Metacognition and Self-Regulated Learning Constructs

Rayne A. Sperling¹, Bruce C. Howard², Richard Staley³, and Nelson DuBois³
¹The Pennsylvania State University, University Park, PA, USA, ²Wheeling Jesuit University Challenger Learning Center, West Virginia, USA, and ³State University of New York at Oneonta, NY, USA

ABSTRACT

Demographic variables, findings from the Metacognitive Awareness Inventory (Schraw & Dennison, 1994), the Learning Strategies Survey (Kardash & Amlund, 1991), and the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991), as well as accuracy ratings of test performance, were examined in 2 studies. Findings indicated convergence of self-report measures of metacognition, significant correlations between metacognition and academic monitoring, negative correlations between self-reported metacognition and accuracy ratings, and positive correlations between metacognition and strategy use and metacognition and motivation. Limitations of the studies and implications for theory development and future research are discussed.

INTRODUCTION

Self-regulated learning is generally believed to include constructs such as background knowledge, metacognitive knowledge, metacognitive regulation, strategy use, various motivational constructs, and epistemological beliefs (Alexander, 1995; Boekaerts, 1995; Corno, 1995; Pressley, 1995; Schunk, 1995; Schunk & Ertmer, 2000; Winne, 1995a, 1995b; Zimmerman, 1995b). There is some consensus regarding what constitutes self-regulated learning.

Address correspondence to: Rayne Sperling, ESPSE, 232 CEDAR Building, The Pennsylvania State University, University Park, PA 16802, USA. Tel.: +1-814-863-2261. Fax: +1-814-863-1002. E-mail: rsd7@psu.edu

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There is also, however, general agreement that the relationships among self-regulatory constructs are largely unknown and that future research should address relationships among self-regulatory constructs (Brownlee, Leventhal, & Leventhal, 2000; De Corte, Verschaffel, & Op’t Eynde, 2000; Weinstein, Husman, & Dierking, 2000; Winne & Perry, 2000).

The lack of clear understanding regarding relationships among self-regulatory constructs is problematic for construct development. Further, the lack of a clear understanding of regulatory constructs also precludes effective interventions and training of self-regulation in practice. The current study directly addresses correlations among three well-accepted self-regulated learning variables: metacognition, academic strategy use, and motivation.

Metacognition has been defined in numerous ways (e.g., Dunlosky, 1998; Flavell, 1979; Flavell, Miller, & Miller, 1993; Hacker, 1998; Nelson & Narnes, 1996). As with self-regulated learning, generally metacognition is defined by its component parts. One framework, initiated by Brown (1978), and employed in later work (e.g., Baker, 1984, 1989; Cross & Paris, 1988; Jacobs & Paris, 1987; Lin-Miao & Zabrucky, 1998; Paris, Cross, & Lipson, 1984; Pereira-Laird & Deane, 1997; Schraw, 1997; Schraw & Dennison, 1994) suggests two components: knowledge of cognition and regulation of cognition. Knowledge of cognition refers to how much learners understand about their own memories and the way they learn. Regulation of cognition refers to how well learners can regulate their own memory and learning (Brown, 1987). Paris et al. (1984) suggested that the knowledge of cognition component of metacognition can be effectively divided into three distinct areas. These areas are declarative knowledge, or knowledge about one’s general processing abilities, procedural knowledge, or knowledge such as how to successfully solve problems, and conditional knowledge, or knowledge such as when to employ specific strategies. There is substantial evidence to suggest that individuals vary considerably in their knowledge of cognition (Palincsar & Brown, 1987; Schraw, 1994, 1997; Schraw & Nietfeld, 1998; Slife, Weiss, & Bell, 1985).

Regulation of cognition theoretically contains several different subcomponents including planning, selecting, monitoring, evaluating, and debugging (Manning, Glasner, & Smith, 1996; Miller, 1991; Paris et al., 1984; Schraw & Dennison, 1994; Slife et al., 1985). Regulation of cognition has been assessed extensively (e.g., Glenberg & Epstein, 1985, 1987; Glenberg, Sanocki, Epstein, & Morris, 1987; Maki & Serra, 1992a, 1992b; Morris, 1990; Pressley

Most believe that the two components of metacognition, knowledge of cognition and regulation of cognition, are related. There remain questions, however, about the exact relationship between the two components. Schraw (Schraw, 1994, 1997; Schraw & Dennison, 1994) and others have considered this question. For instance, some work suggests that it is possible that knowledge of cognition is a prerequisite to regulation of cognition (Baker, 1989). Schraw and Dennison (1994) provided some evidence to suggest that knowledge of cognition may precede regulation of cognition. Using a self-report measure of metacognition, they reported that knowledge of cognition was a better predictor of performance on a reading comprehension test than was regulation of cognition. Further, those with high knowledge of cognition were more likely to demonstrate greater regulation of cognition. Although in the Schraw and Dennison study the relationships between metacognitive components yielded statistical significance ($r = .54$ and $r = .45$), each made unique contributions, leading the authors to state the two did not share a compensatory relationship.

