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Understanding the Influence of Learners' Forethought on Their Use of Science Study Strategies in Postsecondary Science Learning

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Understanding self-regulation in science learning is important for theorists and practitioners alike. However, very little has been done to explore and understand students' self-regulatory processes in postsecondary science courses. In this study, the influence of science efficacy, learning value, and goal orientation on the perceived use of science study strategies was explored using structural equation modeling. In addition, the study served to validate the first two stages of Zimmerman's cyclical model of self-regulation and to address the common methodological weakness in self-regulation research in which data are all collected at one point after the learning cycle is complete. Thus, data were collected across the learning cycle rather than asking students to reflect upon each construct after the learning cycle was complete. The findings supported the hypothesized model in which it was predicted that self-efficacy would significantly and positively influence students' perceived science strategy use, and the influence of students' valuation of science learning on science study strategies would be mediated by their learning goal orientation. The findings of the study are discussed and implications for undergraduate science instructors are proposed.

Keywords: *Self-efficacy; Task value; Achievement goal orientation; Learning strategies; Self-regulation*

Introduction

The purpose of this work was to utilize structural equation modeling (SEM) to understand and validate the influence of Zimmerman's (1998) forethought phase learner

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variables on the use of science learning strategies in undergraduate science course work as they occur across the semester. In his early work, Zimmerman (1989) defined self-regulated learners as 'metacognitively, motivationally, and behaviorally active participants in their own learning process' (p. 329). Subsequently, he stated that, 'self-regulation refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals' (Zimmerman, 2000a, p. 14). The complex nature of science necessitates that students utilize the complex motivational and cognitive strategies encompassed by Zimmerman's conception of self-regulation (e.g. Larson et al., 2014; Zusho, Pintrich, & Coppola, 2003). However, far too little is known about how self-regulation works in science learners (Zusho et al., 2003), especially postsecondary students.

Self-regulated learners are proactive and responsive to challenges through engagement in a variety of self-regulatory processes (e.g. goal setting, metacognition, and performance evaluation). Over the course of the past 25 years, Zimmerman's work has served as a cornerstone in self-regulated learning research (e.g. Butler & Winne, 1995; Pintrich, 1999; Sitzmann & Ely, 2011) and research has supported the positive impact of self-regulated learning on academic outcomes (Greene, DeBacker, Ravindran, & Krows, 1999; Lopez, Nandagopal, Shavelson, Szu, & Penn, 2013; Wolters, 2004).

Although these variables have been studied in science education literature, an understanding of the relationship of the variables that comprise the self-regulatory cycle across a science learning cycle has not been established. Zusho et al. (2003) noted that 'it would indeed be remiss to ignore' issues related to self-regulated learning in the study of science learning (p. 1093). Furthermore, research supports that self-regulatory variables such as sense of efficacy and task or learning value are not highly generalizable across academic domains (Bong, 2004), supporting the need for a better understanding of these variables and how they function in science learners.

In addition, this study takes a unique methodological approach to studying the self-regulatory cycle as researchers have not yet sought to validate the model as it occurs over time during a learning cycle. Instead, research across domains has primarily followed the 'one and done' model of a single instance of data collection in which the student reflects upon all three phases of self-regulation at one time. Researchers have also noted the need to further explore the relationships of the components of self-regulated learning (Stefanou & Salisbury-Glennon, 2002) and to validate Zimmerman's model (Hadwin, Boutara, Knoetzke, & Thompson, 2004). The purpose of the current study was to take a first step in addressing this gap in our understanding of Zimmerman's model of self-regulation in postsecondary science students by exploring and validating phases one and two as they occur in undergraduate science courses.

Theoretical Framework

Social cognitive theory serves as the theoretical framework for Zimmerman's (1989, 1998) work and, therefore, also serves as the framework for this study. From this perspective, self-regulated learning involves a set of dynamic variables that fluctuate to meet learning demands rather than an inflexible, stagnate process. To capture this process, Zimmerman (1998) proposed three cyclical phases that occur across a learning cycle, with the experiences of previous cycles influencing subsequent cycles (Figure 1). In the first phase, forethought, the learners set the stage for learning by estimating the value of the task at hand, evaluating their task-relevant abilities, determining likely outcomes based on past experiences, and setting various goals (Cleary & Zimmerman, 2004). In the next phase, performance control, the learner utilizes learning strategies and actively engages in self-control and self-observation processes to optimize learning. In the final phase, the reflection phase, the learner evaluates his or her performance through processes of self-judgment and self-reactions. These reflections influence the forethought phase in the subsequent learning cycle. The forethought and performance control phases in the postsecondary science learning domain are the focus of this study.

Forethought Phase

The forethought phase incorporates the beliefs, attitudes, and processes that a student engages in prior to tackling a learning activity (Cleary & Zimmerman, 2004). Zimmerman (2000a) describes two separate but related categories of forethought phase activities: (1) task analysis and (2) self-motivational beliefs. Task analysis includes goal setting and strategic planning. Self-motivational beliefs include sense of efficacy, outcome expectations, intrinsic interest, task value, and goal orientation. To include all the subprocesses in one study to validate Zimmerman's model would be ideal; however, the sample size required would be staggering. Thus, the focus of this study was narrowed to three forethought variables: sense of efficacy, learning goal orientation, and learning value. Performance goal orientation, the counterpart to learning or mastery goal orientation, was not included in the current study as previous research indicated it posed a negligible influence on students' self-perceived science learning strategy use (Dunn & Lo, 2014).

