

This article was downloaded by: [University of California, San Diego]

On: 09 June 2015, At: 13:36

Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## The Journal of Experimental Education

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/vjxe20>

### Development of the Efficacy Beliefs for Conceptual Change Learning Questionnaire

Mesut Saçkes<sup>a</sup>, Kathy Cabe Trundle<sup>b</sup>, Bruce W. Tuckman<sup>b</sup> & Lawrence A. Krissek<sup>b</sup>

<sup>a</sup> Balıkesir University, Turkey

<sup>b</sup> The Ohio State University

Published online: 13 Aug 2012.

To cite this article: Mesut Saçkes, Kathy Cabe Trundle, Bruce W. Tuckman & Lawrence A. Krissek (2012) Development of the Efficacy Beliefs for Conceptual Change Learning Questionnaire, The Journal of Experimental Education, 80:4, 338-351, DOI: [10.1080/00220973.2011.600355](https://doi.org/10.1080/00220973.2011.600355)

To link to this article: <http://dx.doi.org/10.1080/00220973.2011.600355>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

---

## MOTIVATION AND SOCIAL PROCESSES

---

# Development of the Efficacy Beliefs for Conceptual Change Learning Questionnaire

Mesut Saçkes

*Balikesir University, Turkey*

Kathy Cabe Trundle, Bruce W. Tuckman, and Lawrence A. Krissek

*The Ohio State University*

The purpose of this study was to develop an instrument to assess college students' efficacy beliefs for conceptual change and to examine the psychometric properties of the instrument. Participants were 692 students. Results of the confirmatory factor analysis supported the hypothesized single factor structure of Efficacy Beliefs for Conceptual Change Learning Questionnaire providing evidence for the construct validity. Evidence for concurrent validity also is provided. On the basis of the evidence provided in this study, the questionnaire appears to produce valid and reliable scores for college students. With the use of the questionnaire, conceptual change researchers might be able to better assess the relationship between students' efficacy beliefs and the change in their conceptual understandings of various science concepts.

**Keywords** *conceptual change, confirmatory factor analysis, motivation, science education, self-efficacy*

THE ROLE OF MOTIVATIONAL BELIEFS in learners' academic achievement has been a focus of educational and psychological studies for a long time. An increasing number of research studies have provided evidence for the important role of students' motivational beliefs in performing various academic tasks. These studies suggest that motivational beliefs, such as self-efficacy, goal orientation, and task value, encourage learners to initiate and sustain the use of various cognitive and metacognitive skills in learning academic content (VanderStoep & Pintrich, 2003; Vosniadou, 1999; Zimmerman, 1995; Zusho & Pintrich, 2003).

Science educators also have been interested in studying students' motivational beliefs in science classrooms (Glynn, Taasoobshirazi, & Brickman, 2007, 2009; Gungor, Eryilmaz, & Fakioglu, 2007; Odgers, 2007; Patrick, Mantzicopoulos, & Samarapungavan, 2009; Tuan, Chin, & Shieh, 2005). More recently, motivational beliefs have become a focus of conceptual change researchers who were interested in the role of "hot cognition" in the change in the students' conceptual understandings of natural phenomena (Pintrich, 1999; Sinatra & Mason, 2008; Sinatra & Pintrich, 2003, p. 2; Vosniadou, 2003). Although the role of motivational factors in restructuring conceptual understanding has been a focus of conceptual change literature since the seminal work of Pintrich, Marx, and colleagues (1993), researchers continue to use existing instruments in studying the role of motivational beliefs, and specific conceptual change instruments have yet to be developed. Without such instruments, efforts to examine the role of motivational beliefs in conceptual change seem to remain inconclusive. Therefore, the present study aimed at designing an instrument that is appropriate to study learners' efficacy beliefs for changing or restructuring their conceptual understandings.

## Theoretical Framework

### *Self-efficacy*

The concept of *self-efficacy* is the core concept of social cognitive theory, which assumes that human behavior, environment, and personal factors mutually interact and serve as determinants of one another (Bandura, 1997). According to Bandura (1997), efficacy belief is the foundation of human agency, because people have little incentive to act if they do not believe that they can accomplish a given task. Bandura (1986) called this type of efficacy belief *perceived self-efficacy* and defined it as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391). Efficacy judgments are not concerned with the quantity of the skill one has but with what one believes one can do with those skills. Judgments of self-efficacy determine the amount of effort and persistence a learner will put forth when faced with an obstacle, and it is also related to the investment of cognitive effort to achieve a task (Bandura, 1982). Thus, self-efficacy can explain both the choice and level of activity engaged in and the likelihood of successful completion (Tuckman & Sexton, 1990).

In learning contexts, *self-efficacy beliefs* can be defined as learners' beliefs about their capabilities to learn or perform an academic task at designated levels (Schunk & Zimmerman, 1997). There is a body of research that shows a positive link between self-efficacy and academic achievement (Schunk, 1990; Tuckman, 2003; Zimmerman, Bandura, & Martinez-Pons, 1992). Pajares and Miller (1994) found that self-efficacy was more predictive of problem solving than of other personal variables such as self-concept, perceived usefulness, task-related prior experience, and gender.

