attribution, and attraction), and it was written to be appropriate for the reading level of first year college students (see Appendix A).

Study materials and checklist. The following materials were available for the participants while they studied the six pages: (a) highlighters, (b) sticky notes, (b) index cards, (c) dictionaries, (d) paper, (e) pens, and (f) study guide. A checklist was given to the participants after they finished reading, and the participants indicated the supplies they used during their reading and study session. The identical checklist was utilized by the two observers to record the supplies used by the participants during the reading and study session (see Appendix B).

Results

Reliability of Measures

Pearson's chi-square test was performed to investigate the association between the responses of observers and participants on the checklist of study strategies. Pearson's chi-square was performed for each item of the study strategies checklist to evaluate the agreement between: (a) the first observer and the second observer, (b) the first observer and the participant, and (c) the second observer and the participant. The analysis showed that Pearson's Chi-square values ranged from 14.933-32.000 and significance for all of the tests was $p < 0.000$, which indicated significant associations. Thus, observers and participants had excellent, and in most cases perfect, agreement on the checklist items that pertained to the use of: (a) study guide, (b) highlighters, (c) sticky notes, (d) index cards, (e) paper, (f) pens, and (g) dictionary.

To assess the reliability of the 20 items of the test on the social cognition material, a Cronbach's alpha was performed, and the strength was found to be adequate (r = .71). Also, the internal consistency reliability was computed for the 11 items that represent academic self-efficacy from Bandura's (1989) MSPSE (r = .78). In addition, the internal consistency reliability was computed for the 52 items of the MAI (Schraw & Dennison, 1994) and found to be of adequate strength (r = .79). Finally, the three subscales of the CSSI (e.g., time management, determining priority, and procrastination), which were used in this study, were computed, and the internal consistency of 22 items was r = .81.

Correlation between OSB and test scores. Since there was agreement between observers and participants about the demonstration of study behaviors during the study session, one observer's checklist scores was randomly selected to represent a total score of observed study behaviors (e.g., possible range for each participant was 0-7 behaviors). This study behavior score was computed to represent one measure of academic performance, and the test score for the social cognition materials was the second measure. However, the correlation between the OSB and test score was nonsignificant (r = .05; p > .05).

Associations of executive functions, academic self-efficacy, and study strategies with academic performance. The findings from the Pearson's correlation analysis indicated nonsignificant correlations between the subscales of executive functions and academic performance as measured by students' score on the test and OSB as reported in Table 1.

Table 1
Correlations between Executive Functions and Academic Performance

	EM.C	INH	SH	SELF -MO	INIT	WOR . ME	PLA N OR	TAS. M	ORG. M	MET	BR
Test	-.08	-.04	-.28	-.02	-.00	-.12	-.14	-.28	-.14	- .09	- .19
OSB	.14	-.27	.05	.01	-.05	-.03	.02	-.08	-.07	- .04	.01

Note. Test = test score; OSB = observed study behaviors; EM.C=Emotional control;.INH=Inhibition; SH=Shifting;; SELF-MO=Self-monitor; INIT = Initiation; WOR.ME =Working memory; PLAN.OR = Planning/organization; TASK.M = task monitoring; ORG.M=Organization of materials; MET=met cognition index; BR=behavior index

Academic self-efficacy was not statistically correlated with both measures of academic performance (see Table 2).

Table 2

Correlations between Academic Self-Efficacy and Academic Performance

	Academic Self-Efficacy
Test	.11
OSB	-.19

Note. Test = test score; OSB = observed study behaviors.

The subscales of the self-reported use of study strategies were not significantly associated with either measure of academic performance, as seen in Table 3.

Table 3

Correlations between Study Strategies and Academic Performance

	Determining priority	Time management	Procrastination
Test	-.16	-.26	.15
OSB	.05	.10	-.13

Note. Test = test score; OSB = observed study behaviors

Correlations between metacognitive skills and academic performance. To investigate the relationship between students' metacognitive skills, as measured by the MAI (Schraw & Dennison, 1994) and academic performance as measured by test score and OSB, Pearson's correlation was performed. This analysis indicated that the students' scores on the scale of procedural knowledge were significantly correlated with their academic performance as measured by test score (r = .39; p < .05). Also, students' scores on the scale of declarative knowledge were significantly associated with their scores on the test (r = .34; p < .05); whereas, the scale of planning was associated with the academic performance as measured by OSB at the level of a statistical trend (r = .36; p = .05; see Table 4).

