International Journal of Environmental & Science Education, 2016, **11**(5), 543-558

The Validation of the Citizen Science Self-Efficacy Scale (CSSES)

Suzanne E. Hiller
George Mason University, USA
Anastasia Kitsantas
George Mason University, USA

•*Received 21 March 2016* •*Revised 23 March 2016* •*Accepted 23 March 2016*

Citizen science programs provide opportunities for students to help professional scientists while fostering science achievement and motivation. Instruments which measure the effects of this type of programs on student motivational beliefs are limited. The purpose of this study was to describe the process of examining the reliability and validity of The Citizen Science Self-Efficacy Scale (CSSES) designed to measure the effectiveness of citizen science programs on student self-efficacy for scientific observation skills. Fifteen (n =15) field experts and 248 (n = 248) eighth grade students participated in three studies. The results suggest that the psychometric properties of this scale are sufficient. Implications for the development and utility of self-efficacy scales in a variety of citizen science contexts are discussed. The aim of the present study is twofold: (a) to establish the psychometric properties of a scale developed to measure student self-efficacy beliefs for scientific observations in citizen science programs and (b) to describe the process in the validation of a self-efficacy scale to support researchers who want to create their own scales for similar citizen science programs. Three studies were conducted to develop the Citizen Science Scale (CSSES) and evaluate its psychometric properties. The purpose of the CSSES was to develop a measure suitable for analysis within a social cognitive career framework and informal natural science contexts. The findings in the present study found that the measure had an acceptable unitary factorial structure and high internal reliability of .89 for the CSSES. The purpose of the Citizen Science Self-Efficacy Scale (CSSES) is to assess individual's beliefs about their capabilities for scientific observational skills. This scale is applicable to measuring individual's self-efficacy in outdoor learning contexts (e.g., horseshoe crab citizen science context). Given that self-efficacy is a strong predictor of academic achievement and motivation, self-efficacy scales like the CSSES may provide a way for stakeholders involved in outdoor education to measure student gains and to substantiate program effectiveness. From a methods standpoint, the contribution of this work is to serve as a guide of how to develop a self-efficacy scale.

Keywords: self-regulation, citizen science, self-efficacy, instruments, scientific observation skills.

Correspondence: Suzanne E. Hiller,
George Mason University, 4400 University Dr, Fairfax, VA 22030, USA
E-mail: shiller@gmu.edu, shiller00020@gmail.com
doi: 10.12973/ijese.2016.405a

ISSN: 1306-3065

INTRODUCTION

An array of research studies have examined the influence of motivational constructs such as self-efficacy, task interest, outcome expectations, and goal setting as major predictors of science achievement (Britner & Pajares, 2006; Hiller & Kitsantas, 2014; Jensen, Scherer, & Schroders, 2015; Lent, Sheu, Singley, Schmidt, Schmidt, & Gloster, 2008; Navarro, Flores, & Worthington, 2007; Patrick, Care, & Ainley, 2011). Self-efficacy, or an individual's assessment of how well they are capable to perform a specific task, is one of the most investigated constructs and the focus of the present study. Learners with high self-efficacy are more likely to become motivated to engage in behaviors such as goal setting, organization, and help seeking, with the ultimate goal of achieving mastery for a specific skill or content knowledge (Zimmerman, 2013; Zimmerman & Schunk, 2009). Thus, self-efficacy beliefs closely align with self-regulation capabilities and academic progress (Zimmerman & Martinez-Pons, 1990). Jointly, self-efficacy beliefs and science achievement influence future course selections and science career choices (Patrick, Care, & Ainley, 2011). For middle school students, there is a strong connection between self-efficacy and career pathways (Hiller & Kitsantas, 2014; Navarro, Flores, & Worthington, 2007; Rogers & Creed, 2011). Individuals with high self-efficacy are more likely to develop sustained interest for a specific activity (Schunk & Pajares, 2005).

Self-efficacy beliefs may vary across subject domains, task requirements, and situations (Bandura, 1997). Within the realm of science instruction, a fundamental issue for students is the ability to improve and apply scientific observation skills, preferably through self-regulatory strategies and modeling (Hiller & Kitsantas, 2015). Differentiating from daily observation skills, scientific observation skills evolve over time, particularly with the guidance of models and involve activities which include practices related to data collection and measurement (Eberbach & Crawley, 2009). Methods behind data acquisition ultimately influence interpretations of results within scientific studies (Cartwright, 1989). As a result, assessing students' self-efficacy for scientific observation skills may provide important information about students' science achievement and career motivation, particularly for students interested in science occupations (Hiller & Kitsantas, 2014). The aim of the present study is twofold: (a) to establish the psychometric properties of a scale developed to measure student self-efficacy beliefs for scientific observations in citizen science programs and (b) to describe the process in the validation of a self-efficacy scale to support researchers who want to create their own scales for similar citizen science programs.

Although often omitted from formal school curriculum, citizen science is an activity which provides opportunities for heightening self-efficacy, motivation, and metacognitive growth in the sciences (Hiller & Kitsantas, 2014; Jeanpierre, Oberhauser, & Freeman, 2005; Sutton, 2009; Trumbull, Bonney, & Grudens-Schuck, 2005). During citizen science programs, professional scientists recruit volunteers to collect data on scientific studies which require large scale data collection (Fowler, Whyatt, Davies, & Ellis, 2013) including biotic and abiotic factors. Scientists who require expansive data sets for their research sometimes rely on the scientific observation skills of citizen scientists (Snäll, Kindvall, Nilsson, & Pärt, 2011).

Adult participation in citizen science programs may assist scientific researchers in assessing a range of topics of study including zone coverage, species distributions, and habitat factors while maintaining quality in terms of hobbyist data collection skills (Crall, Jarnevich, Young, Panke, Renze, & Stohlgren, 2015). Similarly, recent studies have highlighted the accuracy of data collection from children and adolescents, thereby establishing student data submissions as useful in scientific work (Pocock & Evans, 2014). As a result, this type of activity has reciprocal

advantages for scientific researchers and students, particularly when students have access to field experts as models and mentors.

By including students in field work, large data collection is possible, which research suggests has positive implications for school aged children's self-efficacy, career motivation, and achievement (Hiller & Kitsantas, 2014). This type of engagement aligns with recent career literature which cites the influential role of mentors in establishing career self-efficacy (Day & Allen, 2002). For this reason, studies which highlight student participation in field work experiences, require well-designed, context related instruments to assess student self-efficacy beliefs.