In other work, Schraw (1994, 1997) further addressed the relationship between knowledge and regulation of cognition. In the 1994 study, he reported that knowledge and regulation of cognition were significantly related only for those with high monitoring ability.

Further, when addressing domain-generality of metacognitive regulation, Schraw (1997) employed a self-report measure of metacognitive knowledge and his findings indicated that those scoring lower on the knowledge measure were also less able to accurately monitor their performance while the opposite was true for high monitors. Combined, these studies lend additional support that metacognitive knowledge and regulation are related. The current work further examines these constructs.

One difficulty in generalizing from studies that assess metacognition is that previous research has shown that relationships among measures of metacognition are often not strong (Dennison, 1996; Tobias, Everson, & Laitusis, 1999). For example, Schraw and Dennison (1994) reported no
significant relationship between monitoring accuracy and self-report measures of metacognition. Recently, Winne and Perry (2000) echoed this concern in their suggestion that future research should continue to address relationships among measures of self-regulatory constructs. Therefore, in addition to questions about the relationship between and temporal acquisition of metacognitive components, questions remain concerning the relationship among various measures of metacognition. The work presented here employs several measures of metacognition.

There also remain questions regarding the role of metacognition within the superordinate self-regulation model. As stated, there is not clear knowledge about the relationships among metacognition and other self-regulated learning constructs. Two of these additional constructs, strategy use and motivation, are examined here.

Academic strategy use has been examined in numerous studies. Some work has addressed the instruction of learner strategies generally and specifically (e.g., Butler, 1995, 1998; Schunk & Zimmerman, 1995; Zimmerman, 1995a), other work has addressed either descriptive studies of students' use of learning strategies or the relationship between strategies and achievement (e.g., Vanzile-Tamsen & Livingston, 1999; Wolters, 1998). Academic strategies are often considered by cognitive level of processing. Using this approach, strategies are classified as rehearsal strategies, attentional strategies, organizational strategies, construction strategies, and elaboration strategies, for example. The current work considers strategies based upon cognitive level and is consistent with related literature (e.g., Kardas & Amlund, 1991; Mayer, 1998; Pressley, Borkowski, & Schneider, 1987; Van Meter, 2001; Weinstein et al., 2000; Weinstein & Mayer, 1986; Zimmerman, 1995a).

Many assume the mindful use of regulatory processes, specifically knowledge and regulation of cognition, may precede effective use of learning strategies (e.g., Dunlosky, 1998; Flavell, 1979; Hacker, 1998). This may not always be the case. Although metacognitive processes may play a large role in complex tasks or novel learning situations, these processes may be used less frequently as strategies become automatized (Brown, 1987).

It is unclear whether the acquisition and effective use of learning strategies necessarily depends on metacognitive awareness. Therefore, the second goal of this work was to further address the correlations among metacognitive awareness, its components, and the use of learning strategies.

Some have considered (Boekaerts, 1995, 1997; Schunk 1995, Winne, 1995b; Zimmerman, 1995a, 1995b, 2000) that a metacognitive view of self-regulation
may be limiting and that self-regulation should be addressed from a motivational standpoint. Regarding self-regulation, several motivational variables have been studied. Among others, these include self-efficacy (e.g., Schunk & Ertmer, 2000; Shah & Kruglanski, 2000; Zimmerman, 1995a, 1995b, 2000), intrinsic goal orientation (Pintrich, 2000), extrinsic goal orientation (Pintrich et al., 1991), goal variables (Shah & Kruglanski, 2000; Zimmerman, 2000), and a possible-selves framework (Pintrich & Garcia, 1994). For a recent review of related motivational constructs see Murphy and Alexander (2000).

While much of the current literature addresses motivational aspects of self-regulation, less is known regarding the correspondence between metacognitive variables and motivational variables. Developmental work on the Motivated Strategies for Learning Questionnaire (MSLQ), and similar work with the Learning and Study Strategies Inventory (LASSI) (Weinstein, Schulte, & Palmer, 1987) reports expected relationships between these two self-regulatory constructs. The correlations reported between the Metacognitive Self-Regulation scale and the motivational scales of the MSLQ for example, were reported as $r = .50$ with Intrinsic Motivation, $r = .07$ with Extrinsic Motivation, $r = .45$ with Test Anxiety, $r = .46$ with Self-Efficacy, and $r = .17$ with Control of Learning Beliefs (Pintrich et al., 1991).

Other work also supports that there are positive moderate relationships between motivational variables and metacognition (e.g., Landine & Stewart, 1998). The current work further contributes to previous studies by examining these constructs across instruments and within a broader self-regulated learning framework.

Although available research has demonstrated positive relationships among self-regulated learning variables, other research indicates that the relationships between achievement measures and self-regulated learning constructs are not direct. For example, Swanson (1990) demonstrated that metacognitive knowledge and intellectual aptitude were unrelated and that metacognitive skills helped children of lower aptitude compensate on problem-solving tasks. In addition, Pressley and Ghatala (1989) found metacognition to be unrelated to verbal ability and further indicated that achievement and ability measures are not an indication of metacognitive skill. Similarly, in college learners, Pintrich et al. (1991) found that metacognition and strategy use were not highly correlated with academic achievement.