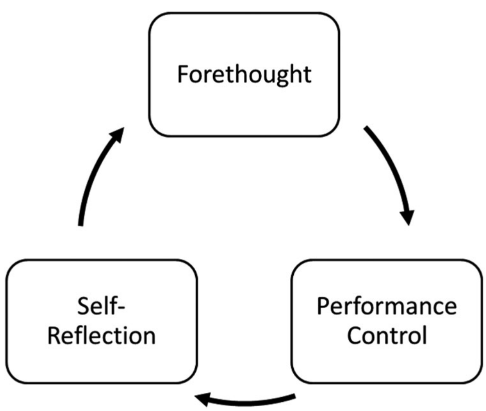

Figure 1. An adapted version of Zimmerman's (1998, 2000b) three-phase cyclical model of self-regulation

Sense of efficacy is defined as one's beliefs in his or her abilities to successfully complete a task (Bandura, 1997). While all motivational beliefs are important, efficacy is a critical motivational process because of its effectiveness in predicting students' choice of activities, effort levels, and persistence in the face of obstacles (Bandura, 1997; Pajares, 1996). Efficacy is most effectively studied at the task-specific level (Bandura, 1986; Pintrich & Schunk, 1996). In this study, sense of efficacy for learning science was the focus and defined as students' belief in their ability to do well on science learning tasks (Tuan, Chin, & Shieh, 2005). Science efficacy beliefs powerfully influence science learners' decisions. For example, if a student does not believe he has the ability to do well on a Biology exam, he is less likely to allocate sufficient time and effort to make a good grade on the test. By comparison, if a student believes she can make a 90% or above on the Biology exam, she will be far more likely to set appropriate learning goals and engage in the learning activities required to do well.

Research supports the claim that a student's sense of efficacy is important to successful science learning. For example, Zusho et al. (2003) found that college-level Chemistry students' sense of efficacy was a salient predictor of final course performance, even after controlling for prior achievement. Andrew (2001) found that for nursing students, sense of science efficacy explained a significant portion of the variance in both physical and biological postsecondary class performance. Science efficacy is also predictive of graduating with a bachelor's degree in science (Larson et al., 2014). Due to the important role of one's sense of efficacy in science achievement as well as graduation, it is important that we better understand science efficacy in the context of the full model of self-regulation (Hadwin et al., 2004; Stefanou & Salisbury-Glennon, 2002; Zusho et al., 2003) as the variables within this model influence one another and are malleable (Doctor, 2004; Greene & Azevedo, 2007; Zimmerman, 2000b).

Berger and Karabenick (2011) found that students' sense of efficacy for mathematics significantly influenced their use of a variety of learning strategies in the performance phase of self-regulation. Moreover, a large body of research suggests that students' sense of efficacy is malleable across a wide array of domains (van Dinther, Dochy, & Segers, 2011). An understanding of the influence of the variables within the model in the context of college-level science classes may provide postsecondary science instructors with valuable insights into how to improve not only self-regulation, but ultimately also science learning.

Achievement goal orientation is also a powerful influence on academic success. Achievement goal orientation refers to the integrated set of beliefs, intentions, and purposes that drive engagement in an academic task (Ames, 1992b; Cho, Weinstein, & Wicker, 2011; Zimmerman, 2000b). A learner with a mastery or learning goal orientation desires to develop competence and focuses on learning, understanding, and mastering tasks (Ames, 1992b; Velayutham, Aldridge, & Fraser, 2011). Research has repeatedly supported that learning goal orientations are associated with a variety of positive learning outcomes, including higher achievement levels (Ames, 1992b; Brookhart, Walsh, & Zientarski, 2006; Velayutham et al., 2011). Some research to the contrary exists. For example, Kingir, Tas, Gok, and Vural (2013) found no relationship between science students' goal orientation and science achievement in an eighth-grade constructivist learning environment (Kingir et al., 2013). Perhaps this is because a constructivist learning environment is more centered on learning and less on performance, negating the impact of a student's personal goal orientation. Cavallo, Potter, and Rozman (2004) found male students' learning goal orientation negatively correlated with meaningful learning in science and achievement.

Although research generally supports the positive impact of learning goal orientation on general learning, the role of goal orientation is less clear in science learning and little is known about these variables in the postsecondary science context. This lack of research and absence of consensus in existing science learning research indicates that more research needs to be conducted to fully understand the role of learning goal orientation in the science learning process. More specifically, research needs to expand upon the current understanding of how forethought variables influence the performance control phase of the self-regulatory cycle in postsecondary science learners.

Task value or learning value is distinct from goal orientation as it refers to the learner's interpretation of how interesting, how important, how useful, and ultimately, how worthwhile the learning task is (Kharrazi & Kareshki, 2010; Pintrich, Smith, Garcia, & McKeachie, 1991, 1993). Task value has more simply been defined as the incentive for engaging in different tasks (Chow, Eccles, & Salmela-Aro, 2012; Wigfield & Eccles, 2000). Thus, learning value incorporates the concept of intrinsic motivation wherein learning or the learning task or the content learned is motivation enough to promote engagement.

Research indicates that the value a student assigns to learning and learning tasks is associated with task selection, greater learner satisfaction, deeper cognitive engagement, and higher achievement levels (Chow et al., 2012; Greene et al., 1999). Learning value predicts achievement in the science classroom. For example, Zusho et al. (2003) found that task value significantly predicted college Chemistry performance, even when prior achievement was controlled for in the statistical model. Tapola, Veermans, and Niemivirta (2013) found that higher task value was associated with higher science performance for middle school science students. Due to its significant connection to science learning, it is important to better understand how the value assigned to learning and learning tasks impacts the cyclical process of self-regulation, especially its influence on performance control phase variables.

Of particular importance to the current study is the influence of learning value on learning goal orientation. Expectancy-value theory and related research supports the influence of learning value on the development of learning goals and subsequent use of learning strategies and academic achievement (Meece, Anderman, & Anderman, 2006). In a study of 250 undergraduate educational psychology students, Al-Harthy and Was (2010) found that learning value shared a significant and moderate positive correlation with learning or mastery goal orientation, which subsequently and positively influenced metacognitive self-regulation. The authors predict that using a domain-specific instrument for these variables will reveal more substantial relationships among these variables. There is a lack of research on the influence of learning value on self-regulated learning strategies as mediated by learning goal orientation not only in general, but also specifically in the science education literature (Zusho et al., 2003).