A current gap in assessments of STEM education is the limited number of measures which assess student learning (Harwell, Guzey, Moreno, Moore, Philllips, & Roehrig, 2015). Similarly, as self-motivational beliefs, including self-efficacy, directly correlate with academic achievement, self-motivation scales become essential in analyzing STEM education benefits, particularly in terms of career motivation. Bandura (1997) initially described the contribution of self-efficacy in increasing self-regulation, motivation, and academic performance and espoused the development of self-efficacy scales related to specific domains. Self-efficacy is central in assisting an individual to set goals and strategies to become a self-regulated learner.

Figure 1 illustrates the role of self-efficacy within a cyclical self-regulatory feedback loop with the focus of scientific observation skills based on Zimmerman's (2000) self-regulated learning model.

The forethought phase, divided into two sub processes of task analysis and self-motivational beliefs, provides the initial support for individuals to attempt a task. Once an individual engages in the forethought phase, they will attempt the task in the performance phase. Students engage in both self-control (self-instruction, self-imagery, attention focusing, and task strategies) as well as self-observation (self-recording and metacognitive monitoring). In the self-reflection phase, individuals will judge their performance in the sub processes of self-judgment and self-reaction. With diminished self-regulatory skills and weak motivational beliefs (e.g., self-efficacy) in the forethought phase, individuals may attribute insufficient performance on luck or a weak instructor rather than on the type of strategies selected for task performance. Ill structured strategies and negative motivational beliefs in the forethought phase hinder progress in the next two phases in terms of student initiative for learning (DiBenedetto & Zimmerman, 2013). In addition, a learner may engage in behaviors such as procrastination in order to avoid starting the cyclical process again (Cleary & Labuhn, 2013). As a result, developing strong self-efficacy perceptions bolsters proactive self-regulatory behaviors; strongly corresponding with motivation, and achievement. This process of guiding students through a task, such as the improvement of scientific observation skills, is one way to provide opportunities for students to increase mastery experiences which is a key source in the development of self-efficacy (Hiller & Kitsantas, 2015).

With citizen science experiences as an opportunity for collecting scientific data, an individual's self-efficacy for scientific observation skills influences goal setting and task strategies in the forethought phase. During this stage, individuals will plan how to collect data on a specific topic such as a living organism. The beliefs an individual has about their capabilities in analyzing the organism influence how the individual plans to procure information about the topic of study. In the following phase (performance), a model or guide is essential for steering accurate observations. The facilitator provides demonstrations and gives feedback as the individual begins to collect data. Without this assistance and high self-efficacy, an individual is likely to rely on maladaptive strategies limiting their cognitive performance. Specifically, they may not notice the nuances which distinguish organisms in terms of classification, age, gender, or distinctive anomalies (Eberbach

& Crawley, 2009). In the self-reflection phase, individuals gauge their performance. Without strong self-efficacy beliefs related to scientific observation skills, rather than reflecting on how to improve their skills, a student may attribute unfavorable outcomes to perceived lack of instruction, the environment, or other uncontrollable influences. Inability to reflect on individual strategies rather than on external influences may result in a lack of motivation to improve in this cyclical process (Bembenutty, Kitsantas, & Cleary, 2013) and engage in the science oriented activity.

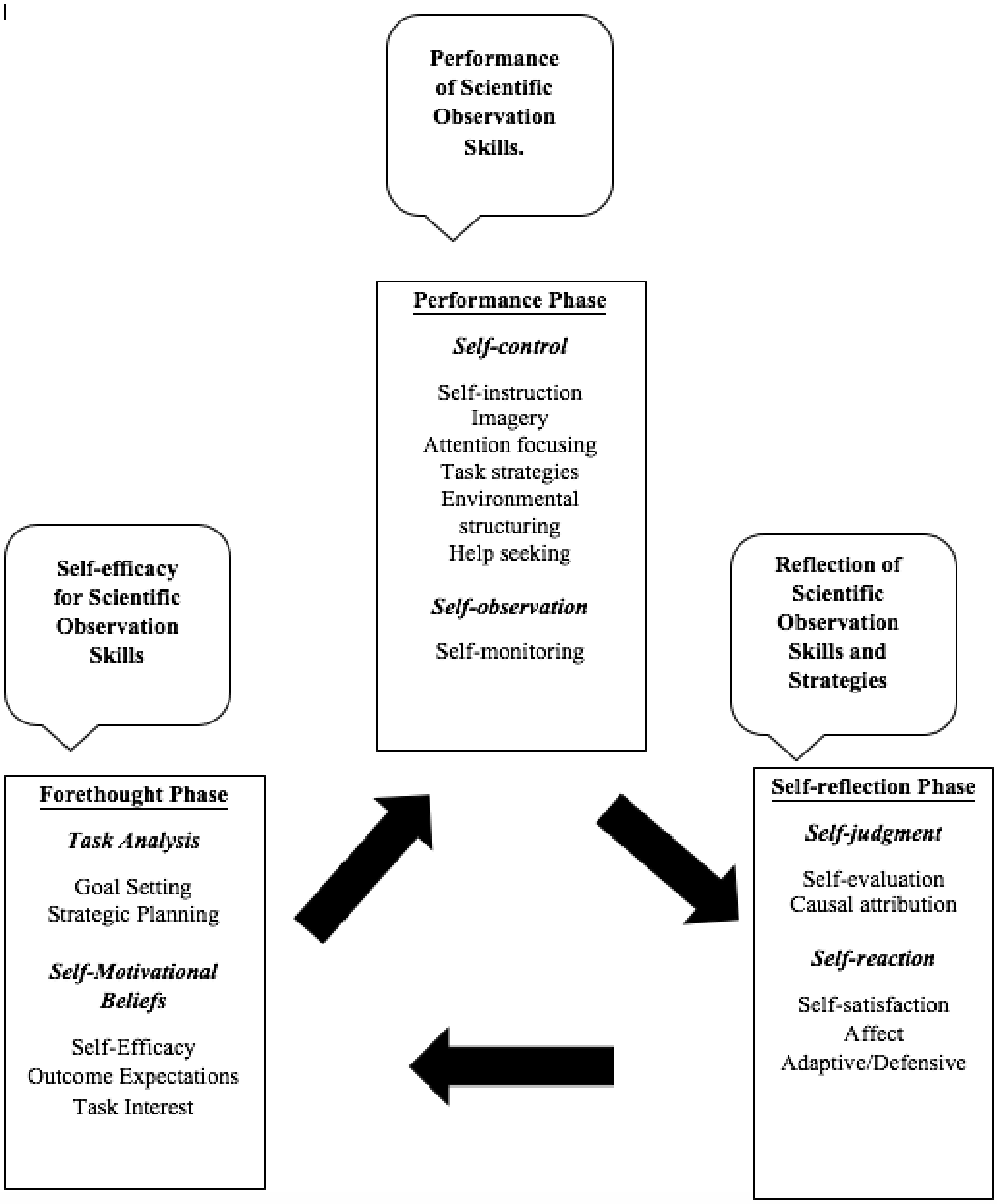

Figure 1. Self-efficacy for scientific observation skills within a cyclical, self-regulatory feedback loop