Several studies provided evidence that learners' self-efficacy belief influences their academic performance by determining the amount of cognitive effort and persistence learners dedicate to a task (Greene, Miller, Crowson, Duke, & Akey, 2004; Schunk, 1990; Tuckman, 2003). Conceptual change requires learners to invest a great amount of cognitive effort and be persistent in understanding the differences between their existing alternative models and scientific models. Hence, learners' self-efficacy belief might be an important factor that influences their level of

conceptual change. In the following subsection, we discuss the relationship between self-efficacy and conceptual change.

### *Self-efficacy and conceptual change*

According to Bandura (1989), self-efficacy beliefs may influence cognitive activity in two ways: self-aiding or self-hindering. Similarly, self-efficacy is believed to have direct effects on conceptual change and indirect effects through behavioral and cognitive engagement. The effect of self-efficacy for conceptual change might vary depending on how self-efficacy is conceptualized. If self-efficacy is defined as one's confidence in one's knowledge of what is being learned, self-efficacy may be detrimental to the conceptual change process because students might have such confidence in their prior beliefs that they are unwilling to change them (Linnenbrink & Pintrich, 2003; Pintrich, Marx, et al., 1993). A recent case study with three high school students provided evidence to support this perspective. In this study, students with high self-efficacy for learning science and low metacognitive skills exhibited resistance to changing their alternative ideas. In contrast, students with low self-efficacy belief but with high metacognitive skills were more likely to change their alternative ideas (Anderson & Nashon, 2007).

Another way to perceive the relation of self-efficacy to conceptual change is the confidence students have in their capabilities to change, organize, integrate, and synthesize scientific concepts. From this perspective, self-efficacy would be the students' confidence in their ability to use the scientific way of thinking or detect inconsistencies between their prior knowledge and newly introduced information. High self-efficacy should enhance conceptual change in that students will feel confident that they can alter their prior theories or construct theories based on new ideas. Self-efficacy may also influence conceptual change through cognitive and behavioral engagement, given that a high level of self-efficacy is associated with increased persistence and effort, whereas low levels of efficacy are related to decreased persistence and effort (Linnenbrink & Pintrich, 2003; Pintrich, 1999; Pintrich, Marx, et al., 1993).

Although a considerable amount of literature has been published on the relationship between efficacy beliefs and academic achievement in various domains, few studies have focused on the relationship between learners' self-efficacy beliefs and their engagement in conceptual change. Some of these studies reported a significant relationship between students' efficacy beliefs for learning science and their conceptual understandings of density and buoyancy concepts (Yin, 2005) and electricity concept (Olson, 1999). Results of these studies seem to support the assertion that higher self-efficacy for science learning may facilitate the students' engagement in conceptual change. However, some other studies found no significant relationship between self-efficacy beliefs and conceptual understandings (Barlia, 1999; Kang, Scharmann, Noh, & Koh, 2005). Moreover, in a recent study with high school students, self-efficacy belief was found to be an obstacle in changing alternative ideas if students had low metacognitive skills (Anderson & Nashon, 2007).

Self-efficacy beliefs determine the amount of persistence, and cognitive effort learners invest to complete a learning task successfully (Bandura, 1982). Conceptual change is a learning task that requires learners to invest a great amount of effort, be persistent in trying to understand when scientific concepts contradict their prior knowledge, and use deep cognitive strategies (such as elaboration and organization) to process and construct scientific concepts (Pintrich, 1999). Therefore, it seems logical to anticipate learners with high self-efficacy to engage in conceptual

change more easily. However, more studies are needed to provide evidence for the hypothesized positive relationship between the self-efficacy beliefs and conceptual change. Such studies would benefit from an instrument that produces scores with sound psychometric properties and is specifically designed to assess learners' efficacy beliefs for performing cognitive skills that are pertinent to conceptual change.

### Purpose of the Study

The purpose of this study was to develop an instrument to assess learners' confidence in their ability to change or restructure their existing conceptual understanding, and to examine the psychometric properties of the scores obtained from the instrument.

### Development of the Instrument

Guidelines for developing a self-efficacy scale provided by Bandura (2006) were followed in designing the instrument in the present study. Bandura (2006) suggested that conceptual analysis of the domain of functioning should be performed to identify important skills and capabilities that make up the subdomains. Items in the instrument should be phrased to reflect judgment of capability to perform targeted skills and the items should be written in an increasing degree of difficulty. A wide response scale (e.g., 10-point Likert-type scale) should be used to better differentiate respondents' level of confidence. The term *self-efficacy* should not be used on the title of the instrument that is given to respondents and the anonymity of the responses should be ensured to minimize response bias.