Performance Control Phase

These forethought phase variables influence learners' engagement in the performance control phase processes of self-control and self-observation (Cleary & Zimmerman, 2004; Zimmerman, 1989, 1998). Self-control processes are used to actively guide the learning process as one seeks to attain a goal. These processes include activities such as self-instruction, effort regulation, and rehearsal (Cleary & Zimmerman, 2004; Pintrich et al., 1991, 1993). Self-observation involves systematic monitoring of ongoing performance as the learner attempts to achieve his or her goals. Examples of self-observation processes include activities such as metacognition, where the learner considers what he or she does know, does not know, and how he or she came to understand that information (Pintrich et al., 1991, 1993). In the performance control phase, the learner actively engages in behaviors directed at achieving the goals set in the forethought phase. In addition, the information gathered in this phase will subsequently influence the evaluation of the effectiveness of the strategic plan that was made and result in improvements to future learning (Cleary & Zimmerman, 2004).

Cognitive and metacognitive strategies, resource management strategies, and active learning strategies were the focus of this study for the performance control phase. Cognitive and metacognitve strategies refer to the cognitive, metacognitive, affective, and behavioral processes people use to achieve their goals and evaluate learning progress and outcomes (Heikkilä & Lonka, 2006; Zimmerman, 2000a). Metacognition reflects self-control and self-observation used to plan, monitor, and modify cognition (Zhang & Huang, 2010; Zimmerman, 2000a). It is defined as awareness of and exertion of control over one's thinking and learning (Flavell, 1979; Hertzog & Dunlosky, 2011). The specific strategies of interest in this study were as follows: critical thinking, metacognitive self-regulation, and help-seeking (Pintrich et al., 1991, 1993; Tuan et al., 2005).

Critical thinking refers to the application of previous knowledge and skills to new situations to interpret, analyze, and evaluate new information to help solve problems and develop new understandings (Hardy et al., 2008; Pintrich et al., 1991, 1993). Metacognitive self-regulation reflects the application of metacognitive strategies to guide the learning process through planning, monitoring, and regulating cognitive activities in the learning process (Pintrich et al., 1991, 1993). Help-seeking is a two-part process in which a student recognizes the need for help and then seeks and manages the needed support of peers and teachers (Karabenick & Newman, 2006; Pintrich et al., 1991, 1993). Help-seeking involves purposeful interaction with peers and teachers focused on clarifying misunderstandings and may result in reaching new insights one may not have achieved alone. In this study, the researchers sought to investigate the influence of forethought phase variables on these science learning strategies as they occurred across time. The science education literature supports the important role of these varied performance control phase learning strategies across a wide array of science learners (Lopez et al., 2013; Rickey & Stacy, 2000; Sandi-Urena, Cooper, & Stevens, 2012; Schraw, Crippen, & Hartley, 2006), but the existing literature does not study these variables as they occur during the learning cycle. Thus, it is critical to better understand these variables, and the influence of the malleable forethought variables that influence the aforementioned performance control process as they occur during science learning (Zusho et al., 2003).

Forethought and Performance Control Research

Research conducting in a variety of academic domains supports the significant influence of forethought variables on performance control variables. For example, Liem, Lau, and Nie (2008) found that sense of efficacy and learning or task value predicted learning strategy use in English. Learning goal orientations have been found to influence the use of learning strategies (Al-Harthy & Was, 2010). Ablard and Lipschultz (1998) found that for a sample of 222 high-achieving seventh-grade students, the use of learning strategies increased as learning goal orientation increased. In a study of 525 seventh- and eighth-grade students in a mathematics course, Wolters (2004) found that learning goal orientation was significantly related to student reported use of cognitive learning strategies ($r = .52$), metacognitive learning strategies ($r = .53$), and course grade ($r = .34$).

Existing literature supports the relationship among the variables of the first two phases of Zimmerman's model in other domains as well as the separate influences of forethought variables and performance control variables on science learning success. However, these data were collected primarily in subject areas other than science as well as at educational levels other than postsecondary. In conjunction with these issues, experts have posited it is critical to establish a better understanding of the relationship among academic self-regulation variables (Hadwin et al., 2004; Stefanou & Salisbury-Glennon, 2002), and Zusho et al. (2003) suggest this need is imperative in science education.

Hypothesized Model

In this study, a better understanding of how forethought phase variables influence performance control phase variables, as the phases occur across the science learning cycle, will be explored in order address this need in undergraduate science learning. In doing so, results will highlight important, malleable variables to which postsecondary science instructors can attend to and likely improve upon in order to facilitate greater success for students via improved learning strategy use. In addition, results will begin to shape our understanding of how these variables are related across time rather than at an arbitrary single data collection point. Through the use of SEM these goals can be achieved, and we may come to better garner the understanding we seek to forge through this work.