The implications of fostering self-efficacy have spurred the development of measures which assess task specific self-efficacy beliefs. For example, Zimmerman and Kitsantas (2007) produced a self-efficacy for self-regulation scale known as the Self-Efficacy for Learning Form (SELF) measuring student self-efficacy beliefs about their ability to adjust within a variety of educational structures. Aside from establishing high validity and reliability, findings showed that the 57-item scale

based on self-efficacy served as a strong predictor of grade point average, student perceptions of responsibility for academic performance, and homework completion in terms of consistency and quality.

In terms of science achievement, Britner and Pajares (2006) focused on creating a self-efficacy scale targeting the four sources of self-efficacy, originally described by Bandura (1997). Britner and Pajares designed the measure to include mastery experiences, vicarious experiences, social persuasion, and physiological states. Mastery experiences describe an individual's perceptions of their level of expertise in a specific area and of the four sources is the greatest predictor of academic performance. Vicarious experiences relate to the influence of models and/or mentors on an individual; social persuasion derives from verbal and nonverbal feedback from peers and adults which shape beliefs related to learning, and anxiety is a physiological state which can be negated through overall heightened sense of self-efficacy (Bandura, 1997). Britner and Pajares concluded that the Sources of Science Self-Efficacy had high reliability for each of the four subscales. Notably, the scale of mastery experiences had a higher predictive value over the other three sources in terms of determining academic performance.

Science education researchers have noted that there is a relationship between self-efficacy, science achievement, and career paths (Navarro, Flores, & Worthington, 2007; Patrick, Care, and Ainley, 2011). For example, self-efficacy may be extended to decision making and self-motivation beliefs related to STEM career paths. The Middle School Self-efficacy Scale is an example of an instrument which measures math and science self-efficacy, as well as career goals and intentions, outcome expectations, and interest (Fouad, Smith, & Enochs, 1997). According to Bandura, since self-efficacy is context specific, researchers should strive to create measures which address subtleties of relevant tasks. Although self-efficacy has been measured within science domains, there has been less emphasis on self-efficacy for scientific observation skills.

Given that much of the literature on citizen science focuses on measuring science literacy (Cronje, Rohlinger, Crall, & Newman, 2011; Sutton, 2009), and the accuracy of volunteer data collection (Crall, Newman, Stohlgren, Holfelder, & Graham, 2011; Fowler, Whyatt, Davies, & Ellis, 2013; Gardiner, Alle, Brown, Losey, Roy, & Smyth, 2012; Pocock & Evans, 2014), the purpose of the present study is to focus on assessing student self-efficacy and establish the validity and reliability of the Citizen Science Self-Efficacy Scale (CSSES) scale. Research suggests that establishing self-efficacy for scientific observation skills promotes stronger self-regulatory processes and achievement in natural science learning environments and promotes science oriented career paths (Hiller & Kitsantas, 2014). Citizen science offers a distinct platform for training children in outdoor environments as data collection protocols often require modeling and guidance from field experts. Valid and reliable self-efficacy measures may enable researchers to highlight the positive influences of pedagogical approaches both in formal and informal learning settings. As self-efficacy scales are dependent on contextual settings, the purpose of this work is to describe the process of developing a self-efficacy scale which may be used to highlight the impact of outdoor programs on student learning.

METHOD

There are three key steps in the development of a self-efficacy scale: (a) consulting experts in the field and piloting the measure based on expert feedback, (b) revising the measure with exploratory factor analysis, and (c) testing the validity of the measure through confirmatory factor analysis. As an example, this work describes the steps taken to create the Citizen Science Self-Efficacy Scale (CSSS) based on a horseshoe crab citizen science program for middle school students.

Three studies were conducted to develop the Citizen Science Self-Efficacy Scale (CSSES) and evaluate its psychometric properties (see Figure 2). The first study framed the process of item development based on the experience of professional field experts who work with children. Items were also piloted with middle school children. In the second study, an exploratory factor analysis was conducted to examine the construct validity and the internal consistency of the scale. Finally, the third study confirmed the structure of the scale and concurrent validity with other related scales

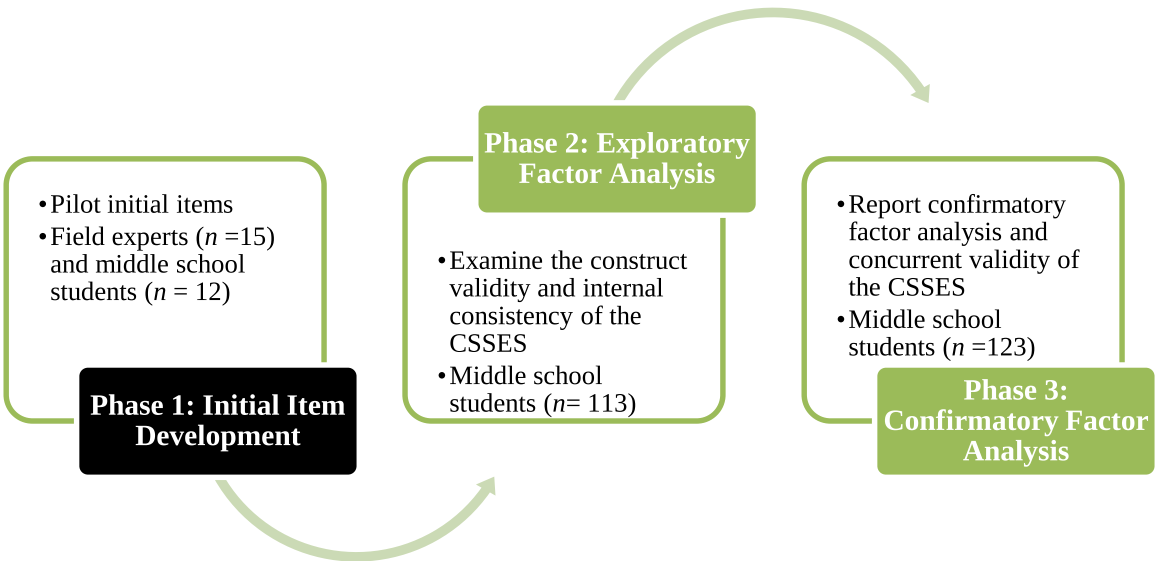

Figure 2. The development of the Citizen Science Self-Efficacy Scale (CSSES)