Following the guidelines proposed by Bandura (2006), initially, the self-efficacy and conceptual change literature was reviewed to identify skills and capabilities that are crucial for learners to engage in conceptual change. Five subdomains were identified via relevant literature (e.g., Anderson & Nashon, 2007; Bandura, 1989; Pintrich, Marx, et al., 1993; Vosniadou, 1994, 2003). These sub-domains were: efficacy for conceptual understanding, efficacy for making connections, efficacy for making revisions, efficacy for awareness of contradiction, and efficacy for awareness of conceptual structure. Sound conceptual understanding of natural phenomena is integral to conceptual change. Learners must feel confident about their ability to understand scientific concepts because they can only begin to explore a new concept, if it makes sense to them (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992). The results of previous studies indicate that learners' ability to organize and integrate novel information within their existing knowledge structures facilitates conceptual change (Kang et al., 2005; Kowalski & Taylor, 2004; McWhaw & Abrami, 2001). Therefore, learners must feel efficacious in making connections between their existing mental models and models presented through science instruction to be able to engage in conceptual change. Making revision within a conceptual structure is the primary mechanism of conceptual change (Vosniadou, 1994, 1999). Alternative conceptions are transformed into scientific conceptions through enrichment or revision of existing conceptual structure (Vosniadou, 1994). Thus, learners must be confident in their ability to revise their mental models for successful conceptual change to occur. Successful and durable conceptual change depends on learners' abilities to recognize the differences between the mental model they hold and the model presented in science instruction as well as their own awareness of the elements of their existing

mental models. Research studies suggest that metacognition plays a crucial role in conceptual change by helping learners to recognize the inconsistencies between their alternative ideas and scientific concepts (Kowalski & Taylor, 2004; Pintrich, Marx, et al., 1993; Thorley, 1990; Vosniadou, 1994, 2007; Vosniadou & Ioannides, 1998). Moreover, metacognition facilitates students' awareness of the changes in their understandings that result from instruction (Mason & Boscolo, 2000; Yuruk, 2007), and it promotes construction of conceptual understandings that are coherent and durable (Georghiades, 2000, 2004a, 2004b; Saçkes & Trundle, 2010; Trundle, Atwood, & Christopher, 2007). Therefore, learners' confidence in their ability to use metacognitive strategies effectively is crucial for efficient regulation of their cognitive processing and the restructuring of their alternative conceptual understandings.

All subdomains were determined to be integral parts of efficacy beliefs for conceptual change. These subdomains do not constitute separate factors. Rather, they were used as a conceptual framework for item generation. For each domain, three to five items with an increasing degree of difficulty were generated. Items were phrased to reflect judgment of capability. A 10-point Likert type response scale was constructed for the instrument. To minimize the response bias, the term *self-efficacy* was not used in the instrument form and the anonymity of the responses were assured by not asking any identifying information from the participants. The pilot form included a total of 16 items.

A panel of experts reviewed items in the pilot form for content and face validity. The panel included an expert with a doctoral degree in science education who specialized in conceptual change and also an expert with a doctoral degree in psychology who specialized in self-efficacy beliefs for academic learning. On the basis of the suggestions of the panel members, four items were revised and two new items were generated. The clarity of the eight items was improved with minor changes. The final form of the instrument included 18 items, and it was named the *Efficacy Beliefs for Conceptual Change Learning Questionnaire* (EBCCL). Table 1 presents the subdomains targeted with the EBCCL, descriptions of the subdomains, and item numbers that correspond to each domain.

TABLE 1  
Conceptual Structure of the Efficacy Beliefs for Conceptual Change Learning Questionnaire

<i>Domain</i>	<i>Description</i>	<i>Item numbers</i>
Efficacy for conceptual understanding	Learners' confidence in their ability to construct a scientific mental model	1, 2, 8
Efficacy for making connections	Learners' confidence in their ability to make connections between their mental models and the models presented in science instruction	3, 5, 11
Efficacy for making revisions	Learners' confidence in their ability to revise their mental models	9, 13, 18
Efficacy for awareness of contradiction	Learners' confidence in recognizing the contradiction between the mental model they have and the model presented in science instruction	4, 12, 14, 15
Efficacy for awareness of conceptual structure	Learners' confidence in recognizing the elements of their mental models	6, 7, 10, 16, 17

## METHOD

### Sample

We collected data from undergraduate students enrolled in a university geology course at a major research university. The researchers recruited students to participate in the study. Volunteers who agreed to participate were asked to complete the instrument at the beginning of the initial laboratory session of the term. All students in attendance chose to participate in the study. Two rounds of data occurred in the present study. In the first round, we collected data from 340 undergraduate students. Of this sample, 170 students were male, 155 students were female, and 15 did not indicate their gender. Participants' ages ranged between 17 to 27 years of age. The majority was White (76%), 12% was African American, and 6% was Asian American, and the remaining 6% did not indicate their race. We used data from the first round of data collection to examine the construct validity of the instrument.