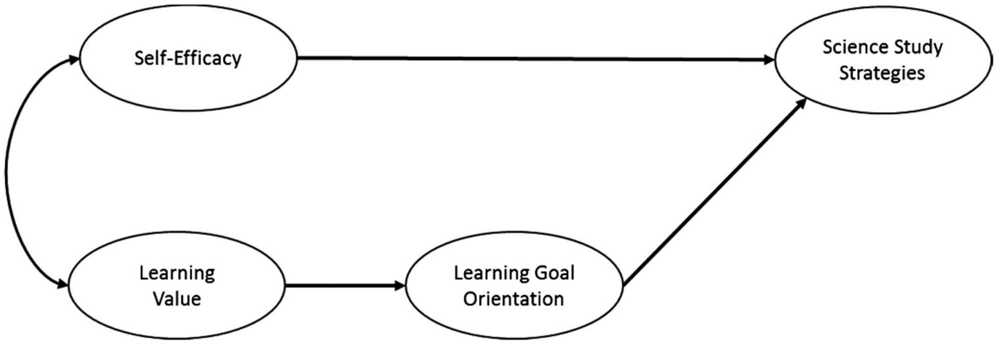

Figure 2. Hypothesized model of learners' forethought on using of science study strategies

The authors hypothesized that sense of science efficacy would have a direct significant and positive influence on science self-regulated learning strategies. In addition, the authors hypothesized that the predicted positive influence of learning value on science study strategies would be mediated by learning or mastery goal orientation. Research in other domains supports the hypothesis that learning value significantly influences the goals one sets (Conley, 2012). Because research suggests that efficacy and learning value are correlated, the authors hypothesized a significant positive correlation between the two variables in this model (Al-Harthy & Was, 2010; Keskin, 2014). The hypothesized model presented in Figure 2 was tested.

Methods

Participants

Participants included students sampled from undergraduate science courses at a large university in the southern USA. Approximately 1,236 students were approached, and of those approached, 215 (18%) students volunteered and returned a full data set. There were 53 males (24.7%) and 160 females (74.4%), and two participants (1%) opted to not provide their gender. Participants ranged in age from 18 to 42 years ($M = 20.42$, SD = 3.14). Approximately 183 (85.1%) of the respondents were Caucasian, 10 (4.7%) were Latino/Latina, 8 (3.7%) were Asian or Asian American, 4 (1.9%) were African American, and 3 (1.4%) were American Indian. The remaining 7 students (3.3%) in our sample reported as 'other'.

Measures

Student's Motivation Toward Science Learning Questionnaire (SMTSL). The SMTSL (Tuan et al., 2005) was used to assess several students' attributes. In developing the measure, Tuan et al. (2005) conducted a pilot study with 315 ninth-grade students to identify an initial item pool. In their second study, they used stratified random sampling with 1,407 students in order to explore the latent factor structure and to establish reliability and validity of this questionnaire. After conducting an exploratory factor analysis, this process led to the identification of six subscales (i.e. Self-Efficacy, Active learning strategies, Science Learning Value, Performance Goal, Achievement Goal, and Learning Environment Stimulation) with 35 items and each item is rated on a 5-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree). According to Clark and Watson (1995), subscales can be used separately as long as the validity of each subscale is established through factor analytic techniques. Therefore, based on our hypothesized model, only the first three subscales (i.e. Self-Efficacy, Active Learning Strategies, and Science Learning Value) were used.

The Self-Efficacy subscale consisted of seven items designed to assess students' beliefs in their ability to do well on science learning tasks, and Cronbach's alpha of this subscale was .82 and factor loadings for each of the items exceeded .55 (Tuan et al., 2005). A sample item from this scale was, 'I am sure that I can do well on science tests' (p. 652). The Active Learning Strategies subscale consisted of eight items designed to assess the degree to which students take a volitional role in using a variety of strategies to construct new knowledge. Items on this subscale focus on critical thinking, metacognitive self-regulation, and help-seeking in science learning. An example item was 'When I make a mistake, I try to find out why' (p. 653). Factor loadings for items on this subscale all exceeded .60 and Cronbach's alpha was .87 (Tuan et al., 2005).

The Science Learning Value subscale consisted of five items, which assessed the value students assigned to science learning such as problem-solving competency, inquiry activity, and relevance of science to daily life (Tuan et al., 2005). A sample item from this subscale was, 'I think that learning science is important because I can use it in my daily life' (p. 653). Factor loadings for items on this subscale all exceeded .50 and Cronbach's alpha was .70 (Tuan et al., 2005).

Student's Adaptive Learning Engagement in Science Questionnaire (SALES). The SALES is a 24-item multidimensional measure derived from factor analytic techniques (Velayutham et al., 2011). It consists of four subscales with eight items for each subscale and respondents are asked to rate items on a 5-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree). Velayutham et al. (2011) validated the SALES on a large sample (1,360) and the SALES showed good validity. Moreover, the internal reliability of the subscales ranged from .91 to .92.

Due to the components in our hypothesized model, only the eight-item Learning Goal (i.e. mastery goal) subscale was used for this study. The Learning Goal subscale was designed to assess the degree to which a student perceived his or her achievement goals as focusing on learning, understanding, and mastering tasks in order to develop competence (Velayutham et al., 2011). A sample item from the Learning Goal subscale was, 'It is important that I improve my science skills' (p. 2178). The factor loadings of items on this subscale ranged from 0.58 to 0.81 and Cronbach's alpha was .91 (Velayutham et al., 2011).

Procedures

After institutional review board approval was acquired, undergraduate science instructors were asked permission to approach their students regarding participation in this study. After providing informed consent, students were given pen and paper copies of surveys, including a demographic questionnaire, during one class meeting and asked to return the completed survey during the next class meeting. There were two data collection points. In the first class session for a new testing unit, students were given the Self-Efficacy and Learning Value subscales from the SMTSL (Tuan et al., 2005) and the Learning Goal subscale from the SALES (Velayutham et al., 2011). Subsequently and in the week prior to the test for the same unit of material, students were asked to complete the Science Study Strategies subscale from the SMTSL. These data collection points were determined to fall in the forethought and performance control phases of the testing unit's learning cycle, respectively. Students returned completed surveys during the next class meeting. On both sets of data, students were asked to provide their student identification number so that data could be matched. Student responses were matched, after which identification numbers were removed from the data set prior to data analysis.