Instrument development: study I

The initial study which steered the phases of development for the CSSES was a qualitative study on field experts' perceptions of fostering environmental education for children. Findings from this study informed subsequent item selection. In the next two studies, the revisions of the CSSES centered on emphasizing scientific observation skills, self-efficacy, and competence via mastery experiences through citizen science programs.

Participants and setting

Participants for the first study included 15 (n = 15) field experts. The criteria for participant selection were professional field experts, trained naturalist volunteers, and practitioners. Recruitment of these individuals initially began with purposive sampling (roger, 2002) through a naturalist organization. All of the participants had worked with children in outdoor education settings. In an effort to capture multiple perspectives based on geographical location and differing demographic backgrounds, participants were subsequently contacted through network sampling (Patton). Fifteen individuals participated in interviews across a 270 mile range in suburban (nine), urban (three), and rural (three) areas. Of these participants, eight were male and seven were female. The racial/ethnic background of the participants included African American (three), Hispanic (one), and White (eleven) In terms of

affiliations with environmentally based organizations, five of the participants were volunteers, six worked for federal agencies, two for nonprofits, one for a private organization, and one worked for county government. Aside from working with children, the participants were professional scientists in a variety of fields including geology, anthropology, entomology, ichthyology, and botany (Hiller & Reybold, 2011).

In addition to the field experts, twelve (n = 12) eighth grade students from a public school in the northeastern part of the United States volunteered for a citizen science program. Participants included five male and seven female students; African Americans (one), White (ten), and Asian (one). Students collected data on horseshoe crabs for a professional scientist at three sites (national park reserve, a beach, and a naturalist center). Participants completed surveys and interviews at the national park reserve.

Data collection

Initially, three field experts participated in semi-structured interviews. The interview centered on examining the participants' perceptions of based on effective educational practices in outdoor settings. These initial interviews led to an analysis approach known as constant comparative analysis (Corbin & Strauss, 2007) in which tiered phases of coding revealed emerging themes from participant viewpoints. Labels applied to these first three interviews established subsequent questions for the second phase known as axial coding. The next 12 participants were asked questions such as "What are key characteristics children need in environmental education programs?" and "How does learning in the outdoors differ from the school setting?" Based on subsequent coding during the axial phase, categories development resulted in three emergent themes; self-efficacy, scientific observation skills, and competence. To establish validity of individual accounts, participants subsequently volunteered to review transcripts as a form of member checking.

Both the field experts' descriptions and the Sources of Science Self-efficacy (Britner & Parajes, 2006) framed a subsequent pilot measure targeting self-efficacy for scientific observation skills. Items were developed based on Bandura's (1997) guidelines, and existing self-efficacy scales (i.e. Sources of Science Self-efficacy Scale). Then experts in science research and pedagogy reviewed these items. Twelve children (n =12) were also asked to respond and comment on the items that were created with the guidance of the field experts. These items focused on asking children how confident they were in using observation skills. For example, participants answered items such as how confident they were to "distinguish between male and female horseshoe crabs," "distinguish horseshoe crabs from other animals," and "collect data for a scientist's research study."

RESULTS

Findings revealed that field experts placed great emphasis on scientific observation skills and student motivational beliefs. By far, all of the naturalists emphasized the need to develop scientific observation skills in the outdoor through modeling, mentoring, and varied experiences regardless of their occupations, geographical locations, gender, or racial/ethnic background. In addition, an individual's perception of their capabilities was central in fostering student experiences in the outdoors. In particular, field experts focused on the need to motivate students and encourage an appreciation for the outdoors through repeated educational experiences. The emergent themes from study one, rooted in field expert perspectives, steered the design of a pilot study in which the CSSES targeted

self-efficacy for scientific observation skills within a citizen science program. Furthermore, feedback and comments provided from the children participants led to further item refinement and provided stronger evidence of content validity in line with the goal to capture self-efficacy for scientific observation skills during an authentic outdoor learning experience.

Exploratory factor analysis: study II

Following this initial phase of item development, the scope of the second study was to examine the construct validity and internal consistency of the CSSES.

Participants and setting

One hundred and thirteen students (n = 113) were recruited from two middle schools for this study. Students received a letter asking them to participate through the middle school science classroom and their names were entered in a drawing for a gift certificate. Consent was obtained from parents and students. The average age of the students was 13.37 years (n = 113, M = 13.37, SD = 1.45) while 40% were male and 60% were female. The racial/ethnic background of these students included 1% Asian, 30% African American, 4% Hispanic, 57% White, and 8% identified themselves as “Other.”

RESULTS

Based on exploratory factor analysis, CSSES items were revised and administered in the third phase, which resulted in eight items, one factor loading, and a Cronbach’s alpha coefficient for internal reliability of .90. In addition, the factor accounted for 58.18% of the variance with an eigenvalue of 4.65. The range of factor loadings was between .66 and .88. Slight changes to wording such as substituting the word “Distinguish” with “Find” in “Find differences between horseshoe crabs” and subsequent analysis resulted in one scale with eight items prior to the third study. Ultimately, in study three, an additional item “using a tape measure” was removed due to a low factor loading prior to conducting confirmatory factor analysis

Confirmatory factor analysis: study III

The purpose of study three was to conduct a confirmatory factor analysis and assess the concurrent validity in comparison with the Sources of Science Self-efficacy (Britner & Pajares, 2006), task interest, outcome expectations, and career goal setting. Participants for study three completed a series of scales to analyze the CSSES with the goal to validate this measure.