To examine the concurrent validity of the instrument, we collected additional data from another sample of 352 undergraduate students. These students also were enrolled in a university geology course at the same institution. Of this sample, 162 students were male and 189 students were female. One student did not indicate gender. Participants' ages ranged between 17 to 33 years of age. The majority was White (78%), 10% was African American, 5% was Asian American, and the remaining 7% did not indicate their race. In this second round of data gathering, participants completed, in addition to the EBCCL, the self-efficacy subscale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1993) and the Procrastination Scale-Short Version (Tuckman, 1991), which were used to investigate the concurrent validity of the EBCCL scores. In addition, participants were asked to provide information about their past science achievement, including their ACT science score, and the grade of the latest science course they completed. This information was used to examine the concurrent validity of the EBCCL scores. We also used data from the second sample to cross-validate the factorial structure of the EBCCL.

### Data Analysis

We performed an analysis of category functioning using WINSTEPS version 3.65 (Linacre, 2006) to examine whether respondents utilized the whole response scale. We calculated descriptive statistics with PRELIS version 2.80 (Jöreskog & Sörbom, 2006) and used confirmatory factor analysis to test the hypothesized one-factor model. Correlation matrix and estimation method that is appropriate for item-level analysis was employed using LISREL version 8.80 (Jöreskog & Sörbom, 2006). In addition, we calculated Pearson correlation to establish the concurrent validity of the EBCCL scores using SPSS version 17 (SPSS Inc., 2008).

## RESULTS

### Data Screening and Examination of the Response Categories

Initially data obtained in the first round of data collection were screened for missing values. The percentage of missing values was less than 2% with no recognizable pattern. The expectancy

maximization algorithm was used to impute missing values using PRELIS version 2.80. We used the imputed data file in subsequent analyses.

We examined participants' responses to individual items to gather information about the response patterns. The examination of the frequency of responses to individual items revealed that some response categories were underused. More specifically, participants tended to use higher response categories than the lower ones. An analysis of the response pattern with WINSTEPS version 3.65 indicated that the expectation of monotonic increase in response categories was not met for some items (e.g. 4, 8, 13, and 14), providing further evidence for the underuse of the lower response categories. Therefore, we combined some response categories to increase the precision of the measurement (Wright & Linacre, 1992). More specifically, we collapsed the lower four response categories (1, 2, 3, and 4) into one category. As a result, the initial 10-point Likert type response category of the instrument was transformed into 7-point Likert type response category. Combining response categories increased the item separation index (10-point scale = 6.50, 7-point scale = 7.18), suggesting an improvement in the precision of the measurement and items' ability to discriminate respondents level of efficacy beliefs. An item separation index indicates how well the sample separates the items into different levels of difficulty. Separation coefficient is the ratio of the true standard deviation to the error standard deviation, and it ranges from zero to infinity (Bond & Fox, 2007; Linacre, 2006).

### Descriptive Statistics and Reliability

We calculated descriptive statistics for the samples from the first ( $n = 340$ ) and the second round ( $n = 352$ ) of data collection. The mean EBBCL score for the female participants ( $M = 77.35$ ,  $SD = 24.94$ ) were higher than that for the male participants ( $M = 74.23$ ,  $SD = 22.53$ ) for the first sample. However, in the second sample the mean EBBCL score for the female participants ( $M = 86.41$ ,  $SD = 18.63$ ) were lower than that for the male participants ( $M = 89.62$ ,  $SD = 16.63$ ). Internal consistency of the observed scores was  $\alpha = 0.96$  and  $\alpha = 0.95$  for the first and the second round of data, respectively. Interitem correlations and item-total correlations for the sample data from the first round ranged from 0.33 to 0.76 and 0.55 to 0.85, respectively.

### Construct Validation With Confirmatory Factor Analysis

We used data collected in the first round of data collection to examine the construct validity of the EBBCL. We hypothesized a single factor structure for the instrument. Therefore, we analyzed data using a confirmatory factor analysis. Because the Pearson correlation matrix is not appropriate for analyzing ordinal level data (Beauducel & Herzberg, 2006; Flora & Curran, 2004), a polychoric correlation matrix and an asymptotic covariance matrix were generated using PRELIS version 2.8. We analyzed these matrices using the robust diagonally weighted least squares method of estimation (Jöreskog, 1990; Jöreskog & Sörbom, 2006). We used LISREL version 8.80 to perform confirmatory factor analysis.

The chi-square test was significant indicating poor fit,  $\chi^2(135) = 459.38$ ,  $p < .001$ . Because the chi-square statistic is easily influenced by the large sample size, researchers suggest using multiple goodness of fit indices to evaluate the fit between the model and the sample data (Bentler & Bonett, 1980). The indices evaluated in the present study were the goodness-of-fit index (GFI = 0.99), the comparative fit index (CFI = 0.98), the normed fit index (NFI = 0.98), and the root mean square error of approximation (RMSEA = 0.084, 90% CI [0.076, 0.093]). Whereas

GFI, CFI, and NFI values above 0.90 and RMSEA values smaller than 0.10 suggest that the model has an acceptable fit to the sample data (Browne & Cudeck, 1993; Schumacker & Lomax, 1996), GFI, CFI, and NFI values close to 0.95 and RMSEA value close to 0.06 suggest that the model fits the sample data well (Hu & Bentler, 1999). The fit indices evaluated in the present study suggest that the one-factor solution with 18 items is a very good fit to the sample data. Table 2 shows the items and their loadings.

