

## Validating and Adapting the Motivated Strategies for Learning Questionnaire (MSLQ) for STEM Courses at an HBCU

Caesar R. Jackson

North Carolina Central University

*This study investigated the validity and reliability of the Motivated Strategies for Learning Questionnaire (MSLQ) for minority students enrolled in STEM courses at a historically black college/university (HBCU). Confirmatory factor analysis was used to test the third-order factor structure and to respecify the model. An adequate fit to the study sample data was achieved for the respecified MSLQ (MSLQ-R), and measurement invariance was verified on four groups within the HBCU sample. The highest correlates with EOC grade on the MSLQ-R were self-efficacy, task value, effort regulation, and time and study environment. Metacognitive self-regulation and strategy use variables were found to not correlate with EOC grade. A useful capability to discriminate on the basis of academic performance was exhibited by the MSLQ-R.*

**Keywords:** *Motivated Strategies for Learning Questionnaire (MSLQ), self-regulated learning, historically black college/university (HBCU), African American students, confirmatory factor analysis*

SCIENCE, technology, engineering, and mathematics (STEM)–educated graduates possess knowledge and skills that are critical to a large portion of the U.S. workforce and contribute to the economic competitiveness and innovation of the nation (National Science Board [NSB], 2015). However, there are persistent challenges in producing and retaining STEM talent in the United States to meet the current workforce demands, as documented in several national reports (National Academy of Science, 2011; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007, 2010; NSB, 2016). Although about 28% of all U.S. college students select a STEM major, more than half switch to a non-STEM field or leave postsecondary education without earning any credentials (Chen, 2009). This departure rate is even higher for individuals from groups underrepresented in STEM, including African Americans (Chen, 2013). Most students who switch from STEM to non-STEM degree programs do so after taking challenging and demanding STEM gatekeeper courses—introductory science, mathematics, and engineering (President’s Council of Advisors on Science and Technology, 2012). Earning low or nonpassing grades in these courses reduces academic self-efficacy and often leads to negative attitudes toward STEM, which can further prompt students to disengage and change majors (Eagan, Hurtado, & Chang, 2010; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012).

Learning in STEM involves many self-regulated learning processes that require students to plan, set goals, think critically, assess and select their approach, build knowledge, monitor progress, and evaluate their actions and outcomes

(Sinatra & Taasobshirazi, 2011). Students must control and manage their behaviors to develop skills, learn from others, utilize available resources, manage their time and effort, and complete tasks. STEM learning also requires students to show interest, be motivated, be inquisitive, have purpose and value, explore, and endure frustration. Highly self-regulated students find ways to learn and overcome obstacles by adjusting their motivation, affect, and learning approach (Zimmerman & Martinez-Pons, 1990). Understanding the motivational beliefs and learning behaviors that students exhibit in STEM courses is of key importance toward improving academic learning and achievement (Komarraju & Nadler, 2013).

Self-regulated learning, the degree to which a student systematically uses metacognitive, motivational, and/or behavioral strategies in his or her own learning process (Schraw, Crippen, & Hartley, 2006; Wolters, Pintrich, & Karabenick, 2005; Zimmerman, 1989, 1990, 2008), has been shown to have positive impact on academic achievement of students (Cassidy, 2011; Cleary, Platten, & Nelson, 2008; DiBenedetto & Bembenuy, 2013). Self-regulated learning is a proactive process and has complex links, including direct and mediated effects, to students’ knowledge base, academic self-efficacy, and achievement (Komarraju & Nadler, 2013; Vanderstoep, Pintrich, & Flagerkin, 1996; Zimmerman, 1989, 2008; Zimmerman & Martinez-Pons, 1990). Self-regulation is essential for students to have in academic settings and is malleable (Dembo & Seli, 2004; Zimmerman, 1989). Students who possess strong self-efficacy beliefs make greater use of effective



cognitive strategies in learning, manage their time and learning environments more effectively, and monitor and regulate their own effort more thoroughly (Chemers, Hu, & Garcia, 2001; Schraw et al., 2006). Students vary widely in their perceptions of academic self-efficacy and use of learning strategies in tasks (DiBenedetto & Bembenuddy, 2013; Zimmerman & Martinez-Pons, 1990). This may be because self-regulated learning is inseparable from the purpose of engagement, where the type of self-regulated action relevant for engagement in a particular task depends on (a) the “subject” who is doing the regulating; (b) the “object” that is being regulated; and (c) the “means” by which regulation is conducted (Kaplan, 2008). Research has shown that self-regulatory learning can be taught (Azevedo & Cromley, 2004; Cleary et al., 2008; Schmitz & Wiese, 2006); therefore, knowledge about self-regulated learning, purpose of engagement, and achievement is important for guiding academic analysis and developing interventions to improve student learning and academic performance (Kaplan, 2008; Kitsantas, Winsler, & Huie, 2008; Zimmerman, 1989). Valid and reliable tools that are designed for diverse populations are needed for measuring self-regulation and to guide interventions.

### Measuring Self-Regulated Learning

The Motivated Strategies for Learning Questionnaire (MSLQ) is one of the most widely used instruments designed to measure self-regulated learning (Dinsmore, Alexander, & Loughlin, 2008; Roth, Ogrin, & Schmitz, 2016; Zimmerman, 2008). The MSLQ, a self-report questionnaire, was designed to correspond to the three elements in the definition of self-regulated learning: motivation, metacognition, and behavior (Pintrich, 2004; Pintrich, Smith, Garcia, & McKeachie, 1991, 1993; Wolters et al., 2005). The MSLQ has two parts: Part I. Motivation and Part II. Learning Strategies (see Appendix A).

Part A, the Motivation section of the MSLQ is intended to assess value, expectancy, and affect reported by students. Self-efficacy, a component of expectancy, is broad and combines judgments of one’s ability to accomplish a task, confidence in one’s skills to perform a task, and expectancy for success in the task. Academic self-efficacy relates positively to academic outcomes (Chemers, Hu, & Garcia, 2001; Komarraju & Nadler, 2013; Schraw et al., 2006). The affect component section is operationalized as test anxiety, although this anxiety is considered an emotional construct as opposed to a motivational one (Hilpert, Stempien, van der Hoeven Kraft, & Husman, 2013).

Part B, the Learning Strategies section of the MSLQ is intended to assess use of cognitive, metacognitive, and resource management strategies reported by students. Cognitive processes incorporate skills to encode, memorize, and recall information. Cognitive strategies include students’ reported use of basic and complex strategies for the processing of information from texts and lectures. Metacognition, knowledge about the task, and knowledge about the strategy influence cognition. Metacognitive control strategies involve the use of strategies

that help students control and regulate their own cognition. Engaging in a task, which includes selective activation of strategies to perform the task and the task effort, is influenced by goals and outcome perceptions (Pintrich, Wolters, & Baxter, 2000; Schraw et al., 2006; Zimmerman, 1989, 1990; Zimmerman & Martinez-Pons, 1990). Resource management strategies capture students’ approaches to managing and controlling other external resources available to them.

The MSLQ has been classified as an aptitude measure of self-regulated learning (Muis, Winne, & Jamieson-Noel, 2007; Zimmerman, 2008), and the instrument assesses the propensity of students to engage in self-regulated learning in a specific context. The MSLQ does not use norms, reflecting the assumption that students’ responses may vary as a function of the task, situation, course, or school context. Course specificity is provided by asking students to respond to questions regarding their learning and motivation in a specific class (Roth et al., 2016). Students report, retrospectively, how they behave in various types of situations. Consequently, students would likely be accessing long-term memory and making generalizations about what they believe they do in a particular situation (Pintrich et al., 2000).

A number of researchers have utilized the MSLQ to examine the relationship between motivation, self-regulated learning, and academic achievement at the college level (Al-Harthy, Was, & Isaacson, 2010; Kitsantas et al., 2008; Komarraju & Nadler, 2013; Lynch, 2006, 2010; Lynch & Trujillo, 2011; Vanderstoep, Pintrich, & Fagerlin, 1996; VanZile-Tamsen, 2001). Consistently, these research studies have found students’ self-efficacy scores to be the strongest predictor of course performance and academic achievement, even in cases where prior achievement was used as a control variable. Also, to varying degrees, students’ scores on specific regulatory scales of effort regulation and time and study environment management have been shown to be the next significant predictors of achievement. Research also has shown differences in self-reported use of self-regulatory strategies to be a consistent measure distinguishing students by achievement level (Effeney, Carroll, & Bahr, 2013; Nandagopal & Ericsson, 2012; Vanderstoep et al., 1996; VanZile-Tamsen & Livingston, 1999; Zimmerman & Martinez-Pons, 1990; Zusho, Pintrich, & Coppola, 2003).