Participants and setting

For the third study, participants (n = 123) from two middle schools in the northeast region of the United States completed the measures. Data collection occurred during science class. All students were in eighth grade between the ages of 13 and 15 (M = 13.30, SD = 1.41). The racial/ethnic background of the students included 1.9% Asian, 24% African American, 5.3% Hispanic, 59.6% White, and 9.1% Other. In all, 41.6% of participants were male and 58.4% were female.

Measures

Sources of Science Self-Efficacy Scale

For study three, all four subscales of Britner and Pajares’ (2006) Sources of Self-Efficacy were included. The Cronbach’ Alpha Reliability Coefficient for each of the

subscales, validated with middle school students, were Mastery (.90), Vicarious (.80), Social Persuasion (.88), and Physiological States (.91). For the present study, the Cronbach's Alpha Reliability Coefficient was (.87, .71, .84, and .90) respectively. Participants completed items from each of the four subscales using a five point Likert-type scale ranging from "Strongly Agree to Strongly Disagree." A sample item from the Mastery subscale was "I will work as long as necessary to complete a difficult science activity." For Vicarious Experiences a sample included "Many of the adults I know have jobs that require a good understanding of science." An example of a Social Persuasion statement was "My friends tell me that I am good at science," and another for Physiological States included "Just thinking about science makes me feel nervous" (Britner & Pajares, 2006).

Citizen Science Self-Efficacy Scale (CSSES)

Revised from the initial Citizen Science Self-Efficacy Scale and study two, items centered on scientific observation skills such as counting, classifying, collecting, and measuring as described by Eberbach and Crawley (2009) and field experts in the phase one study (Hiller & Reybold, 2011). These items were based on a five point Likert-type scale. Participants responded to items on how confident they were that they could complete activities such as "I can write down things I see when looking at horseshoe crabs," and "measure the distance between the eyes of a horseshoe crab accurately." In a final exploratory factor analysis, "Use a tape measure" was removed due to a low factor loading resulting in a one factor, seven item scale with a Cronbach's alpha reliability coefficient of .87.

Task interest scale (adapted from Zimmerman & Kitsantas, 1999)

The purpose of this scale was to measure student interest in outdoor activities which ranged from (a) analyzing water samples, (b) bird watching, (c) measuring horseshoe crabs, (d) collecting seashells, and (e) drawing. In this study, interest was measured using a ranking scale. As a result, there is no reliability coefficient available. Students ranked their preference for each of these activities as mutually exclusive events. In the present paper, this scale established the validity of the CSSES by a correlation comparison.

Citizen Science Outcome Expectations Scale (Hiller & Kitsantas, 2014)

This scale, by Hiller and Kitsantas (2014), measures student perceptions about the outcome (benefits) of participating in a citizen science program and relates to interest as described by social cognitive career theorists. The six scale item includes items such as "Studying horseshoe crabs will help me improve my science skills." The initial pilot test of this scale yielded a Cronbach's Alpha Reliability Coefficient of .88. For the present study, the Cronbach's Alpha Reliability Coefficient was .90.

Career Related Goals Scale (Mu, 1998)

Goal setting serves as an underlying foundation of career trajectories. Mu's (1998) Career Goals Scale assesses goal setting strategies situated in career planning. A sample item is "I am clear about the steps I need to take to achieve my occupational/career goals." Mu reported a Cronbach's alpha reliability coefficient of .92 with high school students. In a subsequent high school study, for two separate treatment groups was .86 and .89 (Roger & Creed, 2011) whereas a study with middle school students indicated the internal reliability as .90 (Hiller & Kitsantas, 2014). For the validation study the Cronbach's Alpha Reliability Coefficient was .86.

RESULTS

Analyses of factorial validity and reliability

The Citizen Science Self-Efficacy Scale (CSSES) is a seven item measure of student perceptions of their capabilities in scientific observation skills. An exploratory principal component analysis based on seven items instead of eight indicated that these factors accounted for 59.15% of the variance with an eigenvalue of 4.14. There was one factor with seven items with loadings ranging between .74 and .82 as shown in Table 1. The Cronbach's alpha reliability coefficient was .87. One item from the phase three scale was removed, "Use a tape measure accurately" due to some weak factor loadings.

Confirmatory factor analysis

A confirmatory factor analysis (CFA) was conducted to examine the factorial validity of the seven item CSSES latent variable. Prior to conducting confirmatory factor analysis, the assumption of multivariate normality for each observation was examined. Using SPSS, each observation was tested for possible limitations in conducting confirmatory factor analysis based on skewness and kurtosis. Results indicated that all data fell below acceptable cut off scores for skewness (< 2.0) and kurtosis (< 7.0) (Dimitrov, 2012).

Comparative fit indices were examined for the goodness-of-fit (GFI) > .95 the comparative fit index (CFI) > .93 (Hu & Bentler, 1999), and the Tucker-Lewis index (TLI) > .93 (Tucker & Lewis, 1973). A value of less than .08 for the standardized mean square residual (SMSR) was considered for the model fit. In addition, the Root Mean Square Error of Approximation (RMSEA) with a value less than .05 and a confidence interval between .00 and .08 (Steiger, 1990) served as an additional indices of goodness of fit.

To test the CSSES, a confirmatory factor analysis (CFA) was conducted to examine the factorial validity of the CSSES latent variable. Using AMOS 22.0 software, the global fit of the hypothesized latent variable was assessed through maximum likelihood estimation. Support for a one-factor solution (see Figure 3) was established as the following fit statistics suggested adequate fit: χ^2 (14) = 18.09, p = .20; CFI = .98; TLI = .96; RMSEA = .06, 90% CI = .00, .12 (Hu & Bentler,1999).

Table 1. Factor Loadings of the Exploratory Factor Analysis of the Citizen Science Self-Efficacy Scale

Scale Item	Factor Loading
Rate how well you can conduct the activities listed below:	
Locate horseshoe crabs	.74
Count horseshoe crabs	.74
Write down things I see when looking at horseshoe crabs.	.82
Find differences between horseshoe crabs	.82
Measure the distance between the eyes of a horseshoe crab accurately	.74
Distinguish horseshoe crabs from other animals	.75
Collect data for a scientist's research study	.76

Concurrent validity

Correlation measures related to sources of science self-efficacy, interest, and career goal settings addressed the predictive validity of the CSSES as shown in Table 2.