We also tested the hypothesized single-factor model yeah with the new sample ( $n = 352$ ) obtained from the second round of data collection. The chi-square statistic and GFI were similar to the analysis of data collected in the first round,  $\chi^2(135) = 512.28, p < .001$ ; GFI = 0.99, CFI = 0.98, NFI = 0.97, RMSEA = 0.089, 90% CI [0.081, 0.098]). These results provided further evidence for the hypothesized single factor structure of the instrument.

TABLE 2  
Items and Loadings

<i>Item number</i>	<i>Item</i>	<i>Loading</i>	<i>Item number</i>	<i>Item</i>	<i>Loading</i>
1	I can understand new science concepts.	.71	10	I can recognize how the science concepts I already know influence the way I understand new science concepts.	.87
2	I can understand the most complex science concepts.	.60	11	I can tell whether the new science concepts I have learned fit with the concepts I already knew.	.86
3	I can tell the difference between the new science concepts and my previous understanding.	.79	12	I can understand why the new science concepts I am learning conflict with my previous understanding.	.86
4	I can recognize whether the new science concepts that I have learned conflict with my previous understanding.	.81	13	I can revise my understandings of science concepts I already knew to make them more aligned with the science concepts I am learning.	.86
5	I can make connections between the science concepts I have learned and the concepts I already knew.	.86	14	I can sense if I have conflicting thoughts for science concepts.	.76
6	I can tell whether the new science concepts are understandable.	.80	15	I can tell when I provide contradictory explanations in explaining a science concept.	.79
7	I can tell whether the new science concepts will help me better understand other science concepts.	.81	16	I can recognize the relationship between the science concepts I already knew and the new science concepts I am learning.	.89
8	I can keep trying to understand the new science concepts even though they seem difficult to understand at first.	.73	17	I can tell if the science concepts I know do not help me to make sense of the new science concepts I am learning.	.81
9	I can revise what I already knew about a science concept based on the new science concepts I have been learning.	.85	18	I can easily relearn or change the way I think about a science concept based on the new information provided in science class.	.76

### Concurrent Validity

To establish the concurrent validity of the EBCCL scores, we administered EBCCL and the self-efficacy subscale of the MSLQ to a sample of undergraduate students in the second round of data collection. The MSLQ is a self-report instrument designed to measure motivation and use of learning strategies by college students (Pintrich, Smith, et al., 1993). The MSLQ consists of six motivation subscales and nine learning strategies scales, for a total of 81 items. In the present study, we used the self-efficacy subscale (eight items). The self-efficacy subscale of the MSLQ is designed to assess students' efficacy beliefs for general academic learning. The instrument can be used to measure efficacy beliefs for any academic domain by providing a relevant prompt to test-takers before the administration of the instrument. In the present study, participants were prompted to consider their learning of science in responding to the MSLQ items. However, items in the subscale of the MSLQ are not designed to assess specific conceptual change skills. Thus, it might be limited in its use with conceptual change studies in science education. Because of the limited nature of the instrument, we expected a moderate correlation between (a) the self-efficacy subscale of the MSLQ, which measures efficacy beliefs for academic learning (science in our case); and (b) the EBCCL, which measures efficacy beliefs for conceptual change learning. As expected, the correlation between the two scales was moderate ( $r = 0.65, p < .01, n = 352$ ), suggesting EBCCL measures a similar yet different construct than does the self-efficacy subscale of MSLQ. Cronbach's alpha was .94 for the self-efficacy subscale of the MSLQ.

To provide further evidence for concurrent validity of the EBCCL scores, the EBCCL and the Procrastination Scale-Short Version were administered to a sample of undergraduate students during the second round of data collection. The scale was developed to assess college students' procrastination tendencies (Tuckman, 1991). The instrument consisted of 16 items and had a single factor structure with a loading of 0.40 or higher on this factor. A high score indicates a high level of procrastination. Studies suggest an inverse relationship between academic procrastination and self-efficacy beliefs (Steel, 2007; Tuckman, 1991, 2007). Thus, we expected a negative correlation between the EBCCL scores and Procrastination Scale-Short Version scores. Results indicated a weak but negative relationship between the two scales ( $r = -0.21, p < .01, n = 352$ ) suggesting that participants who obtained higher scores from the EBCCL tended to obtain lower scores from the Procrastination Scale-Short Version.