Data Analysis

SEM procedures were used to evaluate theoretical relations and to investigate the plausible latent path model in students' science learning. All statistical analyses were conducted using EQS 6.1. After conducting descriptive statistics, the hypothesized model (Figure 2) was tested. Following the recommendation of Hu and Bentler (1998), assessments of model fit were based on multiple criteria including tests and interpretations of individual parameters as well as overall model fit indices. (i.e. chi-square likelihood ratio statistic [χ^2], comparative fit index [CFI], and standardized root mean square residual [SRMR]).

Results

According to Byrne's (2008) recommendation, the measurement of the latent construct had to be established before evaluating the hypothesized model. In other words, 'an important preliminary step in the analysis of full latent variable models is to first test for the validity of the measurement model before attempting to evaluate the structural model' (Byrne, 2008, p. 189).

Descriptive Statistics & Confirmatory Factor Analysis (CFA)

The mean and standard deviations from subscales that reported on both questionnaires are shown in Table 1. Although both scales (i.e. SMTSL and SALES) are multidimensional scales, we only used three subscales from SMTSL (i.e. Self-Efficacy, Active Learning Strategies, and Science Learning Value) and one subscale from

Table 1. Means and standard deviations for four subscales ($N = 215$)

Questionnaire	Number of items	Possible scores	*M*	SD
SMTSL				
Self-efficacy	7	7–35	28.64	4.15
Learning value	5	5–25	20.83	3.00
Study strategies	8	8–40	33.34	4.27
SALES				
Learning goal	8	8–40	35.50	4.37

SALES (i.e. Learning Goal) to evaluate the hypothesized model in this study. CFAs were conducted for these two measurement models in testing the validity of the indictor variables. The three SMTSL subscales were found to have tenable data-model fit ($\chi^2_{(167)} = 330.261$, CFI = 0.906, and SRMR = 0.060). As a unidimensional scale, the Learning Goal subscale from SALES yielded a good fit to the data ($\chi^2_{(20)} = 130.987$, CFI = 0.914, and SRMR = 0.050). The completely standardized solution of the partial SMTSL and SALES is shown in Figures 3 and 4, respectively.

Testing for Hypothesized Model

After the measurement models were established, the initially hypothesized model was tested. The proposed latent structure yielded a marginal data-model fit ($\chi^2_{(346)} = 663.261$, CFI = 0.903, and SRMR = 0.054). In the present study, the latent factor of Learning Goal was proposed as a mediator that *totally* accounted for the relationship between Learning Value and Science Learning Strategies in the initially hypothesized model. However, this latent factor could also be treated as a partial meditator that *partially* accounted for the relationship. After testing the second model (Figure 5), it yielded a marginal data-model fit ($\chi^2_{(345)} = 661.754$, CFI = 0.903, and SRMR = 0.054), which did not yield a statistically significant improvement from the initial model, $\Delta\chi^2_{(1)} = 1.507$, $p = .78$. Although these data-driven modifications are helpful to evaluate and to compare data-model fit, it is very important that any specification should be made by substantive rationale (Bollen, 1989, pp. 296–297). On the basis of both a valid psychometric rationale and a nonsignificant chi-squared difference test result, we concluded that the initially hypothesized model was the final model, and the completely standardized estimates are presented in Figure 6.

Discussion

In this section, the relationships among the variables of the tested model are discussed, limitations of the study are presented, and instructional strategies for supporting the self-regulatory learner characteristics are shared. The findings of the current study supported the hypothesized model and Zimmerman's (1998, 2000a) model. This included the significant, but strong positive relationship between sense of efficacy

