A Structural Analysis of the Attitudes Toward Science Scale: Attitudes and Beliefs About Science as a Multi-Dimensional Composition

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Abstract

The Attitudes Toward Science (ATS) scale, developed by Francis and Greer (1999), was examined from an attitude versus beliefs perspective using data obtained from the Science-in-the-Moment study (Schmidt & Smith, 2008), an investigation of high school students’ cognitive and affective experiences during science instruction. Although Francis and Greer (p. 220) found that the scale “operationalizes the affective attitudinal domain independently of the behavioral and cognitive dimensions,” the current paper argues that this instrument does not manifest itself as a uni-dimensional structure, but, instead, as a multi-dimensional composition. Results from a confirmatory factor analysis indicated that the scale consisted of two distinct clusters of items that measured two different factors: student attitudes toward science and their beliefs about science.
A Structural Analysis of the Attitudes Toward Science Scale: Attitudes and Beliefs about Science as a Multi-Dimensional Composition

Students’ attitudes represent an important dimension of their affect toward particular subject domains in school. Students’ attitudes may, for examine, influence their motivation to pursue study in a domain and persist in their effects to attain subject matter mastery. In the classroom, students’ attitudes reflect how they manage their perceptions regarding academic content and learning, and their behaviors. Thus, attitudes facilitate learning. But, they are also products of students’ learning activities.

In science education, research suggests that students’ affect toward science becomes increasingly less positive (National Education Goals Panel, 1992), as science attitudes scores have been observed to decline as students advance through the grade levels (George, 2000; Reid & Skryabina, 2002). The examination of students’ attitudes toward science provides important information about the status of science education (Simpson, Koballa, Oliver, & Crawley, 1994) in general. Further, the measurement of students’ attitudes enables educational researchers and practitioners to both predict and regulate students’ classroom behaviors. For example, an individual student holding a favorable attitude toward science could be expected to do well on science tests, look forward to science classes and lab experiments, or even choose to pursue a science career. Therefore, having reliable and valid assessments of students’ attitudes toward science is critical to advancing science education.

Attitudes have been defined in a number of ways within the social science literature. For example, Chave (1928) found that an attitude is a complex of feelings, desires, fears, convictions, prejudices, or other tendencies. It expresses one’s readiness to act based on varied
experiences. Sarnoff (1960) described attitude as a disposition to respond favorably or unfavorably to an object. These definitions of attitude are aligned with behaviorist perspectives that explain the behavior of persons based on their past experiences. Attitudes may also contain feelings and emotions associated with the object and are assumed to result from one’s prior experience with the object. Shrigley (1983) determined that attitudes are not innate, but learned, suggesting some past experience with the object. Students develop attitudes toward science, for example, by openly seeking information because of an immediate need (i.e., to obtain a good grade in science class). Subsequently, students may develop negative attitudes towards science because science involves mathematics, which they may find difficult, or because they dislike their science teacher.

The present study adopts the following definition of attitudes: They are learned predispositions to respond in a consistently favorable or unfavorable manner to a given subject (Fishbein & Ajzen, 1975). This definition is also consistent with Gardner’s (1975) definition of attitudes toward science.

Once the individual’s predisposition or attitude has been established, it is expected that he or she will, or will not, perform the associated behavior in question. Shrigley, Koballa, and Simpson (1988), in an analysis of the definition of attitude for science educators, noted that the central attribute of the attitude concept is like or dislike. They consider evaluation the sole element in the definition of an attitude. Therefore, they argue that attitude statements should be assessed within a bipolar affective dimension (e.g., like-dislike, good-bad, or agree-disagree). Likewise, Butler (1999) suggests that attitude statements should include evaluative indicators (e.g., “studying science in school is something that I love to do”) because attitude is an evaluative dimension of a concept.
However, the debate over attitude measurement has not been resolved completely. There are two views on the nature of attitudes in social psychology. These are the cognitive and the affective perspectives, described below.