Sound conceptual understandings of natural phenomena and conceptual change is partly related to good academic performance in science courses and achievement tests (Alao & Guthrie, 1999; Schneider, Krajcik, Marx, & Soloway, 2002). Therefore, measures of participants' science achievement, such as the ACT science test and grade for science course, can be used as indicators of their conceptual understandings. The ACT science test includes items that assess conceptual understandings of physical, life, and earth science contents (ACT, 2007). High grades in science courses also require sound conceptual understandings of course content. Thus, we used participants' ACT science scores and the grade for the latest science course they had completed to provide additional evidence for the concurrent validity of the instrument. As Table 3 shows, the correlation between the EBCCL and the ACT science score and science course grade were higher than the correlation between the self-efficacy subscale of MSLQ and the ACT science score and science course grade (all correlation coefficients were statistically significant,  $p < .01$ ). These results demonstrated that high score on the EBCCL is related to higher science achievement. These

TABLE 3  
Concurrent Validity

	<i>Grade for science course</i>	<i>ACT science</i>
Efficacy Beliefs for Conceptual Change Learning Questionnaire	.42*	.34*
Self-efficacy (Motivated Strategies for Learning Questionnaire)	.36*	.27*

\* $p < .01$ .

findings suggest that the EBCCL may predict science achievement better than the self-efficacy subscale of the MSLQ.

## DISCUSSION

The purpose of this study was to develop an instrument to assess college students' efficacy beliefs for conceptual change and to examine the psychometric properties of the instrument. Initial screening of the data indicated that the 10-point response scale did not function as expected. Thus, nonfunctioning lower response categories were collapsed, transforming the 10-point response scale into a 7-point response scale. We conducted a confirmatory factor analysis on the hypothesized one-factor model using an appropriate correlation matrix and estimation method for ordinal type data. Additional validity evidence was provided examining the correlation between the EBCCL scores and the self-efficacy subscale of MSLQ scores.

Results of the confirmatory factor analysis supported the hypothesized single factor structure of EBCCL providing evidence for the construct validity. Reliability estimates were high for both administrations of the instrument ( $\alpha = .96$  for the first round of data collection,  $\alpha = .95$  for the second round of data collection). Additional evidence for the validity of the EBCCL scores was provided by establishing the concurrent validity of the instrument using the self-efficacy subscale of the MSLQ. The positive moderate correlation between the scores from the EBCCL and the self-efficacy subscale of the MSLQ indicated that the two instruments measure similar yet distinct constructs. The negative correlation between the Procrastination Scale-Short Version and the EBCCL scores provides further evidence for the concurrent validity. The EBCCL scores predicted participants' science course grades and ACT science scores better than the self-efficacy subscale of the MSLQ.

The instruments used in the previous conceptual change studies were not specifically developed to assess strategies and motivational beliefs learners employ in restructuring their existing conceptual understanding. According to Bandura (2006), an instrument to assess self-efficacy beliefs should be task specific. That is, it should be designed to assess learners' beliefs about their capacity to perform a given task at a designated level. The instrument developed in the present study aimed to address the need for a conceptual change specific instrument.

On the basis of the evidence provided in this study, the EBCCL appears to produce valid and reliable scores for college students. With the use of the EBCCL, conceptual change researchers might be able to better assess the relationship between students' efficacy beliefs and the change

in their conceptual understandings of various science concepts. The EBCCL can contribute to studies that examine the role of motivational beliefs in conceptual change and can be a valuable tool for researchers interested in testing the hypotheses of intentional conceptual change theory. Future studies should focus on developing specific conceptual change instruments that assess motivational beliefs other than self-efficacy, such as task value and goal orientation. Studies that adapt the current instrument for the use of samples of students in lower grade levels also are needed.

The sample of the present study came from only a single study site. Therefore, further validation studies should also be conducted to provide additional evidence for the validity and reliability of observed scores of the EBCCL. In the present study, we provided additional evidence for the concurrent validity of the EBCCL scores using participants' grades for the latest college science courses that they had completed and their ACT science scores. The relationship between the participants' scores on the EBCCL and their past science achievement suggest that the EBCCL is related to science achievement. The major limitation of this study is a lack of conceptual change measure in establishing the predictive validity of the EBCCL scores. Therefore, future studies should examine the relationship between students' EBCCL scores and the change in conceptual understandings as a result of conceptual change-oriented instruction to provide evidence for the predictive validity of the EBCCL scores. Moreover, future studies should seek evidence for the discriminant validity of the EBCCL scores. These studies should also examine the relationship between various different constructs and the EBCCL scores to address the limitation that the limited number and nature of variables assessed in this study. For example, the EBCCL could be a strong predictor of learners' use of metacognitive strategies and their metaconceptual awareness. Some EBCCL items also could be easily adapted to use in the evaluation of learners' metaconceptual awareness. The EBCCL could also be a strong predictor of critical thinking skills and problem-solving skills.

According to Bandura (2006), a self-efficacy instrument should be task specific. Following the guidelines provided by Bandura (2006), we aimed to develop a specific conceptual change instrument to be used in conceptual change research in this study. However, items from our instrument could be easily adapted to use in the assessment of students' efficacy beliefs in other domains where students are expected to revise or restructure their existing conceptual understandings of given phenomena.