One would assume that self-regulatory knowledge and skills would facilitate learning and would correspond to increased academic achievement.
Some work supports this contention (e.g., Everson & Tobias, 1998). Support from the research literature, is not, however, consistent. Therefore, further research that examines self-regulatory constructs and achievement is necessary and is provided in the current work.

Combined, the two studies in this work address four main goals to examine Self-Regulated Learning constructs. These goals include first, to further address correlations among metacognitive constructs and between measures of metacognition; second, to further address learning strategy use and metacognition; third, to further examine metacognition and achievement; and fourth, to examine relationships between measures of metacognition and motivational variables.

Overall, Study 1 addressed the first three of these goals. Regarding the first goal, it was hypothesized that knowledge of cognition and regulation of cognition would be significantly positively related as was reported in previous work (Schraw & Dennison, 1994). Regarding the second goal, it was hypothesized that greater reported knowledge and regulation of cognition would be related to greater reported strategy use. It was further hypothesized that regulation of cognition would be more correlated with strategy use than would knowledge of cognition. Third, this study examined relationships between metacognition and SAT scores, high school GPA, and course withdraw data. Consistent with previous findings, using related achievement measures (Pintrich et al., 1991), it was expected that metacognition would be only moderately related or unrelated to SAT scores and high school GPA. Although not used in previous studies, since dropping classes may represent learners’ inability to balance their academic load, we included number of courses dropped as a measure of self-regulatory monitoring. Therefore, it was expected that metacognitive regulation would be negatively correlated with course withdraw data.

STUDY 1

Participants
Participants were 109 primarily 1st-year students enrolled in an academic strategies class at a northeastern state college. Many were enrolled in the course randomly by the registrar as part of a retention initiative. Participants completed the instruments in class early in the fall semester.
Materials
Materials administered included the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994), and the Learning Strategies Survey (LSS) (Kardash & Amlund, 1991). These instruments asked learners to report on their metacognition and strategy use generally and not with respect to one particular class. SAT scores, high school grade point averages, and data about semester credits dropped were gathered from students’ admission records.

Metacognitive Awareness Inventory (MAI)
The MAI (Schraw & Dennison, 1994) is comprised of fifty-two 5-point Likert-scale items that are divided into two scales. These two scales represent the two components of metacognition from the Brown (1978, 1987) theoretical perspective of metacognition. First, the knowledge of cognition scale measures an awareness of one’s strengths and weaknesses, knowledge about strategies, and why and when to use those strategies. A sample Knowledge of Cognition item is, “I learn best when I know something about the topic.” The second scale, Regulation of Cognition, measures knowledge about planning, implementing, monitoring, and evaluating strategy use. An example Regulation of Cognition item is “I ask myself if I am meeting my goals.” Previous analyses of the instrument support two distinct factors. This inventory has been shown to be a reliable measure of metacognition related to academic learning tasks (Schraw & Dennison, 1994).

Learning Strategies Survey (LSS)
The LSS (Kardash & Amlund, 1991), a 27-item, 5-point Likert-scale inventory is also comprised of two scales. The 18-item Covert Cognitive Processes scale measures internal information processing, organization, and elaboration. Example items include, “I learn new material by mentally associating new ideas with similar ideas that I already know” and “I put together ideas or concepts and draw conclusions which are not directly stated in course materials.” The 9-item Overt Processes scale measures observable encoding strategies. Example items include, “I underline details as I read” and “I write summaries in my own words of all my assigned readings.” The LSS was designed to investigate the relative frequency with which students use particular strategies, relationships among learning strategies, and the relationships between strategies and academic achievement. The instrument is particularly relevant for use in the current study since Kardashian and Amlund (1991) defined strategies as “overt and covert information-processing
activities used by learners at the time of encoding to facilitate the acquisition, storage, and subsequent retrieval of information to be learned” (p. 119). This definition is consistent with the theoretical approach to learning strategies within a self-regulated learning model as used in the present work. Their research reports that the instrument is stable and that the scales appear distinct (Kardash & Amlund, 1991).

Results
The first goal in Study 1 was to further examine relationships among metacognitive components. For the 109 participants, the mean MAI score was 129.42 ($SD = 22.11$). The Knowledge of Cognition factor had a mean of 45.31 ($SD = 8.34$) and the Regulation of Cognition factor had a mean of 84.12 ($SD = 15.16$). Knowledge of Cognition showed a strong correlation with Regulation of Cognition ($r = .75$, $p < .001$). This correlation is much higher than that reported in Schraw and Dennison's (1994) two studies ($r = .54$ and $r = .45$, respectively). Total MAI scores, as well as the Knowledge of Cognition factor and the Regulation of Cognition factor scores, were used in subsequent analysis.

When analyzed with an additional measure of metacognition, findings showed MAI scores to be inversely correlated with credits dropped during the fall semester ($r = -.21$, $p < .05$, $n = 102$). Thus, metacognition as measured by this self-report measure, may be related to ability to manage the collegiate system. It is possible that perhaps those who were not as metacognitively aware either enrolled with unclear expectations, or had to drop classes because coping was difficult. Conversely, perhaps those who were more metacognitively aware enrolled in an appropriate number of classes and were better able to manage the academic load.