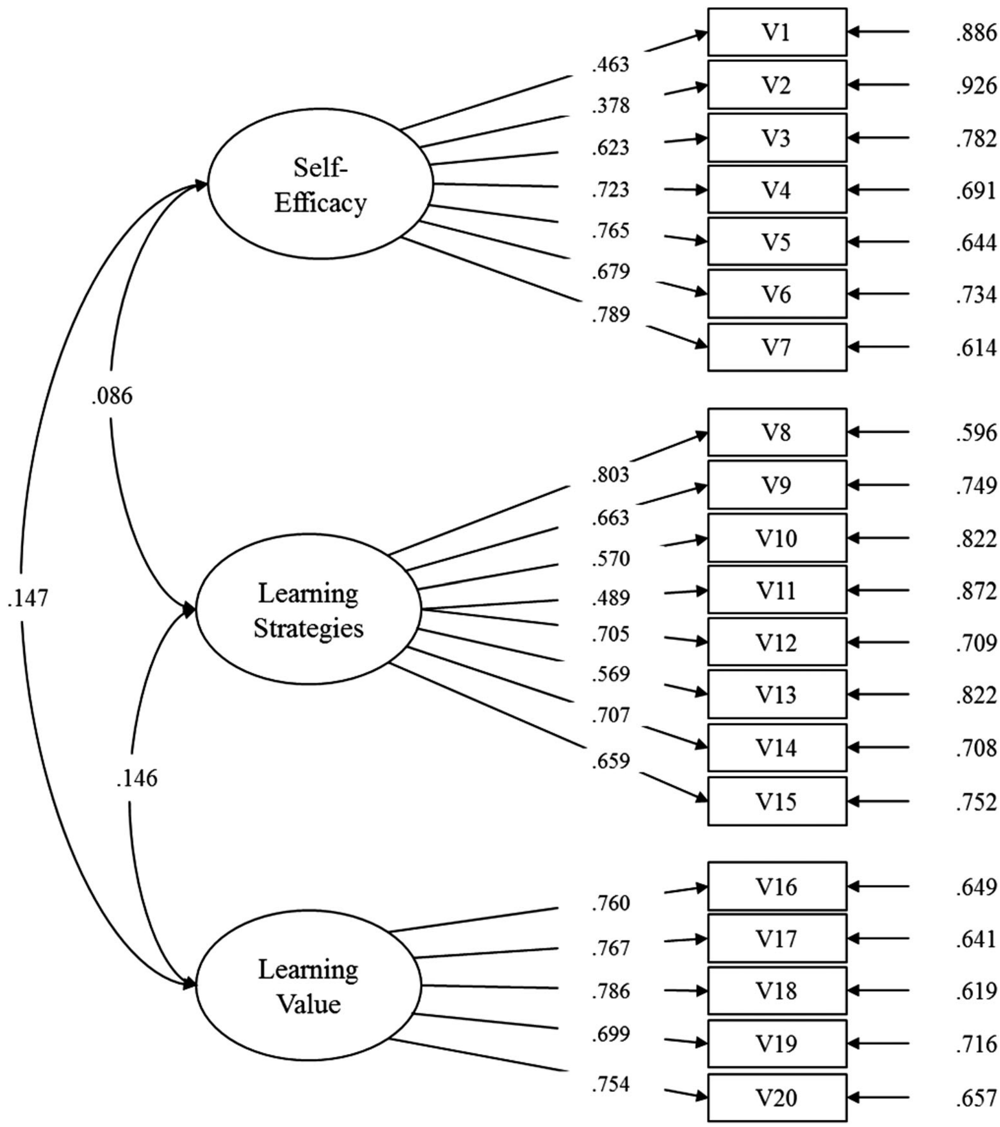

Figure 3. Completely standardized estimations of the three subscales that had been used from SMTSL in this study

and learning value ($r = 0.59$). This indicated that the more equipped the students believed they were to succeed in science learning, the more likely they were to value the science curriculum in their courses. Suggesting that the more confident students were in their ability to succeed, the more likely they were to seek to master the knowledge and skills being presented to them in their undergraduate science coursework.

Previous studies found moderate positive correlations among sense of efficacy and learning value in other academic domains (Al-Harthy & Was, 2010; Keskin, 2014),

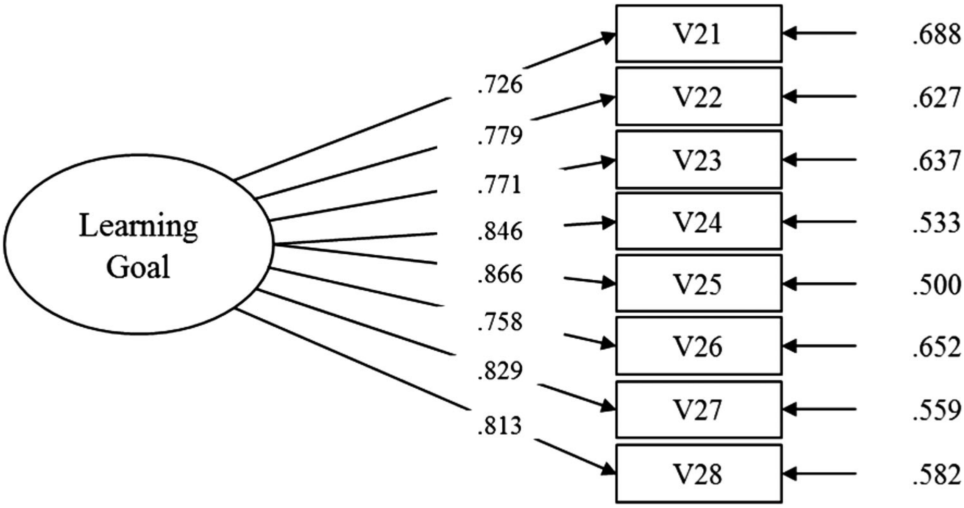

Figure 4. Completely standardized estimations of the learning goal subscale that had been used from SALES in this study

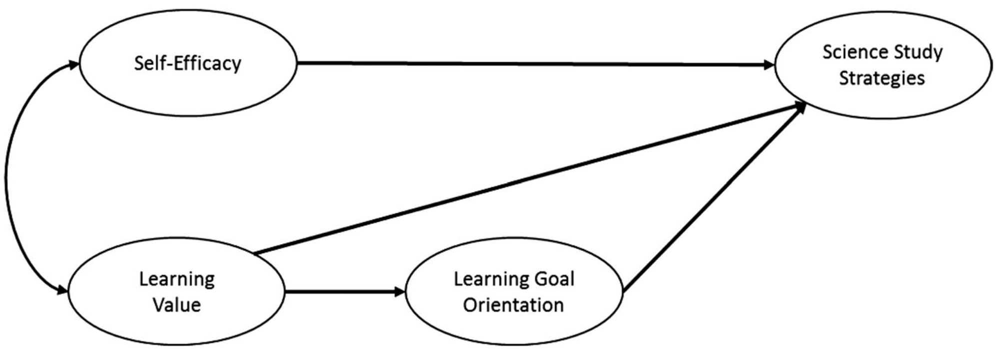

Figure 5. The second hypothesized model with learning goal as a partial mediator factor