Research on the MSLQ with diverse populations and in diverse situations is needed (Cho & Summers, 2012; Pintrich et al., 2000). The validity of questionnaires is influenced by participants’ ability to relate questions about strategies to their own learning experiences and analyze the strategic aspects of their learning in a conscious manner (Roth et al., 2016). Most of the research studies conducted using the MSLQ have included only a small percentage of African American students in the samples (Bembenuddy, 2007; Jakubowski & Dembo, 2004; Kitsantas et al., 2008; Komarraju & Nadler, 2013; Zusho et al., 2003), and no MSLQ studies on a population of African American students while taking STEM courses

at a historically Black college/university (HBCU) have been found. In addition, recent studies have documented psychometric problems with the MSLQ, particularly the factor structure associated with measuring self-regulated learning (Credé & Phillips, 2011; Dunn, Lo, Mulvenon, & Sutcliffe, 2012; Hilpert et al., 2013; Muis et al., 2007; Tock & Moxley, 2017). Pintrich et al. (2000), the authors of the MSLQ, acknowledged problems of lack of a stronger fit between the theoretical model and the actual empirical data, and they recommended more research on self-regulation and control instruments such as the MSLQ with more ethnically and racially diverse populations as well as students across a range of age and achievement levels (Pintrich et al., 2000; Wolters et al., 2005). Consequently, there is a need to assess the validity of the MSLQ for diverse groups in different context and environments.

### Significance of the Study

An instrument that is used as a measure of self-regulated learning should be valid and reliable for different populations and in various contexts and sensitive to differences in the ability levels of respondents. Results from measurements then can provide insights to educators to enable design and implementation of strategic self-regulatory training and focused interventions to target specific motivational beliefs and develop effective self-regulatory skills to enhance learning and academic performance of students. The current study is part of an effort to investigate self-regulated learning behaviors and their relationships to academic achievement for African American undergraduate students in STEM courses at an HBCU. There is insufficient evidence on the validity and reliability of the MSLQ for measuring self-regulated learning on this under-sampled population. The purpose of the current study is to address this need and is as follows: (a) to test factorial validity of the entire MSLQ for the study sample group and setting; (b) presented with findings of an unsatisfactory model fit, to propose and test a better-fitting factorial structure for the MSLQ based on a rigorous statistical respecification method; (c) to test measurement invariance of the respecified instrument across subgroups within the sample; and (d) to explore self-regulated learning with the respecified instrument on the sample. This work will contribute to knowledge of the generalizability of the MSLQ to minority populations and in minority undergraduate institutions and the utility of the modified instrument as a diagnostic tool in understanding learning needs of students in similar content and contexts.

### Method

#### Participants

Participants were undergraduate students ( $N = 258$ ) enrolled in STEM gatekeeping courses (chemistry, mathematics, and physics) at a mid-Atlantic Southern institution

TABLE 1  
*Demographics of Two Population Samples by Gender, Race, Academic Level, and Major*

Variables	HBCU Sample ( $N = 258$ )		PWI <sup>a</sup> Sample ( $N = 380$ )	
	<i>n</i>	%	<i>n</i>	%
<b>Gender</b>				
Female	173	67.1	99	26.3
Male	85	32.9	192	50.5
Missing			89	23.2
<b>Race</b>				
Asian	6	2.3	9	2.4
African American/Black	193	74.8	14	3.7
Hispanic	14	5.4	4	1.1
Nonresident alien	3	1.2		
Other	13	5.0	9	2.4
Two or more	10	3.9		
White	19	7.4	252	66.3
Missing			92	24.2
<b>Academic level</b>				
Freshman	68	26.4	20	5.3
Sophomore	76	29.5	38	10.0
Junior	65	25.2	90	23.7
Senior	48	18.6	133	35.0
Graduate student			7	1.8
Missing	1	0.4	92	24.2
<b>Major</b>				
Business	18	7.0		
Education	27	10.5		
Liberal arts	9	3.5		
Nursing	14	5.4		
Social/behavioral sciences	35	13.6		
STEM	147	57.0		
Undecided	8	3.1		

Note. HBCU = historically Black college/university.

<sup>a</sup>PWI, predominately White institution, refers to the sample in Pintrich, Smith, Garcia, and McKeachie (1991).

designated as an HBCU. The percentage of students enrolled in each course was chemistry, 26%; mathematics, 52%; and physics, 22%. No participant was duplicated in the sample. Demographic information on the participants in the study, hereafter referred to as “HBCU sample,” is shown in Table 1. The HBCU sample was largely female (67.1%) and African American (74.8%), with a mean age of 24 years. The academic classifications of the participants were 26.4% freshmen, 29.5% sophomores, 25.2% juniors, and 18.6% seniors. There were 147 (57%) STEM majors among the participants, distributed in the following disciplines: 83 (56%) biology, 11 (7%) chemistry, 1 (1%) computer science, 8 (5%) mathematics, 34 (23%) pharmaceutical science, and 10

(7%) physics. One hundred and eleven (43%) in the HBCU sample were non-STEM students. The specific courses in which participants were enrolled are considered gatekeeping to the extent that they are required mathematics or science courses in the plans of study in the various degree programs of the participants.

For comparison, demographic information on the validation sample from the original MSLQ study conducted at a predominately White institution (Pintrich et al., 1991, 1993) is shown in Table 1 (hereafter referred to as “PWI sample”).

### Measures

*Self-regulated learning measure.* The full 81-item MSLQ was used for this research. The MSLQ consists of two major sections: motivation (31 items) and learning strategies (50 items). The two sections are further subdivided into 15 scales (Duncan & McKeachie, 2005; Garcia & Pintrich, 1996; Pintrich et al., 1991, 1993). All items use a 7-point rating scale (1 = *not at all true of me*, to 7 = *very true of me*). The items in the original MSLQ are listed in Appendix A. The scales in the original MSLQ are listed in Appendix B. The Motivation section consists of six scales: Intrinsic Goal Orientation (INTR), Extrinsic Goal Orientation (EXTR), Task Value (TASKV), Control of Learning Beliefs (CNTRL), Self-Efficacy for Learning and Performance (SEFF), and Test Anxiety (TANX). The Learning Strategies section consists of nine scales: Rehearsal (RHRS), Elaboration (ELAB), Organization (ORGNZ), Critical Thinking (CRTHK), Metacognitive Self-Regulation (META), Time and Study Environment Management (TSTDY), Effort Regulation (EFFREG), Peer Learning (PEERLRN), and Help Seeking (HPSEEK).

*Academic performance.* Academic performance was measured by collecting end-of-course (EOC) grades for the classes used in this study. EOC letter grades for each class were converted to a 4.0 scale (A = 4.0, B = 3.0, C = 2.0, D = 1.0, and F = 0) and then standardized by z-transform to control for grading differences between different professors and different subjects. EOC letter grades of W, for withdrawal, or I, for incomplete, were reflected as missing data, leaving 233 grades for the sample. In addition to EOC grades, students' cumulative grade point averages (cGPA) were obtained from institutional records to serve as an achievement measure.

### Procedure

Professors teaching STEM gatekeeping courses were asked to allow students in their classes to participate in the MSLQ survey. Agreement was obtained from 10 professors across 18 sections of classes in subject areas chemistry, mathematics, and physics. The full version of the MSLQ survey (Pintrich et al., 1991) was administered to the selected classes before midterm in fall semester 2014. Three graduate

students served as proctors to collect signed consent forms and administer the survey in class sections. As an incentive for participation in the survey, the proctors raffled off three \$25 MasterCard/VISA gifts cards in each class after completion of the survey. The full MSLQ survey was administered during regular class times for each of the mathematics classes and during the associated laboratory session times for each of the chemistry and physics classes that participated. The MSLQ survey took about 20 minutes, and students were instructed to respond to survey items reflecting on the course in which they were enrolled. The response rate was approximately 65% of 488, for a total of 316 completing the survey. Fifty-eight cases had various missing item data and were removed. The final sample size was 258 with no missing MSLQ item data.