The second goal in Study 1 was to examine the correlation between metacognition, as measured by the MAI, and reported use of learning strategies. Means and standard deviations for the LSS are reported in Table 1.

Table 1. Means and Standard Deviations of the Learning and Study Strategies (LSS) Inventory.

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total score</td>
<td>81.69</td>
<td>14.55</td>
</tr>
<tr>
<td>Covert Cognitive Processes</td>
<td>48.13</td>
<td>10.15</td>
</tr>
<tr>
<td>Overt Cognitive Processes</td>
<td>36.96</td>
<td>8.80</td>
</tr>
</tbody>
</table>

*Note. n = 109.*
Table 2. Correlations Between the MAI and the LSS.

<table>
<thead>
<tr>
<th></th>
<th>LSS total</th>
<th>Covert Processes</th>
<th>Overt Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAI total</td>
<td>.50**</td>
<td>.53**</td>
<td>.26*</td>
</tr>
<tr>
<td>Knowledge of Cognition</td>
<td>.44**</td>
<td>.49**</td>
<td>.19</td>
</tr>
<tr>
<td>Regulation of Cognition</td>
<td>.48**</td>
<td>.50**</td>
<td>.25*</td>
</tr>
</tbody>
</table>

Note. n = 109.
* p < .05.
** p < .001.

Covert Cognitive Processes and Overt Processes in the LSS were significantly correlated \( r = .24, p < .05 \). This correlation is similar to those reported in the literature. In two studies with college-aged learners, Kardash and Amlund (1991) reported correlations of \( r = .33 \) and \( r = .20 \).

Table 2 reports the correlations between the MAI and the LSS. It was expected that strong correlations would exist between the two measures. Overall, the two measures were significantly correlated \( r = .50, p < .001 \). As presented in Table 2, stronger correlations were found between the Covert Processes scale of the LSS and metacognition as measured by the total MAI score and both the Knowledge and Regulation of Cognition factor scores. As expected, Regulation of Cognition was more highly correlated with strategies overall than Knowledge of Cognition, but only slightly.

The third goal of these two studies was to address metacognitive awareness as measured by the MAI and indicators of academic achievement. There remains uncertainty in the literature regarding the nature of this relationship. Previous studies with similar populations that have addressed self-report measures of self-regulatory constructs, indicate that achievement is not strongly related to self-regulation, or specifically metacognition (Pintrich et al., 1991). However, if self-regulatory skills facilitate understanding and learning, one would expect that learners who have higher general self-regulation, and self-regulatory constructs, such as metacognition, would also have higher levels of achievement. Table 3 presents the means and standard deviations of the achievement indicators used in this study.

Table 4 reports the correlational findings between metacognition and these indicators. Findings generally indicate little relationship between academic achievement variables and metacognition. This finding was not hypothesized but is not surprising given previous research. There was an
Table 3. Means and Standard Deviations of Achievement Indicators.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT math</td>
<td>445.77</td>
<td>81.36</td>
</tr>
<tr>
<td>SAT Verbal</td>
<td>405.54</td>
<td>69.15</td>
</tr>
<tr>
<td>High School Average</td>
<td>2.39</td>
<td>.75</td>
</tr>
</tbody>
</table>

*Note. n = 109.*

Table 4. Correlations Between the Metacognition and Achievement Measures.

<table>
<thead>
<tr>
<th></th>
<th>MAI total</th>
<th>Knowledge of Cognition</th>
<th>Regulation of Cognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT Verbal</td>
<td>.01</td>
<td>.05</td>
<td>-.06</td>
</tr>
<tr>
<td>SAT math</td>
<td>-.42**</td>
<td>-.31*</td>
<td>-.44**</td>
</tr>
<tr>
<td>High School Average</td>
<td>.02</td>
<td>.04</td>
<td>-.05</td>
</tr>
</tbody>
</table>

*Note. n = 90.*

* *p < .05.
  ** p < .001.

unexpected significant negative correlation between SAT math ability and metacognition.

Although Study 1 addressed three of the main goals of the current work, the fourth goal that considers the relationship between motivational variables and metacognition remained unaddressed. Study 2 addresses this goal. It was expected that correlations between motivational variables and metacognitive variables would be less robust than correlations between metacognition and learning strategy use. This hypothesis was based both on previous findings (Pintrich et al., 1991), and also on the theoretical belief that the conditional knowledge aspects of metacognitive processing prompt academic strategy use (e.g., Dunlosky, 1998; Hacker, 1998).

Study 2 also readdressed the first two goals considered in Study 1. Regarding the first goal, in Study 1, consistent correlations were found between two measures of metacognition, the Metacognitive Awareness Inventory and information about credits dropped. In Study 2, relationships among metacognitive variables again were addressed across two self-report inventories of metacognition, the Motivated Strategies for Learning Questionnaire (MSLQ) and the MAI. Some have argued that self-reporting regulatory constructs may actually represent knowledge of cognition (e.g.,
Brown, 1987). Therefore, in addition to self-report measures of metacognition, confidence judgments on classroom-based tests were employed as further measurement of metacognitive processing.