Table 2. Pearson correlations among self-efficacy, interest, outcome expectations and career goals

Variable	Cronbach's α	a	b	c	d	2	3	4	5
1.Sources of Science Self-Efficacy									
a. Mastery	.87	1.00							
b. Vicarious	.71	.63**	1.00						
c. Persuasion	.84	.80**	.68**	1.00					
d. Anxiety	.90	-.68**	-.51**	-.58**	1.00				
2. Task Interest	-	.12	.30**	.24*	-.09	1.00			
3. Citizen Science Self-Efficacy	.88	.33*	.30**	.40**	-.24**	.44**	1.00		
4. Citizen Science Outcome Expectations	.90	.26**	.37**	.41**	-.12	.47**	.25**	1.00	
5. Career Goals	.86	.27**	.17	.29**	-.17	.14	.18*	.05	1.00

Note. * = $p < .05$, ** = $p < .001$

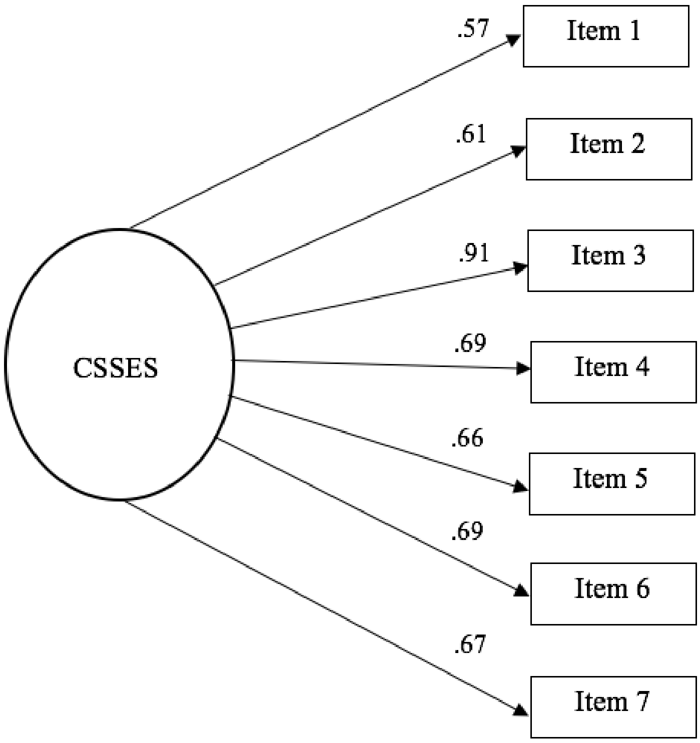

Figure 3. Confirmatory factor analysis of the Citizen Science Self-Efficacy Scale (CSSES)

In general, there were significant correlations among all variables with the exception of Career Goals and Interest (r = .14), and Career Goals and Outcome Expectations (r =.05). The lack of a relationship with these scales may be due to that the career goal questions included broad questions related to career planning that are not science specific. The strongest correlations were between Mastery Experiences and the other three sources of science self-efficacy; Vicarious (r =.63), Social Persuasion (r =.80), and Anxiety (r = -.68). Further the CSSES corresponded with the sources of self-efficacy-mastery(r =.33), vicarious(r =.30), social persuasion (r =.40), and physiological states (r = -.2), and most strongly with interest (r =.44). Similarly, there was a significant relationship between the outcome expectations scale and mastery experiences (r =.26), vicarious experiences (r =.37), social persuasion (r =.41), and interest (r =.47) as well as between the CSSES and the Citizen Science Outcomes Expectations (.25). In line with social cognitive career theory, the findings of this study reveal significant correlations among self-efficacy,

interest, outcome expectations, and goal setting. Corresponding with literature on adolescent achievement, the strongest relationship in this study was between social persuasion and mastery experiences. For students in secondary school, peer interactions are essential in the development of science achievement and self-efficacy status.

DISCUSSION

The present study examined the psychometric properties of the CSSES. The findings show that CSSES had an acceptable unitary factorial structure and high internal reliability of .89. Predictive validity indicated that there were significant correlations for previously established measures including the Sources of Science Self-Efficacy (Britner & Pajares, 2006) and Mu's Career Goal Scale (1998). Further, from a methods standpoint, the contribution of this work is to serve as a guide of how to develop a self-efficacy scale. In this work, the children studied horseshoe crabs, and the scale focused on the tasks required to collect data on the organism. Although, the CSSES may not have wide applicability to all citizen science programs, the contribution of this work is to help researchers produce their own citizen science self-efficacy scale.

Since self-efficacy is a strong predictor of academic achievement, researchers may develop and use self-efficacy scales to examine the influence of outdoor learning on students' motivational and cognitive growth. In this work we outlined how a series of studies resulted in a citizen science self-efficacy scale. Initially, experts were consulted through qualitative methods to create an initial self-efficacy scale. A pilot scale based on their feedback was administered to middle school students. In the next phase, items were revised, administered, and examined through exploratory factor analysis. In the last study, the validity of the items was tested through confirmatory factor analysis. Implementing a series of studies in this way, may yield valid measures for subsequent studies.

In recent years, citizen science research has shifted to examine the impact of authentic real-world experiences on student achievement and career motivation. With the onset of new and affordable hand held technologies, students are able to collect accurate information in the environment with sensors and probes. Access to accurate equipment may make it possible to involve adolescent students in research activities with minimalized concerns over inaccurate measurement collection. In addition, future citizen science programs may offer opportunities for students to interpret results in addition to being involved in data collection. One way for researchers to study the impact of these types of endeavors with school aged children is to develop self-efficacy scales.

Applications for future research include testing the CSSES in horseshoe crab citizen science programs, applying the scale to other age groups, using the measure for longitudinal studies, or generating new self-efficacy scale for studying alternate biotic and abiotic topics. To our knowledge, this is one of the first studies to develop a measure which is applicable to social cognitive career theory within an informal natural science learning environment. Subsequent studies which incorporate researcher developed self-efficacy scales with larger numbers of students may yield useful information in promoting science achievement and career motivation within outdoor learning environments.

RECOMMENDATIONS FOR PRACTICE

In this article, we described the series of studies used to develop a self-efficacy scale which was applicable to a citizen science program. The purpose of the Citizen Science Self-Efficacy Scale (CSSES) is to assess individual's beliefs about their

capabilities for scientific observational skills. This scale is applicable to measuring individual's self-efficacy in outdoor learning contexts (e.g., horseshoe crab citizen science context). The CSSES may be adaptable to other citizen science programs which aim to study self-efficacy for scientific observation skills with adjustments for the topic of study. The development of this type of self-efficacy scale may provide valuable information for researchers studying the impact of informal learning experiences on children's self-regulatory and motivational beliefs. For individuals or organizations which are promoting outdoor education, an obstacle for substantiating funding for outdoor excursions for school aged children is the need to establish the positive benefits of this type of activity. Given that self-efficacy is a strong predictor of academic achievement and motivation, self-efficacy scales like the CSSES may provide a way for stakeholders involved in outdoor education to measure student gains and to substantiate program effectiveness.