**Theoretical Perspectives**

These two prevailing schools of thought regarding the nature of attitudes attempt to explain the relationship between attitudes and behavior. Each perspective differs in its’ approach to measuring attitudes. The cognitively-oriented, multi-dimensional perspective views attitudes as multifaceted and consisting of three distinct domains: affect, behavior, and cognition. Proponents of this perspective argue that “man’s social actions—whether the actions involve religious behavior, ways of earning a living, political activity, or buying and selling goods—are directed by his attitudes” (Krech, Crutchfield, & Ballachey, 1962, p. 139). The affective component of an attitude refers to the emotions connected with the object (i.e., it may be pleasing or displeasing, liked or disliked). For instance, enjoyment for learning science will lead to positive feelings towards science-related activities and scientists. The behavioral component includes the behavioral readiness associated with the attitude (i.e., the disposition to take action with respect to the object). Thus, if a student has a favorable attitude towards science, then he or she may tend to read science magazines for pleasure or go to science museums and exhibitions, for example. Finally, the cognitive component consists of one’s beliefs about the object. For instance, attitude toward science may include beliefs about the ways in which scientists influence public policies about scientific matters, such as climate change, or about the validity of the theory of evolution.

According to Krech et al. (1962), some beliefs do not involve any evaluation; although evaluation is usually considered central to understanding attitudes (Koballa, Crawley, &
Shrigley, 1990). Any change in the cognitive aspect of an attitudinal object entails a change in the attitude toward that object. However, a belief can change independently of an attitude. For example, exposure to new information may change one’s belief about the importance of science, but not lead to a change in attitude toward science content. So, a student might believe that science is important to learn, but still dismiss scientists’ claims about global warming, or hold an attitude of contempt toward the theory of evolution.

The second theoretical perspective argues that attitudes should be measured solely within the affective domain. Proponents of this unidimensional perspective, such as Fishbein and Ajzen (1975), make a clear distinction between attitudes and beliefs, assigning attitudes to the affective domain and beliefs to the cognitive domain. In accordance with this perspective, affect refers to a person’s feeling toward and evaluation of an object, person, issue, or event. Cognition denotes their knowledge, opinions, beliefs, and thoughts about the object. A third construct, conation, refers to one’s behavioral intentions and actions with respect to, or in the presence of, the object. Thus, Fishbein and Ajzen classify psychological concepts into four categories: feelings and evaluation (affect), opinions and beliefs (cognition), behavioral intention (conation), and overt actions (behavior). Fishbein and Ajzen developed a conceptual framework that describes the complex relationships among beliefs, attitudes, intentions, and behaviors. A chain of relations begins with beliefs shaping attitudes which, in turn, influence intentions that then lead to particular expressed behaviors.

According to this framework, beliefs may change due to feedback from one’s attitudes and behavior. For instance, once established, an attitude may influence the formation of new beliefs. If a student repeatedly feels confused throughout a science course, for example, she or he may eventually develop a belief that science is difficult and boring. In the same vein, one’s
performance of a particular behavior may lead to a new belief about the object, which may, in turn, influence the attitude. Thus, if a student performs successfully on a science test, he or she may form a new belief that science is not that difficult after all and may look forward to the next assignment.

According to Fishbein and Ajzen (1975), attitudes are purely affective variables and should be measured accordingly. That is, if we want to know students’ attitudes toward science learning or other science–related behaviors, we need to assess their feelings and not what they assume to be true about science (i.e., their beliefs). In other words, we should seek their personal evaluation of science-related behaviors, apart from their perceptions of science as a societal or technical enterprise. Thus, including aspects of students’ knowledge about science, such as its usefulness, importance or relevance, into an attitude assessment may lead to incorrect conclusions about students’ attitudes.

As for the attitudes-beliefs relationship, Fishbein and Ajzen (1975) describe it in terms of an expectancy-value model. This model assumes that when a person has to make a behavioral choice, the individual will select the alternative having the highest subjective expected value, that is, the alternative likely to lead to the most favorable outcome. A person’s attitude toward an object is a function of his or her belief about the object’s attributes and an evaluation of those attributes. The underlying assumption is that evaluative judgments result from cognitive processes (i.e., making associations between the attitude object and valued attributes). Although beliefs and attitudes are interrelated, beliefs are primary and attitudes are secondary, according to Fishbein and Ajzen. Therefore, a person’s beliefs about science are the source of feelings toward science, which allows a student’s beliefs about science to contribute to the formation of his or her attitudes toward science.
Beliefs

According to Fishbein and Ajzen (1975), beliefs represent the information a person has about an object or idea. A belief links an object to some attribute associated with the object (Koballa, 1988). For instance, the object “science” is linked with characteristics such as important, relevant, or useful. The object, “money spent on science,” is associated with an attribute: “worth spending.” As Rokeach (1969) noted, “the content of a belief may describe the object as true or false, correct or incorrect” (p. 404). This implies that belief statements assess a person’s opinion on its nature (i.e., true or correct). However, beliefs do not trigger or involve emotion or feelings (i.e., attitudes) toward the object.