The second goal of these studies was to assess correlations between metacognition and strategy use. Significant relationships were indicated in Study 1 between metacognition and self-reported strategy use. In Study 2, these variables were again examined. In this study, the learning strategies scales of the MSLQ were compared with the findings from the MAI.

STUDY 2

Study 2 further examined relationships among self-regulatory constructs with a slightly different sample and additional measures. Unlike Study 1, most of the learners in Study 2 were education majors with at least sophomore standing. Due to their class standing and their major, it was hypothesized participants in the second study would report higher metacognition than those in Study 1. Study 2 also addressed the correlation between three measures of metacognition. In addition to the MAI, both the Metacognitive Self-Regulation scale of the MSLQ and confidence judgments of test taking were employed in this study. Significant correlations between the MAI and each of these two measures of metacognition were expected. Study 2 examined correlations between the MAI and strategy use and academic motivation as measured by additional scales of the MSLQ. Significant correlations, as found in Study 1 with the LSS, between the MSLQ strategy scales and the MAI were expected. To address the fourth overall goal of the current research, significant but less robust correlations were expected between motivational constructs as measured by the MSLQ and the MAI.

Participants
Participants in this study were enrolled in the same northeastern state college. Whereas the sample in Study 1 represented a cross section of student majors, in Study 2 participants were enrolled in an educational psychology course and were generally sophomore and junior education majors. Again, students volunteered to complete the instruments during class time. Administration of the instruments was conducted early in the fall semester.
Materials and Procedure
Materials administered included the MAI, the Motivated Strategies Learning Questionnaire (MSLQ) (Garcia & Pintrich, 1995), and confidence judgments of test taking. The MSLQ is comprised of two main sections: learning strategies and motivation. Students answer the inventory with respect to a target class. In this case, the target class was their educational psychology course. The learning strategies section includes several scales. These include four scales that address cognitive strategies. These strategies include Rehearsal, Elaboration, Organization, and Critical Thinking. The Rehearsal scale includes items that address repeating information over and over. The Elaboration scale includes items that address paraphrasing and summarizing. The Organization scale includes items that address strategies such as outlining and creating tables. The Critical Thinking scale includes items that address such strategies as applying prior knowledge to new situations. The strategies section also includes a Metacognitive Self-Regulation scale that consists of 12 items that address the use of strategies to control learning. These strategies would include aspects of regulation of cognition including planning, monitoring, and regulating. Four resource management scales are also included. These include Time and Study Environmental Management, Effort Regulation, Peer Learning, and Help-Seeking (Pintrich et al., 1991).

The motivation section also includes several scales. These include three value scales: Intrinsic Goal Orientation, Extrinsic Goal Orientation, and Task Value. Intrinsic Goal Orientation focuses on mastery of learning. Extrinsic Goal Orientation focuses on grades and approval from others. The Task Value scale focuses on judgments of interestingness and usefulness of content. The motivation section also includes two expectancy scales, Control of Learning Beliefs and Self-Efficacy for Learning and Performance. Control of learning beliefs focus on the beliefs that outcomes are contingent on one’s own effort. The Self-Efficacy for Learning and Performance questions address judgements of own’s beliefs in ability and confidence in ability to accomplish learning tasks. The last scale in the motivation section is an affect scale: test anxiety. Test anxiety addresses worry over taking exams (Pintrich et al., 1991).

Confidence Judgments
Three measures of confidence judgments of test taking were calculated across two 20-item objective tests. Before each test, students were asked to predict how well they would do. After the test, students were asked to rate each item on a 7-point scale describing how certain they were of having answered the
question correctly. Pretest accuracy was calculated by converting predictions and test scores to scale scores 1 through 5 (1 = below 60%, 2 = 60–70%, 3 = 71–80%, 4 = 81–90%, 5 = over 90%) and taking the absolute value of the difference between the predicted scale score and actual scale scores. Thus, the lower the difference, the more accurate the calibration.

Students made posttest ratings on a 7-point rating scale, with 1 being, “Absolutely sure answer is incorrect” and 7 being, “Absolutely sure answer is correct.” Accuracy was calculated by taking the absolute difference between posttest ratings and correctness of response. That is, wrong answers were given a score of 1, while right answers were given a score of 7, and these were compared to the posttest ratings. Scores for the 20 items were averaged for right and wrong answers. Again, overall, the lower the number, the more accurate the monitoring response.

Results
Study 2 addressed the relationships among measures of metacognition. Measures of metacognition included the MAI, the MSLQ metacognitive self-regulation scale, and test-taking accuracy measures. The Metacognitive Awareness Inventory scores in Study 2 had a much higher mean of 197.35 (SD = 15.87) than those in Study 1. Table 5 presents the means and standard deviations for the scale scores for both studies. It is likely the difference between the two studies’ mean scores is due to the nature of the samples. Students in Study 2 were mostly education majors, while those in Study 1 represented a greater cross-section of majors. In Study 2, participants were also more often sophomores and juniors whereas Study-1 participants were generally 1st-year students. In Study 2, the relationship between metacognition and regulation of cognition was $r = .68$, $p < .001$, again illustrating a predicted significant correlation between knowledge of cognition and regulation of cognition as measured by the MAI.