Table 4

Correlations between Metacognitive Skills and Academic Performance

	M	PK	P	DK	E	IMS	DS	CK
Test	-.19	.39*	-.03	.34*	-.22	.01	.02	-.05
OSB	-.07	.00	.36*	.00	-.03	.22	-.15	.03

Note. Test = test score; OSB = observed study behaviors; M=monitoring; PK=procedural knowledge; P=planning; DK=declarative knowledge; E=evaluation; IMS=information management strategy; DS=debugging strategy; CK=conditional knowledge. **p* <.05

Hierarchical Multiple Regressions

Since the metacognitive skills of procedural knowledge and declarative knowledge showed significant association with test score, declarative knowledge was entered in the model over and above procedural knowledge to determine how much variance in test score both metacognitive skills can predict (see Table 5). When declarative knowledge was controlled for in Step 1, procedural knowledge was a significant predictor of test score (p < .05), and it explained 15% of the variability in academic performance as measured by test score. After declarative knowledge was added to procedural knowledge in Step 2, the model explained 16% of variability in test score and was not significant (R^2 = .16; $F(2,26)$ = 2.52; p > .05). In turn, this indicated that the metacognitive skill of declarative knowledge did not explain any significant variance of test score over procedural knowledge, although both variables were significantly (p < .05) correlated with test score.

Table 5

Declarative Knowledge Added Over and Above Procedural Knowledge in Relation with Test Score

	Variable	B	SE(B)	Â	*t*	Sig.(*p*)
Step 1	Procedural knowledge	.409	.183	.395	2.234	.033*
Step 2	Procedural knowledge	.318	.272	.307	1.171	.252
	Declarative knowledge	.109	.236	.121	.460	.650

Note. Step 1: R2=.15, *Step 2: R2*=.16. **p* <.05

Since there was a significant correlation between the study strategy of time management and the metacognitive skill of procedural knowledge (r = .42; p < .05), hierarchical multiple regression was performed to investigate the extent to which time management could explain proportion of variability in test score by adding it over the metacognitive skill of procedural knowledge in a hierarchal regression. As shown in Table 6, when time management was controlled for in Step 1, procedural knowledge explained 15% of variability in the academic performance as measured by test score. After time management was added to procedural knowledge in Step 2, the model explained 39% of variability in test score (R^2 = .39; F(2,26) = 8.62; p < .000). Although time management was not significantly correlated with test score (r = -.26; p > .05; see Table 3), time management was a significant predictor of test score when it was added to procedural knowledge in the hierarchal regression analysis.

Table 6

Time Management Added Over and Above Procedural Knowledge in Relation with Test Score

	Variable	B	SE(B)	Â	*t*	Sig.(*p*)
Step 1	Procedural knowledge	.409	.183	.395	2.234	.033*
Step 2	Procedural knowledge	.656	.175	.633	3.749	.001**
	Time management	-.143	.044	-.547	-3.241	.003*

Note. Step 1: R2=.15; *Step 2: R2*=.39. **p* <.05, ***p* <.01.

A hierarchical regression was conducted examining predictors of OSB that represented the two strongest correlations between metcognitive skills and this academic performance measure, planning (r = *.36, p* < .05) and information management (r = .22; p > .05; see Table 4). When information management strategy was controlled for in Step 1, planning predicted academic performance as measured by OSB at a trend level (p = .05), and it explained 13% of variability in OSB. After information management strategy was added to planning in Step 2, the model explained 22% of variability in OSB and was significant (R^2=.22; F(2,26) = 3.72; p < .05). Also, planning appeared to be a significant predictor of OSB (p < .05). In turn, this implied that the metacognitive skill of information management strategy explained a unique proportion of variance in OSB that was not explained by planning**,** although information management strategy by itself was not a significant predictor of OSB.

Table 7

Information Management Strategy Added Over and Above Planning as Predictors of Study Behaviors

	Variable	B	SE(B)	Â	*T*	Sig.(*p*)
Step 1	planning	1.476	.725	.365	2.034	.052
Step 2	planning	1.723	.714	.426	2.412	.023*
	Information management t	2.437	1.406	.306	1.733	.095

Note. Step 1: R2=.13; *Step 2: R2*=.22. **p* <.05.

Discussion

In this study, the researcher tested the association between each of the constructs of executive functions, academic self-efficacy, study strategies, metacognitive skills, and academic performance as measured by participants' test score and OSB in a mock study session. A comprehensive model with all of these variables has not been tested previously. The examination of such a comprehensive model could illuminate which of these variables are more important in the prediction of individual differences in college students' academic performance. Such findings may help teachers to assist students to employ more effective study strategies.

Two components of metacognitive skills (e.g., procedural knowledge and declarative knowledge) had the strongest association with academic performance as measured by test score. Based on the hierarchical regression analysis, it was procedural knowledge, alone, that explained a significant proportion of the variance in academic performance as measured by test score. This was an indication that students, who adopt procedural knowledge skill as a cognitive study strategy, have the ability to perform well and experience success in a testing situation. This finding contributes to the growing body of research regarding the role of procedural knowledge in academic performance, and it is consistent with Star's (2004) findings. Therefore, procedural knowledge may be involved in the study strategies that were used by the students during the reading session, and this in turn led to better performance on the test of social cognition material. However, the metcognitive skill of declarative knowledge was nonsignificant predictor of students' test score. This author has not been able to find any published study in which the researcher(s) investigated the relationship between declarative knowledge and academic performance.