The MSLQ survey data for the HBCU sample were collected from classes in subject areas chemistry, mathematics, and physics. Five sections were General Chemistry I. Nine mathematics sections were College Algebra and Trigonometry I (six), precalculus (one), and calculus (two). Four physics sections were algebra-based General Physics I and calculus-based General Physics for Scientist and Engineers I (one). The distribution for participants across these class sections was: 44 (17%) Calculus, 81 (31%) College Algebra and Trigonometry I, 66 (26%) General Chemistry I, 43 (17%) General Physics I, 14 (5%) General Physics for Scientists and Engineers I, and 10 (4%) Precalculus.

For comparison, the PWI Sample (Pintrich et al., 1991) was from 37 classrooms spanning five disciplinary subject areas: business (9, 2%), education (25, 7%), humanities (106, 28%), social/behavioral science (153, 40%), and STEM (87, 23%).

### Analysis

The factor validity of the MSLQ to measure the posited motivational and self-regulated learning constructs will be determined by rigorous statistical analysis on the model for the HBCU sample. Other factor-analytic studies on the MSLQ typically test the motivation and learning strategies sections separately and only to first-order factor levels (Cho & Summers, 2012; Pintrich et al., 1993; Smith & Chen, 2017). The present study will test the conceptualized third-order factor structure of the full 81-item MSLQ. The observed structural properties of the MSLQ for the sample will then provide indicators to serve as a baseline for model respecification. Subject to finding and verifying a valid and reliable respecified measure, relationships between self-regulated learning and academic performance will be explored.

Confirmatory factor analysis (CFA) was conducted on the factor structure of the MSLQ to investigate the psychometric properties. Factor structure refers to the relationships between the observed variables (i.e., measured items) and the underlying latent, unobserved factor (the construct being

estimated). CFA can provide a check of construct validity for the expected factor structure for participants in a study (Meyers, Gamst, & Guarino, 2013).

CFAs were conducted using IBM SPSS Amos 23 (Arbuckle, 2014; IBM SPSS Amos 23, 2014). Parameter estimates were generated using maximum likelihood and tests of goodness of fit. Hu and Bentler (1998) recommend always reporting standardized root mean square residual (SRMR)—an absolute fit index—and one relative fit index between the models and the data. Meyers et al. (2013) recommend reporting five fit measures—three absolute fit indices and two relative fit indices. The values of chi-square divided by degrees of freedom ( $\chi^2/df$ ), the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), and the SRMR were reported for the initial analysis for comparison purposes with the original MSLQ validation study of the developers (Pintrich et al., 1993). However, Hu and Bentler (1998) do not recommend using GFI and AGFI as absolute fit indices because they are not sensitive to model misspecification. Therefore, root mean square error of approximation (RMSEA) and Comparative Fit Index (CFI) were used in the remaining analyses as additional indices of absolute fit and relative fit, respectively. For the absolute fit indices, the recommended cutoff values for good model fit are as follows:  $\chi^2/df < 2.0$ , GFI/AGFI  $> .9$ , SRMR  $< .05$ , and RMSEA  $< .08$ . For the relative fit measure, CFI  $> .95$  indicates a good model fit, but above  $.9$  is acceptable. A marginal fit is considered for CFI values between  $.8$  and  $.89$ , and a poor fit is considered for CFI values less than  $.8$  (Meyers et al., 2013).

CFA was also used in subsequent model respecification procedures. Additional fit measures for making comparisons between different models are: Akaike Information Criterion (AIC), Browne-Cudeck Criterion (BCC), Bayesian Information Criterion (BIC), and expected cross-validation index (ECVI). The model with the smallest values for these parameters is considered the better one (Meyers et al., 2013). The sample size of 258 was not large enough to allow for a randomly split CFA test-validation pair of data sets (Guadagnoli & Velicer, 1988); therefore, no replication analysis was conducted for this study.

Measurement invariance testing of the respecified MSLQ was conducted by multiple group CFA, using IBM SPSS Amos 23, to determine whether parameters of the measurement model and/or the structural model are equivalent (i.e., invariant) across two or more groups within the sample. Invariance testing of the measurement model indicates whether the items used for the instrument have the same meaning to respondents from the different groups in the sample. If invariance cannot be established, it would be difficult to determine if the differences observed are due to true differences or different psychometric responses to the items (Chen, Sousa, & West, 2005; Cheung & Rensvold, 2002). The chi-square difference statistic,  $\Delta\chi^2$ , and the Comparative

Fit Index difference,  $\Delta CFI$ , are used as indicators in invariance testing. The value of  $\Delta\chi^2$  represents the difference statistic between two  $\chi^2$  models fitted to data from each in a given group. If  $\Delta\chi^2$  is not statistically significant, then evidence of invariance for that model is claimed, meaning it was as good a fit for data from each within the group (Byrne, 2016; Meyers et al., 2013). Byrne (2016) suggests also that invariance decisions be based on the CFI difference, and if  $\Delta CFI < .01$ , then evidence of invariance of the groups to the model is claimed.

Descriptive statistics, internal consistency estimates of reliability, were calculated for the respecified MSLQ scales for the HBCU sample. Scale variables were constructed by taking the mean value of the items that make up that scale. Bivariate correlations were calculated for the respecified MSLQ scales and EOC grade for the HBCU sample. From the full HBCU sample, high- and low-achieving students were grouped for further analysis. The achievement measure was cGPA. The high achievement (HA) group was formed by assigning students whose cGPA was at or above the 75th percentile ( $M + .675 \times SD$ ), and the low achievement (LA) group was students whose cGPA was at or below the 25th percentile ( $M - .675 \times SD$ ) for the sample. A multivariate analysis of variance (MANOVA) was conducted to determine if the MSLQ would discriminate on students' achievement level to gauge instrument utility as an academic diagnostic tool.

## Results

### *Model Comparisons*

Two CFAs were conducted separately on the motivation and learning strategies sections of the MSLQ in a fashion similar to that done by Pintrich and his colleagues (Garcia & Pintrich, 1996; Pintrich et al., 1993). The first maximum likelihood estimation was carried out on the 31 motivation items to see how well a correlated six-factor model for that section fitted the data. The second maximum likelihood estimation was carried out on the 50 learning strategies items to see how well a correlated nine-factor model for that section fitted the data. The model fit indices for each MSLQ section to the HBCU sample data are shown in Table 2. Both the motivation section and learning strategies section models of the MSLQ fail to fit the HBCU sample data. Based on current standards, the fit indices reported by Pintrich et al. (1991) for the two MSLQ sections to the PWI data also indicate a poor fit (see Table 2).

### *Respecification of MSLQ*

A third-order factor model for the full 81-item MSLQ was configured in SPSS AMOS. The model is illustrated in Figure C1 (Appendix C). The original names of the MSLQ scales were retained as first-order factors (see Appendix B). The first group of second-order factors were Value, Expectancy,

TABLE 2

CFA Fit Statistics for Two-Section MSLQ Model on HBCU Sample and PWI Sample

Model	$\chi^2$	<i>df</i>	$\chi^2/df$	GFI	AGFI	SRMR	CFI	RMSEA
HBCU sample ( <i>N</i> = 258)								
Motivation section	946.96***	419	2.26	.79	.75	.08	.86	.07
Learning strategies section	2,436.27***	1,139	2.14	.70	.66	.09	.74	.07
PWI sample ( <i>N</i> = 380)								
Motivation section			3.49	.77	.73	.07		
Learning strategies section			2.26	.78	.75	.08		

Note. CFA = confirmatory factor analysis; MSLQ = Motivated Strategies for Learning Questionnaire; HBCU = historically Black college/university; PWI = predominantly White institution; GFI = Goodness of Fit Index; AGFI = Adjusted Goodness of Fit Index; SRMR = standardized root mean square residual; CFI = Comparative Fit Index; RMSEA = root mean square error of approximation.

\*\*\**p* < .001.

and Affect. These constituted proposed third-order factor, *Motivation*. The remaining group of second-order factors were Cognitive, Metacognitive, and Resource Management. These constituted proposed third-order factor, *Learning Strategies*. Correlation between *Motivation* and *Learning Strategies* variables was allowed in the model. As shown in Table 3, the third-order factor model of the MSLQ was a very poor fit for the HBCU Sample:  $\chi^2/df = 1.94$ , SRMR = .10, CFI = .69, and RMSEA = .06.