<table>
<thead>
<tr>
<th></th>
<th>Study 1 ($n = 109$)</th>
<th>Study 2 ($n = 40$)</th>
<th># Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAI total score</td>
<td>129.42</td>
<td>197.35</td>
<td>52</td>
</tr>
<tr>
<td>Knowledge of Cognition</td>
<td>45.31</td>
<td>70.21</td>
<td>25</td>
</tr>
<tr>
<td>Regulation of Cognition</td>
<td>84.12</td>
<td>128.10</td>
<td>27</td>
</tr>
</tbody>
</table>
Table 6. Means and Standard Deviations for the MSLQ Strategies Scales and Motivational Scales.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning strategies scales</td>
<td>213.27</td>
<td>30.16</td>
</tr>
<tr>
<td>Rehearsal</td>
<td>21.58</td>
<td>4.24</td>
</tr>
<tr>
<td>Elaboration</td>
<td>31.86</td>
<td>5.51</td>
</tr>
<tr>
<td>Organization</td>
<td>19.41</td>
<td>4.16</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>21.45</td>
<td>4.65</td>
</tr>
<tr>
<td>Metacognitive Self-Regulation</td>
<td>64.75</td>
<td>9.69</td>
</tr>
<tr>
<td>Time and Study Environment Management</td>
<td>48.78</td>
<td>6.91</td>
</tr>
<tr>
<td>Effort Regulation</td>
<td>25.69</td>
<td>3.98</td>
</tr>
<tr>
<td>Peer Learning</td>
<td>9.69</td>
<td>4.07</td>
</tr>
<tr>
<td>Help-Seeking</td>
<td>18.06</td>
<td>4.72</td>
</tr>
<tr>
<td>Motivation scales</td>
<td>133.08</td>
<td>15.72</td>
</tr>
<tr>
<td>Intrinsic Goal Orientation</td>
<td>19.64</td>
<td>3.79</td>
</tr>
<tr>
<td>Extrinsic Goal Orientation</td>
<td>22.13</td>
<td>3.38</td>
</tr>
<tr>
<td>Task Value</td>
<td>34.39</td>
<td>5.59</td>
</tr>
<tr>
<td>Control of Learning Beliefs</td>
<td>23.27</td>
<td>2.89</td>
</tr>
<tr>
<td>Self-Efficacy for Learning and Performance</td>
<td>43.70</td>
<td>5.37</td>
</tr>
<tr>
<td>Test Anxiety</td>
<td>20.95</td>
<td>6.84</td>
</tr>
</tbody>
</table>

Comparisons of measures of metacognition included correlations between the MSLQ Metacognitive Self-Regulation scale and the Knowledge of Cognition and Regulation of Cognition factors of the MAI. As expected, findings indicated that these correlations were positive and significant. The correlation between the total MAI scores and the Metacognitive Self-Regulation scale of the MSLQ was $r = .59, p < .001$. The correlation between the Metacognitive Self-Regulation scale and Knowledge of Cognition as measured by the MAI was $r = .59, p < .001$, and for Regulation of Cognition was $r = .47, p < .01$. Table 6 presents the means and standard deviations by scale of the MSLQ. Table 7 presents the correlations between the learning strategies scales, including the Metacognitive Self-Regulation scale scores, and the MAI.

For three main reasons, the MAI was used as a measure of metacognition for comparison with confidence judgments: First, the MAI was developed to represent both knowledge and regulation of cognition; second, the MSLQ and the MAI scores were significantly related; and third, to limit the number of zero-order correlations. Table 8 presents the means and standard deviations of test-taking accuracy for both predictions and posttest accuracy. Again, the lower the number the higher the accuracy.
Table 7. Correlations Between the MAI and the MSLQ Learning Strategies Scales.

<table>
<thead>
<tr>
<th></th>
<th>MAI total</th>
<th>Knowledge of Cognition</th>
<th>Regulation of Cognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning strategies scales</td>
<td>.60***</td>
<td>.63***</td>
<td>.48**</td>
</tr>
<tr>
<td>Rehearsal</td>
<td>.09</td>
<td>.07</td>
<td>-.023</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.39*</td>
<td>.38*</td>
<td>.31</td>
</tr>
<tr>
<td>Organization</td>
<td>.58**</td>
<td>.62***</td>
<td>.46*</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>.43*</td>
<td>.34</td>
<td>.41*</td>
</tr>
<tr>
<td>Metacognitive Self-Regulation</td>
<td>.59**</td>
<td>.59***</td>
<td>.47**</td>
</tr>
<tr>
<td>Time and Study Environment Management</td>
<td>.46*</td>
<td>.47**</td>
<td>.45*</td>
</tr>
<tr>
<td>Effort Regulation</td>
<td>.40*</td>
<td>.31</td>
<td>.40*</td>
</tr>
<tr>
<td>Peer Learning</td>
<td>.08</td>
<td>.26</td>
<td>-.06</td>
</tr>
<tr>
<td>Help-Seeking</td>
<td>.05</td>
<td>.20</td>
<td>-.07</td>
</tr>
</tbody>
</table>

Note. n = 30.