Citizen science projects have the potential to provide meaningful scientific experiences for students as the relevance and significance of previous citizen science projects can be used to highlight real world implications of these projects. For example, in the UK, data from citizen science projects surveying bird populations in British gardens has been used to inform conservation monitoring (Cannon, Chamberlain, Tomas, Hatchwell, & Gaston, 2005) A recent citizen science project measuring trends in bat populations in the UK captured "Red Alert Levels" declines in bat population, a finding which could trigger environmental policy changes (Barlow et al., 2015). Finding like these can help inspire environmentally conscious students towards scientific careers given the potential for making positive changes as the result of involvement in citizen science programs.

Moreover, while students learn to work on collaborative teams during authentic experiences, the development of self-efficacy for scientific observation skills supports student science development and career aspirations. Citizen science programs geared for middle schools, in conjunction with opportunities to work with field experts, positively impact student self-motivational beliefs such as self-efficacy as well as promoting cognitive development and STEM career motivation (Hiller & Kitsantas, 2014). In fact the Center for Advancement of Informal Science Information (Sako, 2015) cites the need for increased measures to highlight the impact of citizen science on individual development.

In terms of science achievement and career motivation both in formal and informal science undertakings, providing opportunities to foster student growth in scientific observation skills is an essential element in science oriented career endeavors. Programs aiming to immerse children in meaningful activities which foster mastery experiences and self-efficacy, particularly through modeling and mentoring, align with current understandings of promoting student science performance and career growth. As such, establishing the psychometric properties of self-efficacy instruments such as the Citizen Science Self-Efficacy Scale (CSSES) serve as viable means for highlighting student progress and supporting funding opportunities.

CONCLUSION

Self-efficacy scales are a way to measure the impact of educational programs on student self-motivational beliefs. A process which includes consulting experts, administering and revising items based on exploratory factor analysis, and establishing validity through confirmatory factor analysis, are pivotal phases needed to generate this type of scale. The purpose of the CSSES was to develop and validate a measure suitable for use within a social cognitive career framework and informal natural science setting, specifically in studying a biological organism. Findings revealed that CSSES showed acceptable internal consistency and good construct and

predictive validity. This type of scale may be useful in helping educators assess the effectiveness of their citizen science programs in fostering student self-efficacy, a key predictor of behavior and learning. More importantly, the description of the formation of the CSSES may assist researchers in creating context specific measures. As a greater demand in promoting informal learning opportunities arises, researcher developed self-efficacy scales may prove to be a useful tool in highlighting the advantages of outdoor experiences. The methods of this work serve as a model for future endeavors. For example, subsequent studies may center on creating a battery of scales which include outcome expectations, interest, and career goal setting. Understanding student beliefs about their capabilities in a task, the value of the task, and goal setting are integral components in task mastery and cognitive growth. The studies described in this article, outline how to create measures which highlight student progress. The relationship between self-efficacy and these constructs with well-constructed measures may assist researchers in assessing the effectiveness of citizen science activities through new designs.

REFERENCES

Bandura, A. (1997). *The exercise of control*. New York, NY: W. H. Freeman and Company.

Barlow, K. E., Briggs, P. A., Haysom, K. A., Hutson, A. M., Lechiara, N. L., Racey, P. A., Walsh A. L., & Langton, S. D. (2015). Citizen science reveals trends in bat populations: The National Bat Programme in Great Britain. *Biological Conservation 182*, 14-26. doi: 10.1016/j.biocon.2014.11.022

Bembenutty, H., Clearly, T., & Kitsantas, A., (2013). Self-regulated learning applied across diverse disciplines. A Tribute to Barry J. Zimmerman. Information Age Publishing.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching 43*(5), 485-499. doi: 10.1002/tea.20131

Cannon, A. R., Chamberlain, D. E., Tomas, M. P., Hatchwell, B. J., C& Gaston, K. J. (2005). Trends in the use of private gardens by wildbirds in Great Britain, 1995-2002. *Journal of Applied Ecology 42,* 659-671. doi: 10.1111/j.1365-2664.2005.01050.x

Cartwright, N. (1989). *Nature's capacities and their measurements*. Oxford, UK: Clarendon Press.

Cleary, T. J., & Labuhn, A. S. (2013) In Bembenutty, Cleary, & Kitsantas' (Eds.) *Applications of self-regulated learning across diverse disciplines: A tribute to Barry Zimmerman*. Charlotte, NC: Information Age Publishing, Inc.

Corbin, J. & Strauss, A. (2007). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage

Crall, A. W., Jarnevich, C. S., Young, N. E., Panke, B. J., Renze, M., & Stohlgren (2015). Citizen science contributes to our knowledge of invasive plant species distributions. Biological Invasions. doi: 10.1007/s10530-015-0885-4

Crall, A. W., Newman, G. J., Stohlgren, T. J. Holfelder, K. A., Graham, J., & Waller, D. M. (2011). Assessing citizen science; data quality: An invasive species case. *Conservation Letters 4*(6), 433-442. doi: 10.1111/j.1755-263X.2011.00196.x

Cronje, R., Rohlinger, S., Crall, A., & Newman, G. (2011). Does participation in citizen science improve scientific literacy? A study to compare assessment methods. *Applied Environmental Education and Communication 10,* 135-145. doi: 10.1080/1533015X.2011.603611

Day, R., & Allen, T. D. (2002). The relationship between career motivation and self-efficacy with protégé career success. *Journal of Vocational Behavior 64*, 72-91. doi: 10.1016/S0001-8791(03)00036-8

DiBenedetto, M. K., & Zimmerman, B. J. (2013). Construct and predictive validity of microanalytic measures of students' self-regulation of science learning. *Learnng and Individual Differences 26*, 30-41: doi: 10.1016/j.lindif.2013.04.004

Dimitrov, D. M. (2012). *Statistical methods for validation of assessment scale data in counseling and related fields.* Alexandria: American Counseling Association.