Having unsatisfactory model fit results, CFA procedures were used to respecify the factorial structure to better account for the observed data (Floyd & Widaman, 1995). First, any scale that loaded on second-order factors at <.5 was removed. Consequently, the following scales were removed: Extrinsic Goal Orientation, Test Anxiety, Peer Learning, and Help Seeking. Second, any item that loaded on first-order factors at <.5 was removed. In the end, there were 48 items across 11 scales that remained after respecification, and a third-order factor structure was retained. As shown in Table 3, the fit indices for respecified MSLQ model, labeled MSLQ-R, were:  $\chi^2/df = 1.88$ , SRMR = .07, CFI = .84, and RMSEA = .06. Except for SRMR, these indices support an adequate but marginal fit (Meyers et al., 2013). In addition, the model comparison fit measures, AIC, BCC, BIC, and ECVI, are all three times smaller for MSLQ-R compared to MSLQ, indicating a substantially improved fit to data.

*Invariance across groups.* Invariance testing was conducted on the MSLQ-R across distinct groups within the HBCU sample following the procedure from Chen et al. (2005). The analysis used IBM SPSS Amos 23 to evaluate the difference between an unconstrained model, which assumes that the groups are yielding different values of the parameters when the model is applied to the data; and a constrained model, which assumes that the groups are yielding equivalent values of the parameters when the model is applied to the data. The series of tests for multigroup invariance examined six increasingly restrictive hierarchical CFA

models. Model 1 was baseline, tested across a group by multigroup CFA and in which simultaneously fit indices for each member were estimated at the same time. The fit to Model 1 served as the baseline or configural model for the groups being considered and had no constraints imposed on any parameter. Therefore, the configural model presented the same structure to each group before deriving fit results to which all other models were compared. Model 2 constrains all factor loadings to be equal across groups. Testing invariance of factor loadings across groups evaluates  $\Delta\chi^2$  and  $\Delta CFI$  generated for the differences between Model 2 and Model 1. Models 3 through 6 apply additional constraints of equality, in hierarchical order, on factor variances (Model 3), factor covariances (Model 4), factor errors (Model 5), and item errors (Model 6). Invariance testing for each of these increasingly more stringent, nested models evaluates the associated  $\Delta\chi^2$  and  $\Delta CFI$  generated on the current and preceding model.

Tests for multigroup invariance were run separately on groups identified by major (STEM = 147, not STEM = 111), gender (female = 173, male = 85), classification (freshman/sophomore = 144, junior/senior = 114), and course-taking (mathematics = 135, science = 123). The MSLQ-R was found to be invariant across major, gender, classification, and course-taking for CFA Models 1 through 5 with all values of  $\Delta\chi^2$  nonsignificant and all values of  $\Delta CFI < .01$ . Table 4 shows fit indices for groups identified by major and is illustrative of the fit outputs for each of the other groups identified within the HBCU sample. For Model 6, the most stringent constraints, even though  $\Delta\chi^2$  was statistically significant at *p* < .05 level for all groups, the values of  $\Delta CFI < .01$  for all groups. Therefore, only at the level of item errors (Model 6) is the MSLQ-R only slightly noninvariant for all groups.

*MSLQ-R subscales and latent factors.* The 11 scales (48 items) of the MSLQ-R are listed in Appendix B. Correlation between the second-order factors, Motivation-R and Learning Strategies-R, is .59. The Motivation factor

TABLE 3

CFA Fit Statistics for Full MSLQ and (Respecified) MSLQ-R Models on HBCU Sample

Model	$\chi^2$	<i>df</i>	$\chi^2/df$	SRMR	CFI	RMSEA	AIC	BCC	BIC	ECVI
HBCU sample ( <i>N</i> = 258)										
MSLQ	6,100.00***	3,139	1.94	.10	.69	.06 <sup>a</sup>	6,464.01	6,634.57	7,110.65	25.15
MSLQ-R	1,998.02***	1,064	1.88	.07	.84	.06 <sup>b</sup>	2,222.02	2,274.78	2,619.95	8.65

Note. CFA = confirmatory factor analysis; MSLQ = Motivated Strategies for Learning Questionnaire; HBCU = historically Black college/university;  $\chi^2$  = chi-square statistic; *df* = degrees of freedom; CFI = Comparative Fit Index; SRMR = standardized root mean residual; RMSEA = root mean square error of approximation; AIC = Akaike Information Criterion; BCC = Browne-Cudeck Criterion; BIC = Bayesian Information Criterion; ECVI = expected cross-validation index; CI = confidence interval; MSLQ-R = MSLQ-R = respecified Motivated Strategies for Learning Questionnaire.

<sup>a</sup>RMSEA: .063 CI [.058, .063].

<sup>b</sup>RMSEA: .058 CI [.054, .062].

\*\*\**p* < .001.

TABLE 4

Goodness-of-Fit Statistics for Tests of MSLQ-R Multigroup Invariance: STEM/Non-STEM Major

Model Description	$\chi^2$	<i>df</i>	CFI	SRMR	RMSEA	RMSEA 90% CI	Model Comparison	$\Delta\chi^2$	$\Delta df$	<i>p</i>	$\Delta CFI$
Model 1: Configural (no constraints)	3,651.477	2,134	0.768	.078	.053	.050, .056					
Model 2: Constrain factor loadings	3,687.779	2,171	0.768	.079	.052	.049, .055	2 vs. 1	37	36.302	0.502	.000
Model 3: Constrain factor loadings + factor variances	3,700.192	2,180	0.767	.079	.052	.049, .055	3 vs. 2	46	48.716	0.364	.001
Model 4: Constrain factor loadings + factor variances + factor covariances	3,700.654	2,183	0.768	.077	.052	.049, .055	4 vs. 3	49	49.177	0.466	-.001
Model 5: Constrain factor loading + factor variances + factor covariances + factor errors	3,714.881	2,194	0.767	.080	.052	.049, .055	5 vs. 4	60	63.404	0.357	.001
Model 6: Constrain factor loading + factor variance + factor covariances + factor errors + item errors	3,795.969	2,242	0.762	.084	.052	.049, .055	6 vs. 5	108	144.492	0.011	.005

Note. Four groups within the HBCU sample were identified by: major (STEM = 147, not STEM = 111), gender (female = 173, male = 85), classification (freshman/sophomore = 144, junior/senior = 114), and course-taking (mathematics = 135, science = 123). Group invariance results shown in this table are for major (STEM, not STEM). MSLQ-R = MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; CFI = Comparative Fit Index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; CI = confidence interval.

consists of Value-R (intrinsic goal orientation [4], Task Value-R [5]) and Expectancy (control of learning beliefs [4], self-efficacy for learning and performance [8]). The Learning Strategies factor consists of Cognitive-R and Resource Management-R scales. Cognitive-R factor consists of rehearsal (4), elaboration-R (5), organization-R (2), critical thinking-R (4), and metacognitive self-regulation-R (8). Resource Management-R factor consists of time and study environment-R (4) and effort regulation-R (2). Note that there were three scales on MSLQ-R that remained identical to the scales of the original MSLQ. Also, organization-R and effort regulation-R scales are specified by only two items each, and they did not cause negative error variances (Heywood cases) on MSLQ-R.

The standardized and unstandardized coefficients for the MSLQ-R are shown in Table 5. The beta weight for self-efficacy for learning and performance at .67 is the lowest in the Expectancy-R factor. The beta weight for Critical Thinking-R at .71 is the lowest in the Strategy Use-R factor. The remaining beta weights are strong. Correlations between latent variables on the MSLQ-R and EOC grades are shown in Table 6. Notable is the Strategy Use-R factor does not correlate with EOC grade.

Scale statistics and reliability coefficients for MSLQ-R are shown in Table 7. Scale reliabilities associated with MSLQ-R, range from acceptable to excellent values. The reliabilities for the four latent variables of the MSLQ-R are also included in Table 7. The reliabilities of latent

TABLE 5  
Standardized and Unstandardized Coefficients for CFA Respecified MSLQ-R

Observed Variable	Latent Variable	$\beta$	$B$	$SE$
TASKV-R (task value-R)	Value-R	.90	1.00	
INTR (intrinsic goal orientation)	Value-R	.98	1.35	.15
SEFF (self-efficacy for learning and performance)	Expectancy	.67	1.00	
CNTRL (control of learning beliefs)	Expectancy	.98	2.30	.34
ELAB-R (elaboration-R)	Strategy use-R	.84	1.00	
META-R (metacognitive self-regulation-R)	Strategy use-R	.99	1.15	.16
CRTHK-R (critical thinking-R)	Strategy use-R	.71	.95	.14
ORGNZ-R (organization-R)	Strategy Use-R	.95	.93	.14
RHRSL (rehearsal)	Strategy use-R	.87	.92	.14
TSTDY-R (time and study environment-R)	Resource management-R	.95	1.00	
EFFREG-R (effort regulation-R)	Resource management-R	.99	1.11	.12

Note. CFA = confirmatory factor analysis; MSLQ-R = respecified Motivated Strategies for Learning Questionnaire.