*p < .05.

**p < .01.

***p < .001.

Table 8. Means and Standard Deviations of Accuracy of Confidence Judgments.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preaccuracy Test 1</td>
<td>1.09</td>
<td>1.01</td>
<td>33</td>
</tr>
<tr>
<td>Preaccuracy Test 2</td>
<td>.84</td>
<td>.96</td>
<td>32</td>
</tr>
<tr>
<td>Accuracy-Correct Test 1</td>
<td>6.09</td>
<td>.51</td>
<td>34</td>
</tr>
<tr>
<td>Accuracy-Incorrect Test 1</td>
<td>5.45</td>
<td>.96</td>
<td>31</td>
</tr>
<tr>
<td>Accuracy-Correct Test 2</td>
<td>5.75</td>
<td>.72</td>
<td>32</td>
</tr>
<tr>
<td>Accuracy-Incorrect Test 2</td>
<td>5.20</td>
<td>.71</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 9 presents the correlations between overall metacognition, knowledge of cognition, and regulation of cognition and accuracy measures. Findings here were inconclusive, due to somewhat limited student participation and large standard deviations as indicated in Table 8. In addition, although two of six accuracy judgments were correlated with one of the MAI components, one was a significant inverse relationship, contrary to hypotheses. It had been expected that MAI scores would be correlated with regulation as was supported in previous work by Schraw (1997). The lack of relationship between metacognitive knowledge and accuracy of confidence judgments is, however, similar to findings reported by Dennison (1996).
Table 9. Correlations Between Metacognition and Accuracy of Confidence Judgments.

<table>
<thead>
<tr>
<th></th>
<th>MAI total</th>
<th>Knowledge of Cognition</th>
<th>Regulation of Cognition</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preaccuracy Test 1</td>
<td>.01</td>
<td>-.07</td>
<td>-.02</td>
<td>33</td>
</tr>
<tr>
<td>Preaccuracy Test 2</td>
<td>-.28</td>
<td>-.04</td>
<td>-.42*</td>
<td>32</td>
</tr>
<tr>
<td>Accuracy-Correct Test 1</td>
<td>.16</td>
<td>.37*</td>
<td>.02</td>
<td>34</td>
</tr>
<tr>
<td>Accuracy-Incorrect Test 1</td>
<td>.01</td>
<td>-.07</td>
<td>-.07</td>
<td>31</td>
</tr>
<tr>
<td>Accuracy-Correct Test 2</td>
<td>.01</td>
<td>.08</td>
<td>.04</td>
<td>32</td>
</tr>
<tr>
<td>Accuracy-Incorrect Test 2</td>
<td>-.11</td>
<td>.06</td>
<td>-.20</td>
<td>30</td>
</tr>
</tbody>
</table>

*p < .05.

The second goal of both studies overall considered relationships between metacognition and strategy use. As mentioned, theoretically it was hypothesized that metacognition and strategy use would be related. Study 1 supported this hypothesis with significant correlations between the MAI and the LSS. Similarly, the MSLQ manual reports positive correlations between the metacognitive Self-Regulation scale of the MSLQ and the remaining strategy scales (Pintrich et al., 1991). In Study 2, these relationships were further examined. Table 7 presented the correlations between the remaining Strategy scale scores of the MSLQ and the Metacognitive Awareness Inventory.

Overall, a significant correlation between metacognition as measured by the MAI and learning strategies as measured by the MSLQ was indicated ($r = .60, p < .001$). This finding was also consistent for both the Knowledge of Cognition ($r = .63, p < .001$) and the Regulation of Cognition scales ($r = .48, p < .01$) of the MAI.

When examining individual scales, significant correlations were indicated on scales that represent similar constructs to the LSS scales in Study 1. Rehearsal, Peer Learning, and Helpseeking were not significantly related to metacognition as measured by the MAI while aspects of elaboration, organization, and critical thinking were significantly related.

The fourth goal of both studies, an examination of the self-regulatory constructs of metacognition and motivation, was addressed in Study 2. Table 6 presents the means and standard deviations for the motivation scales of the MSLQ. Table 10 presents correlations between motivation scales of the MSLQ and metacognition as measured by the MAI. The MSLQ manual reported significant, but somewhat more modest relations between metacognition and motivation than between metacognition and the learning strategies scales. This finding was also supported in the current work. Overall,
Table 10. Correlations Between the MAI and the MSLQ Motivation Scales.