#### AUTHOR NOTES

**Mesut Saçkes** is an assistant professor of early childhood education in the Necatibey School of Education at Balıkesir University. His research focuses on the cognitive and motivational factors that influence children's and early childhood teachers' learning of scientific concepts. **Kathy Cabe Trundle** is an associate professor of science education in the School of Teaching and Learning at The Ohio State University. Her research interests include early childhood education, conceptual understanding, and the use of technology to promote conceptual change. **Bruce W. Tuckman** is a professor of educational psychology in the School of Educational Policy & Leadership of the College of Education and Human Ecology at The Ohio State University and is the founding director of the Walter E. Dennis Learning Center, an organization that provides students with academic assistance in the form of training in learning and motivation strategies. **Lawrence**

**A. Krissek** is a professor in the School of Earth Sciences at The Ohio State University. His research interests include paleoceanography, earth's climate history, and earth science education.

## REFERENCES

- ACT. (2007). *The ACT technical manual*. Retrieved from [http://www.act.org/aap/pdf/ACT\\_Technical\\_Manual.pdf](http://www.act.org/aap/pdf/ACT_Technical_Manual.pdf)
- Alao, S., & Guthrie, J. T. (1999). Predicting conceptual understanding with cognitive and motivational variables. *The Journal of Educational Research, 92*, 243–253.
- Anderson, D., & Nashon, S. (2007). Predators of knowledge construction: Interpreting students metacognition in an amusement park physics program. *Science Education, 91*, 298–320.
- Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*, 122–147.
- Bandura, A. (1986). *Social foundation of thought and action*. Englewood Cliffs, NJ: Prentice-Hall.
- Bandura, A. (1989). Regulation of cognitive process through perceived self-efficacy. *Developmental Psychology, 25*, 729–735.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.
- Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307–337). Greenwich, CT: IAP.
- Barlia, L. (1999). *High school student's motivation to engage in conceptual change-learning in science*. Unpublished doctoral dissertation, The Ohio State University, Columbus, OH.
- Beauducel, A., & Herzberg, P. Y. (2006). On the performance of maximum likelihood versus means and variance adjusted weighted least squares estimation in CFA. *Structural Equation Modeling, 13*, 186–203.
- Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*, 588–606.
- Bond, T., & Fox, C. (2007). *Applying the Rasch model: Fundamental measurement in the human sciences*. Mahwah, NJ: Erlbaum.
- Boomsma, A. (2000). Reporting analyses of covariance structures. *Structural Equation Modeling, 7*, 461–483.
- Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.
- Flora, D. B., & Curran, P. J. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychological Methods, 9*, 466–491.
- Georgiades, P. (2000). Beyond conceptual change learning in science education: Focusing on transfer, durability and metacognition. *Educational Research, 42*, 119–139.
- Georgiades, P. (2004a). Making pupils conceptions of electricity more durable by means of situated metacognition. *International Journal of Science Education, 26*(1), 85–99.
- Georgiades, P. (2004b). From the general to the situated: Three decades of metacognition. *International Journal of Science Education, 26*, 365–383.
- Glynn, S. M., Taasobshirazi, G., & Brickman, P. (2007). Nonscience majors learning science: A theoretical model of motivation. *Journal of Research in Science Teaching, 44*, 1088–1107.
- Glynn, S. M., Taasobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching, 46*, 127–146.
- Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology, 29*, 462–489.
- Gungor, A., Eryilmaz, A., & Fakioglu, T. (2007). The relationship of freshmen's physics achievement and their related affective characteristics. *Journal of Research in Science Teaching, 44*, 1036–1056.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55.
- Jöreskog, K. (1990). New developments in LISREL: Analysis of ordinal variables using polychoric correlations and weighted least squares. *Quality and Quantity, 24*, 387–404.
- Jöreskog, K., & Sörbom, D. (2006). *Interactive LISREL 8: Structural equation modeling with the SIMPLIS command language*. Chicago, IL: Scientific Software International.