TABLE 6  
Bivariate Correlations Between MSLQ-R Latent Variables and EOC Grades

Subscale	EOC Grade	Value-R	Expectancy	Strategy Use-R
EOC grade	—			
Value-R	.20	—		
Expectancy	.33	.69	—	
Strategy use-R	.09	.51	.31	—
Resource management-R	.23	.45	.30	.68

Note. All values are statistically significant at  $p < .001$ .  $N = 233$ . MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; EOC = end-of-course.

factors Strategy Use-R and Resource Management-R are .88 and .79, respectively, and these are much improved over both of their composite scales. The reliabilities of latent factors Value-R and Expectancy-R are not improved over their composite scales. The reliability for Expectancy-R is worse than its composite subscales control of learning beliefs and self-efficacy for learning and performance. These two subscales are exactly the same as on the original MSLQ and have been shown to be good-performing individually. Therefore, issues remain with Expectancy-R as a latent construct.

Correlations between EOC grades and MSLQ-R scales are shown in Table 8. Scales that reflect self-regulation behaviors include Task Value-R, Self-Efficacy for Learning and Performance, Time and Study Environment-R, and Effort Regulation-R and these have the highest correlations with EOC grade. In addition, Elaboration-R, Organization-R are significantly correlated with EOC grades. Surprisingly, Metacognitive-R is not correlated with EOC grades. A hierarchical regression analysis was conducted to identify combinations of MSLQ-R variables that predict EOC grades while controlling for cumulative GPA of students in HBCU Sample. Only Self-Efficacy for Learning and Performance remained

as a predictor of EOC grade when controlling for cGPA and accounts for 4% of variance in EOC grades,  $\Delta R^2_{adj} = .04$ ,  $\Delta F(1, 2310) = 23.80$ ,  $p < .001$ .

*Multivariate analysis of variance.* The mean cGPA for entire HBCU Sample ( $N = 258$ ) was  $M = 2.79$ ,  $SD = .74$ . Group comparisons were made between 65 HA students ( $M = 3.71$ ,  $SD = .23$ ) and 55 LA students ( $M = 1.78$ ,  $SD = .56$ ) from the study sample. With cGPA as a covariate, the multivariate main effect was significant by achievement levels, Wilks'  $\lambda = .69$ ,  $F(11, 108) = 4.41$ ,  $p < .001$ , partial  $\eta^2 = .31$ , and observed power = 1.00. This is strong indication that some MSLQ-R scales can discriminate between high and low achievement levels. A summary of univariate ANOVAs is given in Table 9, and the MSLQ-R scale means and standard deviations by achievement level are given in Table 10. Seven MSLQ-R scales show significant differences between achievement groups with the high-achieving group presenting higher mean scores on all of these scales. The Self-Efficacy for Learning and Performance scale has the largest discriminating effect,  $F(1, 118) = 25.70$ ,  $p < .001$ , partial  $\eta^2 = .18$ . The scales with the next largest discriminating effect are: Effort Regulation-R,  $F(1, 118) = 9.90$ ,  $p < .01$ , partial  $\eta^2 = .08$ ; and Time and Study



TABLE 7

Scale Means, Standard Deviations, and Reliabilities for MSLQ-R on HBCU Sample.

Scale	N Items	HBCU Sample			PWI Sample <sup>a</sup>
		Mean	SD	Cronbach's $\alpha$	Cronbach's $\alpha$
Motivation-R					
Value-R		4.57	1.18	.78	
INTR	4	4.60	1.08	.67	.74
TASKV-R	5	4.55	1.50	.88	.90
Expectancy		4.98	1.04	.67	
CNTRL	4	5.19	1.16	.73	.68
SEFF	8	4.76	1.24	.92	.93
Learning Strategies-R					
Cognitive-R		4.53	1.00	.88	
RHRSL	4	4.54	1.25	.70	.69
ELAB-R	5	4.51	1.30	.80	.76
ORGNZ-R	2	5.00	1.39	.61	.64
CRTHK-R	4	3.84	1.33	.80	.80
META-R	6	4.75	1.00	.77	.79
Resource management-R		4.94	1.18	.79	
TSTDY-R	4	4.79	1.27	.75	.76
EFFREG-R	2	5.08	1.33	.66	.69

Note. MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; HBCU = historically Black college/university; PWI = predominantly White institution; INTR = intrinsic goal; TASKV = task value; CNTRL = control of learning beliefs; SEFF = self-efficacy of learning and performance; RHRSL = rehearsal; ELAB = elaboration; ORGNZ = organization; CRTHK = critical thinking; META = metacognitive self-regulation; TSTDY = time and study environment management; EFFREG = effort regulation.

<sup>a</sup>From Pintrich, Smith, Garcia, and McKeachie (1991).

TABLE 8.

Bivariate Correlations Between MSLQ-R Subscales and End-of-Course Grades for HBCU Sample.

Subscale	1	2	3	4	5	6	7	8	9	10	11	12
1 INTR	—											
2 TASKV-R	.67*	—										
3 CNTRL	.39*	.42*	—									
4 SEFF	.64*	.71*	.51*	—								
5 RHRSL	.37*	.35*	.19*	.29*	—							
6 ELAB-R	.46*	.29*	.11	.36*	.50*	—						
7 ORGNZ-R	.38*	.34*	.16*	.28*	.59*	.52*	—					
8 CRTHK-R	.47*	.26*	.03	.25*	.44*	.65*	.36*	—				
9 META-R	.43*	.37*	.15**	.35*	.61*	.63*	.63*	.60*	—			
10 TSTDY-R	.33*	.36*	.08	.32*	.46*	.49*	.56*	.37*	.63*	—		
11 EFFREG-R	.36*	.42*	.14**	.38*	.50*	.49*	.53*	.35*	.61*	.67*	—	
12 End-of-course grade	.10	.24*	.16**	.40*	.03	.14**	.15**	-.04	.06	.18*	.24*	—

Note. MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; HBCU = historically Black college/university; INTR = intrinsic goal; TASKV = task value; CNTRL = control of learning beliefs; SEFF = self-efficacy of learning and performance; RHRSL = rehearsal; ELAB = elaboration; ORGNZ = organization; CRTHK = critical thinking; META = metacognitive self-regulation; TSTDY = time and study environment management; EFFREG = effort regulation.

\* $p < .05$ . \*\* $p < .01$ .

Environment Management,  $F(1, 118) = 8.36, p < .01$ , partial  $\eta^2 = .07$ . Other research studies have also shown the self-efficacy scale to reveal the largest differences in scores by achievement level (Vanderstoep et al., 1996; VanZile-Tamsen

& Livingston, 1999; Zusho et al., 2003). The effort regulation and time and study environment management variables additionally yield significant observable differences by achievement level in the current study.

TABLE 9  
*Summary of Univariate ANOVAs for Achievement Groups on MSLQ-R*

	Subscale	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Significance	Partial Eta Squared	Observed Power
Regression	TASKV-R	8.73	1	8.73	3.91	.05	.03	.50
	CNTRL	7.65	1	7.65	5.45	.02	.04	.64
	SEFF	34.58	1	34.58	25.70	.00	.18	1.00
	ELAB-R	7.29	1	7.29	5.29	.02	.04	.63
	ORGNZ-R	12.06	1	12.06	7.65	.01	.06	.78
	TSTDY-R	12.26	1	12.26	8.36	.01	.07	.82
	EFFREG-R	15.87	1	15.87	9.90	.00	.08	.88
Residual	TASKV-R	263.79	118	2.24				
	CNTRL	165.76	118	1.41				
	SEFF	158.78	118	1.35				
	ELAB-R	162.49	118	1.38				
	ORGNZ-R	186.03	118	1.58				
	TSTDY-R	173.20	118	1.47				
	EFFREG-R	189.10	118	1.60				
Total	TASKV-R	2,959.16	120					
	CNTRL	3,525.69	120					
	SEFF	3,131.19	120					
	ELAB-R	2,764.48	120					
	ORGNZ-R	3,370.50	120					

*Note.* MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; TASKV = task value; CNTRL = control of learning beliefs; SEFF = self-efficacy of learning and performance; ELAB = elaboration; ORGNZ = organization; TSTDY = time and study environment; EFFREG = effort regulation.