<table>
<thead>
<tr>
<th>Motivation scales</th>
<th>MAI total</th>
<th>Knowledge of Cognition</th>
<th>Regulation of Cognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrinsic Goal Orientation</td>
<td>.40*</td>
<td>.28</td>
<td>.41*</td>
</tr>
<tr>
<td>Extrinsic Goal Orientation</td>
<td>.24</td>
<td>.27</td>
<td>.23</td>
</tr>
<tr>
<td>Task Value</td>
<td>-.07</td>
<td>-.12</td>
<td>-.04</td>
</tr>
<tr>
<td>Control of Learning Beliefs</td>
<td>.35</td>
<td>.30</td>
<td>.35</td>
</tr>
<tr>
<td>Self-Efficacy for Learning and Performance</td>
<td>.38*</td>
<td>.18</td>
<td>.41*</td>
</tr>
<tr>
<td>Test Anxiety</td>
<td>.35</td>
<td>.29</td>
<td>.36*</td>
</tr>
<tr>
<td></td>
<td>.15</td>
<td>.04</td>
<td>.13</td>
</tr>
</tbody>
</table>

Note. n = 30.

*p < .05.

**p < .01.

***p < .001.

Motivation scales were significantly related to total metacognition ($r = .40$, $p < .05$) and Regulation of Cognition ($r = .41$, $p < .05$) but not Knowledge of Cognition.

**Discussion**

Study 2 addressed three of the goals of the current research. First, correlations among measures of metacognition were examined. Findings included positive significant correlations between the MSLQ and the MAI. Contrary to expectations, accuracy of confidence judgments was generally not related positively to self-report measures of metacognition. As hypothesized, and supported by findings from Study 1, positive significant relationships were apparent between reported learning strategies and metacognition. Finally, also as expected, correlations between metacognition and motivation were less robust.

**GENERAL DISCUSSION**

Overall, the current research set out with four goals. The first goal was to continue the examination of relationships among metacognitive constructs and between measures of metacognition. Across both studies, knowledge and regulation components of metacognition were strongly related to each other, as predicted. There were rather large differences between metacognition
across samples as indicated by MAI mean scores. There were also varying correlations between knowledge of cognition and regulation of cognition across samples and previous work (Schraw & Dennison, 1994). This is likely due to sample characteristics. Future research should examine the development of self-regulated learning in college students. Often, previous work has treated college students as one sample. In this work, Study 1 was conducted with 1st-year students while sophomore and junior primarily education students completed Study 2.

In Study 1, significant negative relationships between academic management and metacognition were indicated. In Study 2, results showed a positive significant correlation between two self-report measures of metacognition, the MAI and the MSLQ. These findings were expected and in the hypothesized direction. Conversely in Study 2, however, little support for relationships between self-report measures of metacognitive processing and accuracy of confidence judgments was indicated. Conclusions from these findings should be tempered due to both the limited participation and large standard deviations. The lack of strong positive correlations was not predicted. In addition, although two of six accuracy judgments were correlated with one of the MAI components, one was a significant inverse relationship, contrary to hypotheses. Future research should further examine consistency among measures of metacognition, as well as employ multiple and varied methods of measuring metacognition and other self-regulatory constructs (see Winne & Perry, 2000, for recent similar conclusions).

The second goal of the current studies was to examine relationships between metacognitive processing and strategy use. Across both studies, findings illustrated positive and significant correlations between metacognition and strategy use measures. This finding was expected based upon theoretical frameworks of metacognition and control (e.g., Dunlosky, 1998; Flavell, 1979, Hacker, 1998) as well as models of self-regulation (e.g., Zimmerman, 2000). As hypothesized, MAI components were correlated with both measures of learning strategies.

Theoretically, metacognitive awareness may precede effective strategy use. The finding that higher metacognitive awareness was significantly correlated with higher reported strategy use, therefore, is in line with such a hypothesis. Overall, these correlations provide support for relationships among these constructs within the broader self-regulated learning model.

Third, the relationship between metacognition and achievement was not predicted to be strong. There is not consensus in existing literature regarding
the relationship between achievement and metacognition. Nonetheless, findings indicating negative correlations between SAT math and measures of metacognitive awareness were surprising. It is evident that future work must continue to examine the relationships among self-regulatory constructs and achievement.

Finally, this work also examined correlations among metacognition and motivational constructs. Findings suggested less robust correlations between metacognition and motivation than for metacognition and strategy use. This was consistent with predictions based upon previous research. Although more modest, the findings still are consistent with theories of self-regulated learning that include both constructs (e.g., Weinstein et al., 2000; Zimmerman, 2000). Future work should focus on aspects of motivation and include additional motivational constructs, such as possible-selves variables.

Future examinations should include further exploration of the relationships between metacognition and other self-regulatory constructs, including further work with motivation and epistemology as discussed by Winne (1995b) and Boekaerts (1995) and examined by Paulsen and Feldman (1999). Additional work should examine aptitudes to further examine the unexpected MAI and SAT M correlation. This future work should employ large diverse samples and modeling analyses.

Similarly, subsequent work that addresses several self-regulated learning variables simultaneously, including those addressed in the current work, as well as constructs such as background knowledge and epistemological beliefs, is warranted. Further, this work should employ multiple methods of measurement of self-regulated constructs. Additional research is necessary for future theory development and the design of effective interventions for practice.

REFERENCES


SELF-REGULATED LEARNING