Beliefs are described as the probability of a relationship between the object of belief and many other objects, concepts, or goals (Andre, Whigham, Hendrickson, & Chambers 1999). They are the probability dimension of the relationship between two concepts. That is, is the relationship likely or unlikely? Thus, beliefs represent an individual’s evaluation of the relationship between the given object and the particular attribute associated with the object. For example, the United States (a concept) is related to the phrase “needs to have many more scientists” (another concept). In this example, evaluation is aimed at the relationship between the two concepts and not at the concepts. Response to this statement indicates how strongly a person believes in the expressed idea (i.e., that the US needs many more scientists). As opposed to an attitude statement, a belief statement does not evaluate an object.

Fishbein and Ajzen (1975) report that individuals learn or form beliefs about objects based on: (a) direct observation and (b) information received from outside sources, or (c) by way of various inference processes. However, more often beliefs are neither formed on the basis of direct experience with the object of the belief or by some inferential process. For example,
students may have little direct experience with claims such as “the United States needs to have many more scientists,” or “science has ruined the environment.” Instead, students often accept information about an object as provided by an outside source such as the media (e.g., books, newspapers, radio, TV, Internet) or other people (e.g., parents, teachers, or classmates). This may be particularly true of disciplines such as science where students have little or no relevant experience.

Students may conclude logically that science is important, based on their received information. Science is knowledge and most people agree that knowledge is important. However, no matter how this belief is formed (by direct observation, external source, or inferential process), it remains unrelated to students’ attitude toward science. Asking students to evaluate statements on the importance or relevance of science assesses their level of agreement with the statement, but not their feeling about science. According to Koballa and Crawley (1985), a belief is reserved for information that a person accepts to be true. A prominent attribute that distinguishes attitudes from beliefs is that attitudes engender a predisposition to respond emotionally, but beliefs do not.

Fishbein and Ajzen (1975) suggest that beliefs should first be assessed by a unipolar response to establish the link between an object and an attribute. Once the object-attribute link is established, belief statements can be rated on a probabilistic scale (e.g., agree-disagree, likely-unlikely, like-dislike) to measure belief strength. Therefore, statements evaluating the relationship between two concepts (e.g., “science” and “is relevant to everyday life”) measure the student’s perception regarding the strength of the given relationship. To determine if statements assess beliefs, it is recommended that each statement be prefaced with the phrase “I believe…” An example is, “I believe that science has ruined the environment.” Such a statement
represents a dimension of subjective probability relating science to an attribute (‘ruined the environment’). Students do not establish the existence of the relationship between the concepts (i.e., this has been done already by those who designed the statement). Students only evaluate the proposed relationship indicating to what extent they agree or disagree with the given statement.

The semantic meanings of statements are crucial in attitudinal measures and require special attention and care. The semantic meaning of some statements used in assessing students’ attitudes toward science urges students to demonstrate their knowledge about science. This knowledge may be acquired from external sources, developed by internal mental processes, or based on personal experiences. Thus, responses to such statements represent cognitive processes and not affective reactions to a target statement. If statements measure students’ evaluation of the relationship between science and other objects, concepts, and attributes they are belief items. Therefore, such statement should not be included in attitude toward science measurement.

The purpose of the study described here was to analyze a measure of students’ attitudes toward science that was reported by its’ developers to be a unidimensional scale.(Francis & Greer, 1999). Our use of the scale in a study of high school students’ affective experiences and behaviors in science classes led us to more closely examine the measure, the Attitudes Toward Science scale.

**Methods**

**Data Source**

Analyses were conducted using data collected as part of the SciMo project (Schmidt & Smith, 2008), which employed a variety of data-gathering techniques including the Experience Sampling Method, student surveys, teacher interviews, and live and videotaped classroom observations; however, the data for the study reported here pertains to a student attitudinal
survey. The purpose of the SciMo project was to learn more about the daily processes that contribute to high school students’ engagement in science. Students’ in-the-moment classroom experiences were recorded as they occurred to get a better understanding of their cognitive and affective engagement while learning high school science. Students’ attitudes toward science were assessed to determine the effects of science instruction on these attitudes.