TABLE 10  
*Group Means and Standard Deviations of MSLQ-R Subscale Scores by Achievement Level for HBCU Sample*

Subscale	Achievement Level			
	High Achieving		Low Achieving	
	Mean	<i>SD</i>	Mean	<i>SD</i>
TASKV-R	5.00	1.39	4.41	1.61
CNTRL	5.55	1.08	4.98	1.28
SEFF	5.49	1.00	4.31	1.27
ELAB-R	4.82	1.21	4.45	1.16
ORGNZ-R	5.44	1.20	4.79	1.32
TSTDY-R	5.14	1.21	4.60	1.24
EFFREG-R	5.52	1.16	4.79	1.38

*Note.* MSLQ-R = respecified Motivated Strategies for Learning Questionnaire; HBCU = historically Black college/university; TASKV = task value; CNTRL = control of learning beliefs; SEFF = self-efficacy of learning and performance; ELAB = elaboration; ORGNZ = organization; TSTDY = time and study environment; EFFREG = effort regulation.

### Discussion

Evidence regarding the reliability and validity of the MSLQ for diverse ethnic groups has not been readily available. The

current study tested the validity of MSLQ on a sample of college students that was 75% African American who were taking STEM courses at an HBCU. The MSLQ did not fit the sample data; therefore, this work provides additional evidence of psychometric problems with the MSLQ for diverse populations. Unlike previous factor-analytic studies that separately analyzed the Motivation and Learning Strategies sections of the MSLQ, this study analyzed the MSLQ as a third-order factor model inclusive of the entire 81 items and 15 scales and presents a revised instrument that may be a more sensitive measure of self-regulated learning behaviors of the population in the study. A stringent model respecification procedure, including a cutoff for variables loading  $<.5$ , subsequently guided removal of some first-order factors, specifically Extrinsic Goal Orientation, Test Anxiety, Peer Learning, and Help Seeking scales. Removal of these specific scales is consistent with several other studies that consistently reported them as not performing well (Credé & Phillips, 2011; Hilpert et al., 2013). Further systematic analysis, including a cutoff for survey items loading  $<.5$ , identified removal of survey items on several scales, including Metacognitive Self-Regulation, Effort Regulation, and Time and Study Environment Management scales. The resulting respecified measure, MSLQ-R, consisted of 48 of the original 81 items that were structured in 11 scales, five second-order factors, and two

third-order factors while retaining close resemblance to the scale terminology defined by Pintrich and colleagues (1993). An acceptable model fit to the HBCU sample data was achieved for the MSLQ-R as determined by current guidelines for comparison indices in factor analysis. Several subgroups within the HBCU sample that were identified had independent group associations by major, gender, undergraduate classification, and STEM course type. Model invariance testing was carried out, and baseline tests revealed that the same meaning for the MSLQ-R was attributed by each group. Results from more stringent hierarchical tests of measurement invariance showed equivalence of the MSLQ-R across all comparison groups on (a) number of factors in the model, (b) factor loading, (c) item and factor variances and covariances, and (d) factor errors.

Results supported a third-order factor structure for the MSLQ-R (see Appendix C, Figure C1). There were mixed results regarding the four second-order latent constructs of the MSLQ-R (see Table 5). The Value and Resource Management constructs had excellent associations with each of their underlying factors, however the Expectancy construct did not. The Control of Learning Beliefs scale and Self-Efficacy for Learning and Performance scale were both unchanged from the original MSLQ and they comprise the Expectancy construct. Although the association of learning beliefs variable with Expectancy was excellent, there was a poor association of self-efficacy variable with Expectancy. This was unexpected because self-efficacy had the highest reliability and was the strongest predictor of student academic performance. Also, the reliability for Expectancy was more than 8% less than the lowest of the two subscales that comprised this construct (see Table 7). The conclusion is that the self-efficacy and learning beliefs variables, as defined by MSLQ, do not combine well to indicate an expectancy latent construct. There may be a non-unidimensional problem with the 8-item Self-Efficacy for Learning and Performance scale of MSLQ.

For the first-order factors, the reliability coefficients for all 11 of the MSLQ-R scales were at or above acceptable levels (Table 7). Reliability coefficients were excellent for Task Value-R and Self-Efficacy for Learning and Performance scales. Results of MSLQ-R scale correlations with EOC grade (see Table 8) show self-efficacy, task value, effort regulation, and time and study environment management variables as the highest correlates with EOC grades. These findings are consistent with other studies that report one or more of these four motivation and behavioral variables as the highest correlates with EOC grades (Al-Harthy et al., 2010; Credé & Phillips, 2011; Kitsantas et al., 2008; Komaraju & Nadler, 2013; Lynch, 2006; Zusho et al., 2003). For the cognitive strategy use variables, only organization was significantly correlated with EOC grade for the HBCU sample. However, neither metacognitive self-regulated learning nor any of the other cognitive strategy use variables correlated significantly with EOC grade. End-of-course grade may not be a suitable outcome measure for

cognitive and metacognitive learning strategies because EOC grades are aggregates of several disparate elements such as homework, lab work, reports, quizzes, and exams, and some or none of the learning strategies as defined by the MSLQ may be effective for each of these tasks.

The respecified MSLQ (MSLQ-R), with 11 scales, appears to be valid and reliable for the HBCU sample. The MSLQ-R appears to be valid and reliable for three latent constructs denoted as: Value-R, Cognitive-R, and Resource Management-R. Two respecified scales, Time and Study Environment-R and Effort Regulation-R describe self-regulation behaviors, comprise latent construct Resource Management-R therefore, Academic Self-Regulation would be a more suitable name for this latent construct.

The current study also examined differences in self-regulated learning propensities by achievement level of students. Large effect differences by achievement levels were observed when measured by MSLQ-R for a motivation variable (self-efficacy) and two self-regulation variables (time and study environment management and effort regulation). Therefore, these scales of the MSLQ-R can distinguish between high- and low-achieving students, as similarly found in other studies (Vanderstoep et al., 1996; VanZile-Tamsen & Livingston, 1999; Zusho et al., 2003). This capacity for differential measurement by academic achievement level is useful for research and practice as a potential diagnostic to target areas of need and to develop and test suitable self-regulated learning interventions.

#### *Limitations of the Study*

In the current study, factor structure of the MSLQ was assessed through confirmatory factor analysis. A better model fit to the HBCU sample data was achieved through respecification of the MSLQ, carried out in a systematic way using CFA exploratory techniques, and the results are repeatable and reproducible. However, this procedure may have limited the possibility of finding loadings for new and different factors more compatible with the population, context, and content associated with the study. The sample size precluded the option of conducting a split-sample exploratory factor analysis and follow-on independent sample CFA. Consequently, there was no testing on an independent sample to assess the stability of the respecified MSLQ.

#### **Conclusion**

Improving the rate of success for students in STEM gatekeeper courses logically should lead to their persistence in the STEM major and ultimately their degree completion. The academic performance and achievement outcomes that are possible through self-regulated learning resonates with educators and researchers who are committed to producing more under-represented minorities with STEM degrees. In the current study, testing and adapting a widely used instrument on an

under-sampled population revealed some different and similar findings compared to the body of literature on self-regulated learning at the college level. For example, student's self-efficacy for learning and performance in the course was the only predictor of EOC grade when controlling for cGPA, however no self-regulated learning variables correlated significantly with EOC grade.

Although the static, self-report instrument used in this study does not capture the dynamic self-regulated learning behaviors idealized in the literature (Chemers et al., 2001; Schraw et al., 2006), the power of the instrument is evident in group difference measurements. A snapshot of the self-regulated learning pattern captured on high-achieving students tended toward higher self-efficacy for learning and performing tasks, control of learning beliefs, and task value; and higher regulation of effort, organization, and management of time and study environment (see Table 10). In contrast, perhaps students in the low achieving group, not exhibiting this pattern, come into the course already convinced or conclude later, after failure on an assignment, that they are not effective at STEM learning. If students do not believe that their efforts will lead to success on STEM tasks, then they do not become self-efficacious about their learning strategies. Consequently, these students break from their goals and put their efforts into "just getting through" the task or the class. According to Kaplan (2008), students in this disengagement mode do not adopt learning as their main purpose of engagement and exhibit more "self-regulated achievement" than "self-regulated learning behavior."