- Kang, S., Scharmann, L. C., Noh, T., & Koh, H. (2005). The influence of students' cognitive and motivational variables in respect of cognitive conflict and conceptual change. *International Journal of Science Education*, 27, 1037–1058.
- Kowalski, P., & Taylor, A. K. (2004). Ability and critical thinking as predictors of change in students' psychological misconceptions. *Journal of Instructional Psychology*, 31, 297–303.
- Linacre, M. (2006). *Winsteps, Version 3.65*. Chicago, IL: MESA Press.
- Linnenbrink, E., & Pintrich, P. R. (2003). Achievement goals and intentional conceptual change. In G. L. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 347–374). Mahwah, NJ: Erlbaum.
- Mason, L., & Boscolo, P. (2000). Writing and conceptual change. What changes? *Instructional Science*, 28, 199–226.
- McWhaw, K., & Abrami, P. C. (2001). Student goal orientation and interest: Effect on students' use of self-regulated learning strategies. *Contemporary Educational Psychology*, 26, 311–329.
- Odgers, B. M. (2007). Elementary pre-service teachers' motivation towards science learning at an Australian university. *The International Journal of Learning*, 14, 201–216.
- Olson, J. K. (1999). *Learner factors associated with radical conceptual change among undergraduates* (dissertation). University of Southern California, Los Angeles, California.
- Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, 86, 193–203.
- Patrick, H., Mantzicopoulos, P., & Samarapungavan, A. (2009). Motivation for learning science in kindergarten: Is there a gender gap and does integrated inquiry and literacy instruction make a difference. *Journal of Research in Science Teaching*, 46, 166–191.
- Pintrich, P. R. (1999). Motivational beliefs as resource for and constraints on conceptual change. In W. Schnotz, S. Vosniadou, & M. Carretero (Eds.), *New perspective on conceptual change* (pp. 33–50). Amsterdam, The Netherlands: Pergamon.
- Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63, 167–199.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, 53, 801–813.
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 221–227.
- Saçkes, M., & Trundle, K. C. (2010, March). *The role of metaconceptual awareness in the change and the durability of conceptual understandings*. Paper presented at the annual meeting of the National Association of Research in Science Teaching, Philadelphia, PA.
- Schneider, R. M., Krajcik, J., Marx, R. W., & Soloway, E. (2002). Performance of students in project-based science classrooms on a national measure of science achievement. *Journal of Research in Science Teaching*, 39, 410–422.
- Schumacker, R. E., & Lomax, R. G. (1996). *A beginner's guide to structural equation modeling*. Mahwah, NJ: Erlbaum.
- Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational Psychologist*, 25(1), 71–86.
- Schunk, D. H., & Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychologist*, 32, 195–298.
- Sinatra, G. M., & Mason, L. (2008). Beyond knowledge: Learner characteristics influencing conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 560–582). New York, NY: Routledge.
- Sinatra, G. M., & Pintrich, P. R. (2003). The role of intentions in conceptual change learning. In G. L. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 1–18). Mahwah, NJ: Erlbaum.
- SPSS for Windows, Rel. 17.0. (2008). *Statistical package for social sciences*. Chicago, IL: SPSS Inc.
- Steel, P. (2007). The nature of procrastination: A meta-analytic and theoretical review of quintessential self regulatory failure. *Psychological Bulletin*, 133(1), 65–94.
- Strike, K. A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. Duschl & R. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice* (pp. 147–176). Albany, NY: SUNY.
- Thorley, N. R. (1990). *The role of conceptual change model in the interpretation of classroom interactions*. Unpublished doctoral dissertation, University of Wisconsin-Madison.
- Trundle, K. C., Atwood, R. K., & Christopher, J. E. (2007). A longitudinal study of conceptual change: Preservice elementary teachers' conceptions of moon phases. *Journal of Research in Science Teaching*, 44, 303–326.
- Tuan, H., Chin, C., & Shieh, S. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, 27, 639–654.

- Tuckman, B. W. (1991). The development and concurrent validity of the procrastination scale. *Educational and Psychological Measurement, 51*, 473–480.
- Tuckman, B. W. (2003). A performance comparison of motivational self-believers and self-doubters in competitive and individualistic goal situations. *Personality and Individual Differences, 34*, 845–854.
- Tuckman, B. W. (2007). The effect of motivational scaffolding on procrastinators' distance learning outcomes. *Computers and Education, 49*, 414–422.
- Tuckman, B. W., & Sexton, T. L. (1990). The relation between self-beliefs and self-regulated performance. *Journal of Social Behavior and Personality, 5*, 465–472.
- VanderStoep, S. W., & Pintrich, P. R. (2003). *Learning to learn: The skill and will of college success*. Columbus, OH: Prentice Hall.
- Vosniadou, S. (1994). Capturing and modeling the process of conceptual change. *Learning and Instruction, 4*(1), 45–69.
- Vosniadou, S. (1999). Conceptual change research: State of the art and future directions. In W. Schnotz, S. Vosniadou, & M. Carretero (Eds.), *New perspectives on conceptual change* (pp. 3–13). Amsterdam, The Netherlands: Pergamon.
- Vosniadou, S. (2003). Exploring the relationships between conceptual change and intentional learning. In G. L. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 377–406). Mahwah, NJ: Erlbaum.
- Vosniadou, S. (2007). The conceptual change approach and its reframing. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the conceptual change approach in learning and instruction* (pp. 1–15). Oxford, England: Elsevier.
- Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: A psychological point of view. *International Journal of Science Education, 20*, 1213–1230.
- Weston, R., & Gore, P. A. (2006). A brief guide to structural equation modeling. *The Counseling Psychologist, 34*, 719–751.
- Wright, B., & Linacre, J. (1992). Combining and splitting categories. *Rasch Measurement Transactions, 6*, 233–235.
- Yin, Y. (2005). *The influence of formative assessments on student motivation, achievement, and conceptual change*. Unpublished dissertation, Stanford University, Palo Alto, California.
- Yuruk, N. (2007). A case study of one student's metaconceptual process and the changes in her alternative conceptions of force and motion. *Eurasia Journal of Mathematics, Science & Technology Education, 3*, 305–325.
- Zimmerman, B. J. (1995). Self-regulation involves more than metacognition: A social cognitive perspective. *Educational Psychologist, 30*, 217–221.
- Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*, 663–676.
- Zusho, A., & Pintrich, P. R. (2003). Skill and will: the role of motivation and cognition in the learning of college chemistry. *International Journal of Science Education, 25*, 1081–1094.