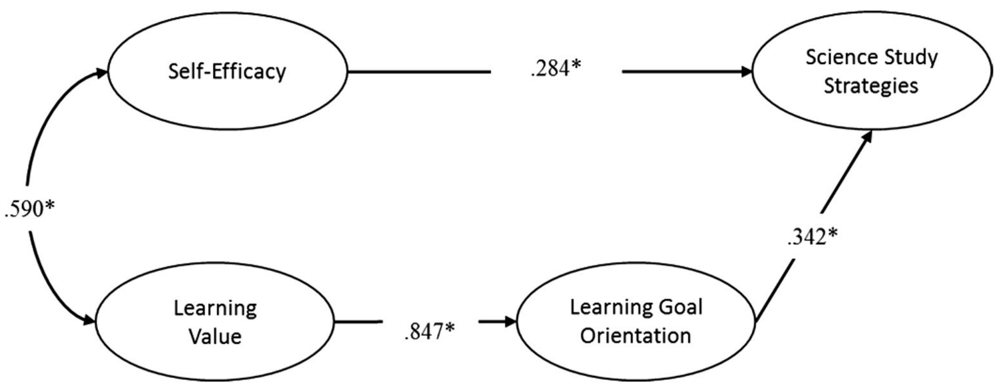

Figure 6. Completely standardized estimates of the final model

and our findings supported an even stronger relationship for this sample of science learners. Science is a complex subject matter with a high degree of abstract and logical reasoning required; these complexities may be a leading cause for the differential findings across domains. Science is a difficult subject for many students to comprehend; by better understanding how self-regulatory variables function and influence one another, instructors may better understand and be equipped to address noncontent-based issues that need their attention during the learning process. Future research should further explore the relationship of the self-efficacy and learning value across a myriad of domains to better understand them.

In addition, sense of science efficacy significantly and moderately influenced science study strategies ($r = 0.28$). This finding supports the existing literature in science education and other fields that suggests self-efficacy is a cornerstone in learning and related academic behaviors (Larson et al., 2014; Zusho et al., 2003). In this study, increases in students' sense of science efficacy were associated with increases in science study strategies. This indicated that the more confident students were that they possessed the skills necessary to succeed, the more likely they were to perceive that they employed the strategies necessary to succeed. Many students perceive science course work as difficult, which may in turn impact their efficacy; therefore, it is critical that science instructors understand this relationship as well as how to bolster students' sense of efficacy for science tasks.

Efficacy is also a critical variable to study as previous studies suggested that science efficacy is predictive of science achievement (Andrew, 2001; Zusho et al., 2003) and bachelor's degree graduation rates (Larson et al., 2014). Thus, it is critical that postsecondary science educators consider that not all students come to their classes with a strong sense of efficacy for science. It is not just K-12 teachers who must consider the development of their students beyond simple acquisition of science knowledge.

Learning value significantly, strongly, and positively influenced participants' learning goal orientation ($r = 0.85$), and indirectly, through the mediation of learning goals had a moderate positive impact on science study strategies. This aligns with previous studies that found learning values to be associated with deeper cognitive engagement (Chow et al., 2012) and both higher and lower order learning strategy use (Berger & Karabenick, 2011). The value that one places on learning powerfully influences whether or not his or her approach to learning is focused on learning all there is to know on the topic or mastering a skill set (Al-Harthy & Was, 2010; Meece et al., 2006). If students value what is being taught, they are more likely to adopt learning goal orientations as opposed to focusing on how intelligent they appear or how well they score.

Learning goal orientation positively influenced students perceived use of science learning strategies ($r = 0.34$). This finding supported the work of Meece et al. (2006) and Al-Harthy and Was (2010) in other academic domains. This relationship indicated that the more interested a student was in acquiring competence in science, the more likely the learner was to employ the learning strategies to achieve the goal of mastering the science content. Collectively, the results supported that it is important for science instructors at the postsecondary level to help students value the content and facilitate in those students a desire to master the material covered, rather than just to perform well on a test.

Together, learning value and learning goal orientation explained 71.8% of the variance in participant's science study strategies. The use of learning or study strategies has been repeatedly shown to be a critical influence on students' success (Lopez et al., 2013; Rickey & Stacy, 2000; Sandi-Urena et al., 2012; Schraw et al., 2006). This study suggests that if professors attend to establishing the value of assignments and science learning, promote the development of learning or mastery goal orientations, and foster a stronger science efficacy in their students, undergraduate science students are more likely to engage in more science study strategy use, and ultimately, succeed in postsecondary science.

In addition to highlighting the need for university instructors to attend to more than content, the current findings support the validity of the first two stages of Zimmerman's model (2000a). Also, results suggest that in the study of self-regulation, it is important to consider the order of influence or interrelationships more within the forethought phase and possibly other phases. Specific to this study, learning value's influence on self-regulatory behaviors was mediated by learning goal orientation, which aligns with expectancy-value theory (Meece et al., 2006; Wigfield & Eccles, 2000). The findings demonstrate the importance of not becoming too myopic in our understanding of academic phenomenon even within specific constructs such as self-regulation. Thus, future research should continue to explore the influence of various variables within each self-regulatory phase across time as well as the mediating and moderating nature of the relationships within the phases rather than the common clustering approach of all forethought variables being entered simultaneously into statistical models. It is also important that postsecondary science education researchers and instructors further research these variables and explore means of addressing the variables through instructional design and behaviors. Limitations of the study, instructional implications, and other suggestions for future research are discussed below.

Limitations

The study included several limitations. For example, the sample size was relatively small for the methodology employed and the response rate was extremely low (18%). Future researchers may wish to consider incentivizing the completion of surveys. In addition, this study was limited by the use of self-report measures. Self-report measures are often accompanied by a number of possible limitations such as ego-protecting and social desirability biases (van de Mortel, 2008). The study may have been improved by teacher observation reports or responses to surveys. However, these were very large course sections and such data collection would likely have been too taxing for the professors. If smaller undergraduate science courses could be identified, it would be wise to include instructor self-report measures. In addition, student interviews or open-ended responses may have enriched the findings from the self-report measures in this study. A final design-based limitation was the use of a convenience sample and the resultant lack of generalizability of findings;

future researchers may want to seek to randomly assign students from various postsecondary science courses to complete future studies in order to increase generalizability.

Another limitation of the study was that the participants were primarily Caucasian. Future studies should seek to explore more diverse samples. Although this sample provided a uniquely female majority (75%) postsecondary science student sample, there were too few male students to explore gender differences in the hypothesized model. Future researchers should explore differences in the hypothesized model that may manifest based on various student characteristics such as gender.