The metacognitive skill of planning was a significant, albeit at a trend level (p = .05) predictor of performance as measured by OSB. This was an indication that students, who were able to plan cognitively, tended to employ effective study behaviors. Thus, it could be concluded that planning, as a metacognitive skill, which is involved in strategic cognitive learning, is more likely to lead to strategic study behaviors since both variables were related to strategic learning. Although the metacognitive skill of information management strategy had a small positive correlation with OSB, it did explain the proportion of variability in OSB when it was entered into the model with planning. This finding is consistent with the results of the Zulkiply et al. study, in that, they found that information management strategy was a nonsignificant predictor of students' GPA.

Also, the study strategy of time management was a significant predictor of performance on test score when entered into the model over and above procedural knowledge. Thus, time management explained a unique proportion of variability in test performance that was not explained by procedural knowledge. This finding was consistent with the Zulauf and Gortner (1999) finding, in which they found a positive relationship between time management skills and academic performance as measured by GPA for college students. However, in the present study, two techniques were used to assess academic performance instead of reliance only on self-reported GPA. Moreover, in the present study, time management was used in combination with other variables in their relationship with academic performance. The time management scale from the CSSI (Probst, 2010) was used to examine whether a student understood the advantages of using a prioritized to-do list that tells when and what activities need to be focused on in order to complete course assignments. In contrast, the metacognitive skill of procedural knowledge is knowledge about how to use strategies within study tasks or knowing how to perform a task (Schraw & Dennison, 1994). Therefore, both scales require the kind of responses that embody strategy or schema; however, for time management, the student uses overt or behavioral strategy to design schema or time planning, whereas, for procedural knowledge, the student must adopt deep or covert cognitive schema while he or she is engaged in the academic task.

Both measures of academic performance, OSB and test score, were not associated. This, in turn, may refer to the content of both measures. For instance, the use of highlighters does not mean necessarily that student is focused on the main idea of reading. On the other hand, the test items may not have required these sorts of study behaviors. Also, the checklist of study behaviors included seven behavioral strategies that were used by the participants; however, it is hard to determine *how or for what purpose* the participant used these behaviors. In other words, even if the participant used the seven study materials as overt behavioral strategies, it is difficult to know whether the use of those materials was competent or not. To acquire this information, a qualitative study of interviews with students would be helpful.

Both measures of executive functions and academic self-efficacy were not associated with academic performance as measured by test score and OSB, which contradicted the findings from previous research (Bandura et al., 2003; Espy et al., 2004; Taylor et al., 1996). This contradiction may be due to the types of measures which were used. The participants in this current study self-reported their executive functions and their academic self-efficacy; therefore, they may have reported what they think they did, which may be different from what they *actually* did. Also, the 20 test questions, on the social cognition material, may not have required the use of a high level of executive functions or academic self-efficacy.

In this current study, there may be positive implications for students, teachers, and researchers. Students can learn to develop deep cognitive skills and acquire metacognitive skills that enhance their deep engagement in the academic tasks, this in turn, enhances their academic performance. Teachers could encourage students to improve time management skills and develop skills, such as planning as well as procedural and declarative knowledge, while they engage in academic tasks. These findings may raise the interests of researchers to replicate the current study in similar or different environments or use different variables with some of the constructs that were used in the current study.

Finally, taking into account some limitations in the current study, the sample size used in this study to examine the research questions was small and limited to females only. This limited the generalizability of these findings. Future researchers should include a large and mixed gender sample, so that the research questions for the present study can be addressed in a manner that will produce better external validity. The metacognitive skills of procedural knowledge, planning, declarative knowledge, and information management strategy were measured, but the responses were dependent upon the student's self-report; thus, there is no assurance that the students actually used all of the metacognitive skills that they reported nor that they used all of the reported strategies. Future researchers should use observational technique to assess metacognitive skills and study strategies, such as, have students speak aloud about their strategies and cognitive engagement while they engage in the reading task or problem solving. In general, direct or observational measures could be used in future research on the predictors of academic performance to avoid students' tendencies toward impression management and to identify the most ecologically valid picture of the variety of variables that contribute to successful learning and achievement in college.

Biography

Nasar Said, prefosser at Department of Behavioral Sciences, Omar Al-Mukhtar University, Libya, has been interested in conducting research on cognitive/motivational constructs that are thought to be associated with college students' academic performance.

Research:

Said, N., & Welsh, M. (2011). *Correlations among executive functions, self-efficacy, study skills, and academic achievement*. Unpublished manuscript. School of Psychological Sciences, University of Northern Colorado.

Said, N.(2012). *Predicting academic performance: Executive functions, metacognition, study strategies, and self-efficacy.* Unpublished manuscript. School of Psychological Sciences, University of Northern Colorado.

Said, N. (In press). *The dimensions of self-regulated learning: High and low achieving college students.*

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