## Appendix A

### *Motivated Strategies for Learning Questionnaire (MSLQ)*

#### Part I. Motivation

1. In a class like this, I prefer course material that really challenges me so I can learn new things.
2. If I study in appropriate ways, then I will be able to learn the material in this course.
3. When I take a test I think about how poorly I am doing compared with other students.
4. I think I will be able to use what I learn in this course in other courses.
5. I believe I will receive an excellent grade in this class.
6. I'm certain I can understand the most difficult material presented in the readings for this course.
7. Getting a good grade in this class is the most satisfying thing for me right now.
8. When I take a test I think about items on other parts of the test I can't answer.
9. It is my own fault if I don't learn the material in this course.
10. It is important for me to learn the course material in this class.
11. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.
12. I'm confident I can learn the basic concepts taught in this course.
13. If I can, I want to get better grades in this class than most of the other students.
14. When I take tests I think of the consequences of failing.
15. I'm confident I can understand the most complex material presented by the instructor in this course.
16. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.
17. I am very interested in the content area of this course.
18. If I try hard enough, then I will understand the course material.
19. I have an uneasy, upset feeling when I take an exam.
20. I'm confident I can do an excellent job on the assignments and tests in this course.
21. I expect to do well in this class.
22. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.
23. I think the course material in this class is useful for me to learn.
24. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.
25. If I don't understand the course material, it is because I didn't try hard enough.
26. I like the subject matter of this course.
27. Understanding the subject matter of this course is very important to me.
28. I feel my heart beating fast when I take an exam.
29. I'm certain I can master the skills being taught in this class.
30. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.
31. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.

#### Part II. Learning Strategies

32. When I study the readings for this course, I outline the material to help me organize my thoughts.
33. During class time I often miss important points because I'm thinking of other things.
34. When studying for this course, I often try to explain the material to a classmate or friend.
35. I usually study in a place where I can concentrate on my course work.
36. When reading for this course, I make up questions to help focus my reading.

37. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.
38. I often find myself questioning things I hear or read in this course to decide if I find them convincing.
39. When I study for this class, I practice saying the material to myself over and over.
40. Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.
41. When I become confused about something I'm reading for this class, I go back and try to figure it out.
42. When I study for this course, I go through the readings and my class notes and try to find the most important ideas.
43. I make good use of my study time for this course.
44. If course readings are difficult to understand, I change the way I read the material.
45. I try to work with other students from this class to complete the course assignments.
46. When studying for this course, I read my class notes and the course readings over and over again.
47. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.
48. I work hard to do well in this class even if I don't like what we are doing.
49. I make simple charts, diagrams, or tables to help me organize course material.
50. When studying for this course, I often set aside time to discuss course material with a group of students from the class.
51. I treat the course material as a starting point and try to develop my own ideas about it.
52. I find it hard to stick to a study schedule.
53. When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.
54. Before I study new course material thoroughly, I often skim it to see how it is organized.
55. I ask myself questions to make sure I understand the material I have been studying in this class.
56. I try to change the way I study in order to fit the course requirements and the instructor's teaching style.
57. I often find that I have been reading for this class but don't know what it was all about.
58. I ask the instructor to clarify concepts I don't understand well.
59. I memorize key words to remind me of important concepts in this class.
60. When course work is difficult, I either give up or only study the easy parts.
61. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.
62. I try to relate ideas in this subject to those in other courses whenever possible.
63. When I study for this course, I go over my class notes and make an outline of important concepts.
64. When reading for this class, I try to relate the material to what I already know.
65. I have a regular place set aside for studying.
66. I try to play around with ideas of my own related to what I am learning in this course.
67. When I study for this course, I write brief summaries of the main ideas from the readings and my class notes.
68. When I can't understand the material in this course, I ask another student in this class for help.
69. I try to understand the material in this class by making connections between the readings and the concepts from the lectures.
70. I make sure that I keep up with the weekly readings and assignments for this course.
71. Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.
72. I make lists of important items for this course and memorize the lists.
73. I attend this class regularly.
74. Even when course materials are dull and uninteresting, I manage to keep working until I finish.
75. I try to identify students in this class whom I can ask for help if necessary.
76. When studying for this course I try to determine which concepts I don't understand well.
77. I often find that I don't spend very much time on this course because of other activities.
78. When I study for this class, I set goals for myself in order to direct my activities in each study period.
79. If I get confused taking notes in class, I make sure I sort it out afterwards.
80. I rarely find time to review my notes or readings before an exam.
81. I try to apply ideas from course readings in other class activities such as lecture and discussion.

## Appendix B

Motivated Strategies for Learning Questionnaire (MSLQ) Scales and (Respecified) MSLQ-R Scales

Scale	Subscale	Acronym	MSLQ		Acronym	MSLQ-R	
			Count	Items Comprising Scale		Count	Items Comprising Scale
Motivation Value	Intrinsic goal orientation	INTR	4	1, 16, 22, 24	Value-R	4	1, 16, 22, 24
	Extrinsic goal orientation	ENTR	4	7, 11, 13, 30			
	Task value	TASKV	6	4, 10, 17, 23, 26, 27			
Expectancy	Control of learning beliefs	CNTRL	4	2, 9, 18, 25	Expectancy	4	2, 9, 18, 25
	Self-efficacy for learning and performance	SEFF	8	5, 6, 12, 15, 20, 21, 29, 31			
Affective	Test anxiety	TANX	5	3, 8, 14, 19, 28			
	Learning Strategies Strategy Use				Strategy Use-R		
Learning Strategies Strategy Use	Rehearsal	RHRSL	4	39, 46, 59, 72	Strategy Use-R	4	39, 46, 59, 72
	Elaboration	ELAB	6	53, 62, 64, 67, 69, 81			
	Organization	ORNGZ	4	32, 42, 49, 63			
	Critical thinking	CRTHK	5	38, 47, 51, 66, 71			
	Metacognitive self-regulation	META	12	33R, 36, 41, 44, 54, 55, 56, 57R, 61, 76, 78, 79			
Resource Management	Time and study environment	TSTDY	8	35, 43, 52R, 65, 70, 73, 77R, 80R	Resource Management-R	4	35, 43, 65, 70
	Effort regulation	EFFREG	4	37R, 48, 60R, 74			
	Peer learning	PEERLRN	3	34, 45, 50			
	Help seeking	HPSEEK	4	40R, 58, 68, 75			

## Appendix C

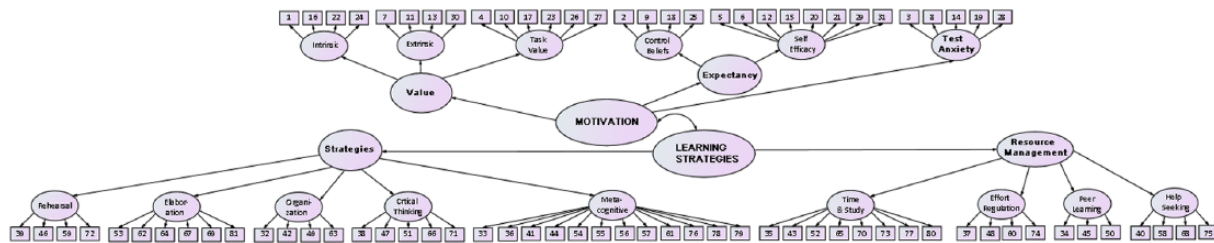


FIGURE C1. Initial third-order factor model for full Motivated Strategies for Learning Questionnaire.