Instructional Strategies

Science efficacy. In a meta-analytic study of variables affecting postsecondary students' sense of science efficacy, van Dinther et al. (2011) found evidence that enactive mastery experiences are the most salient means of improving students' sense of efficacy. Enactive mastery experiences are authentic experiences that provide students with authentic evidence of their ability to succeed at a task or within a domain (Bandura, 1997; Palmer, 2006). Studies reviewed stressed the importance of providing students with practical experiences with sustained time on task for successful improvement of students' sense of efficacy. van Dinther et al. (2011) also revealed that the appropriate level of authenticity needs to be identified to render the mastery experience successful. Ryan and Deci (2000) also highlight the importance of an optimal task challenge in addition to the need to provide effectance feedback in order to bolster a student's sense of competence. Effectance feedback informs students of the impact and control they had on task outcomes. Postsecondary science teachers may want to consider the development of authentic learning activities that target students at the appropriate ability levels and include effectance feedback. Future research should explore the impact of these instructional strategies on students' sense of science efficacy as well as the impact of any increases in efficacy on science study strategy use.

In addition to the careful design and selection of authentic learning activities, Koh and Frick (2009) identified a teaching pattern that best supported authentic learning activities in computer science courses. In this pattern, the teacher uses progress checking to monitor students' task progress and performance. This practice yielded students increased interaction and question asking with the professor. This allotted the professor an opportunity to monitor and control for frustration by identifying errors earlier in the learning process and allowed the sharing of alternative approaches and perspectives. Future research should evaluate the impact of transferring this pattern of instruction to postsecondary science coursework, and ultimately on science students' sense of efficacy.

Mastery experiences and the use of coping models may serve as another means to increasing a student's sense of efficacy. Bandura's (1997) work suggests that mastery experiences that target a learner's ability level, not too hard and not too easy, help to build one's sense of efficacy. In addition, research also suggests that the use of coping models during class can significantly increase student efficacy. A coping model is someone who has overcome similar struggles to the student; thus, a coping model is not your top student who finds classwork easy (Schunk, Hanson, & Cox, 1987; Zimmerman & Ringle, 1981). Instead, a coping model is a student who struggled and can explain how he or she overcame challenges to succeed in that particular class. If teaching in a small setting, it would be feasible to work on meeting students at the appropriate challenge level to build their efficacy through personal mastery experiences. Large class settings, such as a 300-student undergraduate Biology course, may make this difficult. Thus, an instructor in this setting may want to consider capturing an interview with a student who overcame challenges and posting it to the class website or playing it during class. The majority of research on the use of these instructional techniques has been completed with K-12 learners or with undergraduate psychology courses. Future research should explore means of implementing these efficacy-building techniques in both large and small undergraduate science courses.

Learning goal orientation and value. Ames (1992a) outlined key aspects for creating a learning- or mastery-oriented classroom environment via the acronym TARGET, a framework supported by decades of research (see Urdan, 2010 for a review). TARGET stands for task, authority, recognition, grouped, evaluation, and time. The task dimension emphasizes the importance of the design of activities and assignments, focusing on aspects of the task such as variety, personal relevance, and meaningfulness. The task component also focuses attention on how the instructor introduces the assignment, for learning or for performance. By attending to and addressing these aspects of task development and introduction, science instructors may help students value what they are asked to do and learn in their science course work.

Next, authority highlights the importance of providing students opportunities to take control of their learning, developing a sense of student autonomy, and allowing for student leadership roles in class. Recognition relates to the role of formal and informal uses of incentives for recognizing not only performance, but also student effort and growth. The grouped component reflects the need to be mindful of helping students work effectively with others in an environment where student differences in ability do not correspond to differences in motivation. The evaluation dimension highlights the need to not only assess student performance, but also concurrently assess for mastery of material and improvement. Another critical component of mastery is the nature of feedback provided. Feedback should focus on mistakes as opportunities for learning. Moreover, allowing students to revise their work to regain some or all of their points reflects an instructor's focus on learning and improvement rather than performance. Time focuses on the instructional pace, time for completing tasks, and overall workload. When instructors are flexible and match these facets of time with students' learning needs, students begin to focus more on mastering material rather than cramming for a test.

Essentially, students' interpretation of instructor or classroom goal structures influences students' adoption of learning-oriented goals or performance-oriented goals

(Church, Elliot, & Gable, 2001). O'Keefe, Ben-Eliyahu, and Linnenbrink-Garcia (2013) found that adolescents in a course with a learning-structured learning environment were more likely to adopt a mastery learning goal in that course. It is likely that attending to the TARGET guidelines for setting instructional goals and developing a mastery-structured learning environment will also support more student adoption of achievement goal orientations for learning rather than performance in postsecondary science courses; however, future research should test this hypothesis.

Conclusions

This study has several instructional design and practice implications for science educators. Students, no matter the level, simply do not all come prepared for success. The question becomes, is university-level science education merely an extension of evolutionary theory in which only the fit survive the dissemination of content, or is it a place where educators may develop effective learners and impart knowledge? The reviewed literature and current results suggest that considering students' sense of science efficacy, learning value, and learning goal orientation in course design and instructional practice may improve students' science study strategies use and subsequently the quality of their learning and their achievement levels. Future research should explorethe influence of the use of the suggested instructional practices and other self-regulatory variables on undergraduate science learning.

The current study also served to further validate the first two stages of Zimmerman's (1998, 2000a) model and to provide an alternative model for the assessment of self-regulation—data collection across time rather than at a one, less meaningful moment. By separating the phases by temporally appropriate data collection and in the analysis, more depth is added to the understanding of self-regulated learning. Future researchers should consider this approach, which mirrors the occurrence of phases over time, as they continue to unravel the complexities of self-regulated learning.

Disclosure statement

No potential conflict of interest was reported by the authors.

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