Eberbach, C., & Crowley, K. (2009). From everyday to scientific observation: How children learn to observe the biologist's world. *Review of Educational Research 79*(1), 39-68. doi: 10.3102/003465430832589

Fouad, N., Smith, P. L., & Enoch, L. (1997). Reliability and validity evidence for the middle school self-efficacy scale. *Measurement and Evaluation in Counseling and Development 30*(1), 17-31. doi: 10.1037/t20421-000

Fowler, A., Whyatt, J. D., Davies, G., Ellis, R.: How Reliable are Citizen-Derived Scientific Data? Assessing the Quality of Contrail Observations Made by the General Public. Transactions in GIS, 17(4): 488–506 (2013) doi:10.1111/tgis.12034

Gardiner, M. M., Alle, L. L., Brown, P. M. J., Losey, J. E., Roy, H. E., & Smyth, R. R.(2012). Lessons from lady beetles: Accuracy of monitoring data from US and UK citizen-science programs. *Frontiers in Ecology and the Environment*. doi:10.1890/110185

Harwell, M., Guzey, S. S., Moreno, M., Moore, T. J., Phillips, A., & Roehrig, G. H. (2015). A study of STEM asssessments in engineering, science, and mathematics for elementary and middle school students. *School Science and Mathematics 115*(2). doi: 10.1111/ssm.12105

Hiller, S. E., & Kitsantas, A. (2015). Fostering student metacognition and motivation in STEM through citizen science programs. In A. Peña-Ayala's (Ed.) *Metacognition: Fundaments, Applications, and Trends*. Cham, Switzerland: Springer.

Hiller, S. E., & Kitsantas, A. (2014). The effect of a horseshoe crab citizen science program on student science performance and STEM career motivation. *School Science and Mathematics Journal 114*(6), 302-311. doi: 10.1111/ssm.12081

Hiller, S. E., & Reybold, L. E. (2011, October). Field expert's perceptions of scientific observations in the natural world. Presentation at the annual research symposium of the North American Association for Environmental Education, Raleigh, NC.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling 6*, 1-55. doi: 10.1080/10705519909540118

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching 42*(6), 668-690. doi: 10.1002/tea.20069

Jensen, M., Scherer, R., & Schroeders, U. (2015). Students' self-concept and self-efficacy in the sciences: Differential relations to antecedents and educational outcomes. *Contemporary Psychology 41*, 13-24. doi: 10.1016/j.cedpsych.2014.11.002

Lent, R. W., Sheu, H-B., Singley, D., Schmidt, J. A., Schmidt, L. C., & Gloster, C. S. (2008). Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students. *Journal of Vocational Behavior 73*, 328-335. doi: 10.1016.j.jvb.2008.07.005

Mu, X. (1998, August). *High school experience and career maturity in young adulthood*. Paper presented at the 24th international congress of Applied Psychology. San Francisco, CA.

Navarro, R.L., Flores, L. Y., & Worthington, R. L. (2007). Mexican American middle school students' goal intentions in mathematics and science: A test of social cognitive career theory. *Journal of Counseling Psychology 54*(3), 320-335. doi: 10.1037/0022-0167.54.3.320

Patrick, L., Care, E., & Ainley, M. (2011). The relationship between vocational interests, self-efficacy, and achievement in the prediction of educational pathways. *Journal of Career Assessment 19*(1), 61-74 (2011) doi: 10.1177/1069072710382615

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Newbury Park, CA: Sage.

Pocock, M. J. O., & Evans, D. M. (2014). The success of the Horse-Chestnut Leaf Miner, Cameraria ohridella, in the UK reveladed with hypothesis-led citizen science. *PLoS ONE, 9*(1), 1-9. doi: 0.1371/journal.pone.0086226

Rogers, M. E., & Creed, P. A. (2011). A longitudinal examination of adolescent career planning and exploration using a social cognitive career theory framework. *Journal of Adolescence 34*, 163-172. doi: 10.1016/j.adolescence.2009.12.010

Sako, K. (2015). *Citizen science inaugural conference: Updates from the field*. Retrieved from the National Center for Advancement of Informal Science Education website: http://www.informalscience.org/news-views/2015-citizen-science-association-inaugural-conference-updates-field

Schunk, D. H., & Pajares, F. (2005). Competence perceptions and academic functioning. In Elliott and Dweck's (Eds.), *Handbook of competence motivation*. New York, NY: The Guilford Press.

Snäll, T., Kindvall, O., Nilsson, J., & Pärt, T. (2011). Evaluating citizen-based presence data for bird monitoring. *Biological conservation, 144*, 804-810. doi: 10.1016/j.biocon.2010.11.010.

Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research 25*, 173-180. doi: 10.1207/s15327906mbr2502_4

Sutton, S. (2009). Increasing science literacy among English language learners through plant phenological monitoring: A citizen science program at Sequoia and Kings Canyon National Parks. (Master's thesis). Proquest Information and Learning Company, UMI Number, 1473523

Trumbull, D. J., Bonney, R., & Grudens-Schuck, N. (2005). Developing materials to promote inquiry: Lessons learned. *Science Education 89*, 879-900. doi: 10.1002/sce.20081

Tucker, L. R. & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika* 38, 1-10. doi: 10.1007/bf02291170

Zimmerman, B. J. (2013). From cognitive modeling to self-regulation: A social cognitive career path, *Educational Psychologist 48*(3), 135-147 (2013) doi: 10.1080/00461520.2013.794676

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekart, P. R. Pintrich, and Zeidner, M. (Eds.) *Handbook of Self-Regulation*. New York, NY: Academic Press.

Zimmerman, B. J., & Kitsantas, A. (2007). Reliability and validity of Self-Efficacy for Learning Form (SELF) scores of college students. *Journal of Psychology 215*(3), 157- 163. doi: 10.1027/0044-3409.215.3.157

Zimmerman, B. J., & Kitsantas, A. (1999). Acquiring writing revision skill: Shifting from process to outcome self-regulatory goals. *Journal of Educational Psychology 91*, 1-10. doi: 10.1037//0022-0663.91.2.241

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and stategy use. *Journal of Educational Psychology 82*, 51-59. doi: 10.1037/0022-0663.82.1.51

Zimmerman, B. J., & Schunk, D. H. (2009). Motivation: An essential dimension of self-regulated learning. In Zimmerman & Schunk's (Eds.), *Motivation and Self-Regulated Learning.* New York: Routledge.

◈◇◈