## References

- Al-Harthy, I. S., Was, C. A., & Isaacson, R. M. (2010). Goals, efficacy and metacognitive self-regulation a path analysis. *International Journal of Education, 2*(1).
- Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*(3), 523–535.
- Bembenutty, H. (2007). Self-regulation of learning and academic delay of gratification: Gender and ethnic differences among college students. *Journal of Advanced Academics, 18*, 586–616.
- Byrne, B. M. (2016). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (3rd ed.). New York, NY: Routledge.
- Cassidy, S. (2011). Self-regulated learning in higher education: Identifying key component processes. *Studies in Higher Education, 36*(8), 989–1000.
- Chemers, M. M., Hu, L. T., & Garcia, B. F. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of Educational psychology, 93*(1), 55–64.
- Chen, F. F., Sousa, K. H., & West, S. G. (2005). Teacher's corner: Testing measurement invariance of second-order factor models. *Structural Equation Modeling, 12*(3), 471–492.
- Chen, X. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education* (Stats in Brief NCES 2009-161). Washington, DC: National Center for Education Statistics.
- Chen, X. (2013). *STEM attrition: College students' paths into and out of STEM fields* (NCES 2014-001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.
- Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*(2), 233–255.
- Cho, M. H., & Summers, J. (2012). Factor validity of the Motivated Strategies for Learning Questionnaire (MSLQ) in asynchronous online learning environments. *Journal of Interactive Learning Research, 23*(1), 5–28.
- Cleary, T. J., Platten, P., & Nelson, A. (2008). Effectiveness of the self-regulation empowerment program with urban high school students. *Journal of Advanced Academics, 20*(1), 70–107.
- Credé, M., & Phillips, L. A. (2011). A meta-analytic review of the Motivated Strategies for Learning Questionnaire. *Learning and Individual Differences, 21*(4), 337–346.
- Dembo, M. H., & Seli, H. P. (2004). Students' resistance to change in learning strategies courses. *Journal of Developmental Education, 27*(3), 2–11.
- DiBenedetto, M. K., & Bembenutty, H. (2013). Within the pipeline: Self-regulated learning, self-efficacy, and socialization among college students in science courses. *Learning and Individual Differences, 23*, 218–224.
- Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review, 20*(4), 391–409.
- Duncan, T. G., & McKeachie, W. J. (2005). The making of the motivated strategies for learning questionnaire. *Educational Psychologist, 40*(2), 117–128.
- Dunn, K. E., Lo, W. J., Mulvenon, S. W., & Sutcliffe, R. (2012). Revisiting the Motivated Strategies for Learning Questionnaire: A theoretical and statistical reevaluation of the metacognitive self-regulation and effort regulation subscales. *Educational and Psychological Measurement, 72*(2), 312–331.
- Eagan, M. K., Hurtado, S., & Chang, M. J. (2010, October). *What matters in STEM: Institutional contexts that influence STEM bachelor's degree completion rates*. Paper presented at the annual meeting of the Association for the Study of Higher Education, Indianapolis, IN.
- Effeney, G., Carroll, A., & Bahr, N. (2013). Self-regulated learning: Key strategies and their sources in a sample of adolescent males. *Australian Journal of Educational & Developmental Psychology, 13*, 58–74.
- Floyd, F., & Widaman, K. (1995). Factor analysis in the development and refinement of clinical assessment instruments. *Psychological Assessment, 7*, 286–299.
- Garcia, T., & Pintrich, P. R. (1996). Assessing students' motivation and learning strategies in the classroom context: The Motivated Strategies for Learning Questionnaire. In M. Birenbaum, & F. Dochy (Eds.), *Alternatives in assessment of achievements, learning processes and prior knowledge* (pp. 319–339). Dordrecht, the Netherlands: Springer.
- Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher Education, 53*(2), 229–261.
- Guadagnoli, E., & Velicer, W. F. (1988). Relation to sample size to the stability of component patterns. *Psychological Bulletin, 103*(2), 265–275.
- Hilpert, J. C., Stempien, J., van der Hoeven Kraft, K. J., & Husman, J. (2013). *Evidence for the latent factor structure of the MSLQ*. *SAGE Open, 3*(4). doi:10.1177/2158244013510305
- Hu, L. T., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods, 3*(4), 424–453.
- Jakubowski, T. G., & Dembo, M. H. (2004). The relationship of self-efficacy, identity style, and stage of change with academic self-regulation. *Journal of College Reading and Learning, 35*(1), 7–18.
- Kaplan, A. (2008). Clarifying metacognition, self-regulation, and self-regulated learning: What's the purpose? *Educational Psychology Review, 20*(4), 477–484.
- Kitsantas, A., Winsler, A., & Huie, F. (2008). Self-regulation and ability predictors of academic success during college: A predictive validity study. *Journal of Advanced Academics, 20*, 42–68.
- Komarraju, M., & Nadler, D. (2013). Self-efficacy and academic achievement: Why do implicit beliefs, goals, and effort regulation matter? *Learning and Individual Differences, 25*, 67–72.
- Lynch, D. J. (2006). Motivational factors, learning strategies and resource management as predictors of course grades. *College Student Journal, 40*(2), 423–429.
- Lynch, D. J. (2010). Motivational beliefs and learning strategies as predictors of academic performance in college physics. *College Student Journal, 44*(4), 920–927.
- Lynch, D. J., & Trujillo, H. (2011). Motivational beliefs and learning strategies in organic chemistry. *International Journal of Science and Mathematics Education, 9*(6), 1351–1365.

- Meyers, L. S., Gamst, G., & Guarino, A. J. (2013). *Applied multivariate research: Design and interpretation*. Thousand Oaks, CA: SAGE.
- Muis, K. R., Winne, P. H., & Jamieson-Noel, D. (2007). Using a multitrait-multimethod analysis to examine conceptual similarities of three self-regulated learning inventories. *British Journal of Educational Psychology*, *77*(1), 177–195.
- Nandagopal, K., & Ericsson, K. A. (2012). An expert performance approach to the study of individual differences in self-regulated learning activities in upper-level college students. *Learning and Individual Differences*, *22*(5), 597–609.
- National Academy of Science, Members of the Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Retrieved from [https://grants.nih.gov/training/minority\\_participation.pdf](https://grants.nih.gov/training/minority_participation.pdf)
- National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Retrieved from <https://www.nap.edu/read/11463/chapter/1>
- National Academy of Sciences, National Academy of Engineering, & Institute of Medicine (2010). *Rising above the gathering storm, revisited: Rapidly approaching Category 5*. Washington, DC: National Academies Press.
- National Science Board. (2015). *Revisiting the STEM workforce, a companion to science and engineering indicators 2014*. Arlington, VA: National Science Foundation.
- National Science Board. (2016). *Science & engineering indicators*. Arlington, VA: National Science Foundation.
- Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review*, *16*(4), 387–407.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning.
- Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, *53*, 167–199.
- Pintrich, P., Wolters, C., & Baxter, G. (2000). Assessing metacognition and self-regulated learning. In G. Schraw & J. Impara (Eds.), *Issues in the measurement of cognition* (pp 44–97). Lincoln, NE: Buros Institute of Mental Measurement.
- President's Council of Advisors on Science and Technology. 2012. *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics*. Washington, DC: Executive Office of the U.S. President.
- Roth, A., Ogrin, S., & Schmitz, B. (2016). Assessing self-regulated learning in higher education: A systematic literature review of self-report instruments. *Educational Assessment, Evaluation and Accountability*, *28*(3), 225–250.
- Schmitz, B., & Wiese, B. S. (2006). New perspectives for the evaluation of training sessions in self-regulated learning: Time-series analyses of diary data. *Contemporary Educational Psychology*, *31*, 64–96.
- Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education*, *36*, 111–139.
- Sinatra, G. M., & Taasoobshirazi, G. (2011). Intentional conceptual change. In D. H. Schunk, & B. Zimmerman (Eds.), *Handbook of self-regulation of learning and performance* (pp. 203–216). New York, NY: Routledge.
- Smith, S. M., & Chen, C. (2017). Modified MSLQ: An analysis of academic motivation, self-regulated learning strategies, and scholastic performance in information systems courses. *Issues in Information Systems*, *18*(3), 129–140.
- Tock, J. L., & Moxley, J. H. (2017). A comprehensive reanalysis of the metacognitive self-regulation scale from the MSLQ. *Metacognition and Learning*, *12*(1), 79–111.
- Vanderstoep, S. W., Pintrich, P. R., & Fagerlin, A. (1996). Disciplinary differences in self-regulated learning in college students. *Contemporary Educational Psychology*, *21*, 345–362.
- VanZile-Tamsen, C. (2001). The predictive power of expectancy of success and task value for college students' self-regulated strategy use. *Journal of College Student Development*, *42*(3), 233–241.
- VanZile-Tamsen, C., & Livingston, J. A. (1999). The differential impact of motivation on the self-regulated strategy use of high- and low-achieving college students. *Journal of College Student Development*, *40*(1), 54–60.
- Wolters, C. A., Pintrich, P. R., & Karabenick, S. A. (2005). Assessing academic self-regulated learning. In K. Anderson Moore, & L. H. Lippman (Eds.), *What do children need to flourish?* (pp. 251–270). Boston, MA: Springer.
- Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339.
- Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, *25*(1), 3–17.
- Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183.
- Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulatory learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, *82*, 284–290.
- Zusho, A., Pintrich, P. R., & Coppola, B. (2003). Skill and will: The role of motivation and cognition in the learning of college chemistry. *International Journal of Science Education*, *25*(9), 1081–1094.

### Author

CAESAR R. JACKSON is professor of physics. His current research is science education research focusing on issues associated with increasing the number of minorities pursuing degrees and careers in STEM.