Sample

The sample was 234 public school students (i.e., grades 9-12) from 12 science classrooms drawn from one northern Illinois suburban high school. There were 112 females and 122 males. The sample was comprised of 102 students from 9th grade, 45 from 10th grade, 79 from 11th grade, and 8 students from 12th grade. Ethnically, the sample had: 42% Latino (state 23%); 37% Caucasian (state 51%), 12% African American (state 18%), 2% Asian American (state 4%), 1% Native American (state 10%), and 6% multi-racial (state 3%) (Illinois Interactive Report Card, 2011).

Instrument

Students’ attitudes toward and beliefs about science were measured by the Attitudes Toward Science (ATS) scale (Francis & Greer, 1999). The instrument contains 20 items on a 4 point Likert-type scale ranging from 1 = strongly disagree to 4 = strongly agree (see Table 1). According to Francis and Greer, the 20 items of the scale were culled from an original batch of 62 science-related questions. The initial 62 questions contained items indicative of cognitive and behavioral dimensions. A close reading of the final 20 items on the ATS scale suggested that many of these items expressed independent belief statements that were interwoven with attitudinal statements. Thus, to distinguish attitude items from belief items, the current study used three criteria derived from the literature for assessing attitudes. First, an attitude refers to
how an individual feels about performing a behavior (Jaccard, Litardo, & Wan, 1999). Second, attitudinal statements cannot be factual (Edwards, 1957) because assessing one’s agreement with factual statements does not yield accurate information about personal feelings toward the attitudinal object. Third, attitudes are learned through some prior experience with the target object (Koballa, 1988), so attitudinal statements should describe a previous experience with which students can associate.

**Results**

One purpose of this study was to use sample-based data from the ATS scale to test dimensionality pertaining to determine if the one-factor structure (i.e., attitudes) developed by Francis and Greer (1999) was a proper model fit or if the *a priori*, literature-based proposed two-factor model, comprised of attitudes and beliefs, was a more appropriate fit for the sample data. The concept of model fit was operationalized via the use of fit indices indicating that one model, compared to its rival, was stable with its data, yet not perfect and assumed a reasonable amount of error, but not so error-laden as to necessitate re-specification. Once the two rival models were compared via measures of fit indices using Confirmatory Factor Analysis (CFA) to determine how well a particular model fit the data, a second purpose of the study emerged. This purpose was to make a decision about the number of factors, and their relational properties, which supported the set of measured items for the final model chosen. Criteria for the number of factors and the structure of the solution were: (1) eigenvalues; (2) pattern coefficients; (3) structure coefficients; and (4) communality measures.

**Descriptives**

In terms of subject to item ratio to determine the *a priori* sample size needed to conduct a factor analysis, the literature indicates that a 10:1 ratio is desired (Costello & Osborne, 2005). The current study’s ratio was over 12:1. Descriptive statistics related to the sample’s responses
from the 20-item instrument are seen in Table 1, which indicates that the data were normally distributed with the highest values of skewness (1.03) and kurtosis (4.72) -- well within Kline’s (1998) cut-points of skew < 3.00 and kurtosis < 8.00 -- which indicated that there was no evidence of univariate non-normality. Data were screened for instances of multicollinearity via analysis of tolerance (TOL) and variance inflation factor (VIF). Multicollinearity was not present as all TOL indices were > .10 (i.e., the smallest = .25) and all VIF measures were < 4.00 (i.e., the largest = 3.95), which met noted cut-off points of not > .10 and < 10.00 for the two indices, respectively (Belsley, Kuh, & Welsch, 1980; Hair, Anderson, Tatham, & Black, 1995). Relationally, the Kaiser-Mayer-Olkin (KMO) value, which is often employed within factor analytic studies to discern the sufficiency of the sample-based data under study, was = .91. Barco, Castano, Carroza, Delgado, and Perez (2007) found that KMO values ≥ .90 indicated sufficient data conformity for factor analysis. Thus, given the results from the various tests conducted pertaining to the normal distribution of the data, maximum likelihood estimation was used for the CFA (Fabrigar, Wegener, MacCallum, & Strahan, 1999).

**Model Fit Indices**

Model fit indices were used to determine how closely a model represented the data and also how multiple models’ fit indices compared to one another. Three categories of fit indices were employed using two measures from each group: incremental or relative, absolute, and comparative. As relative fit measures, the Incremental Fit Index (IFI) and the Comparative Fit Index (CFI) were employed. For both indices, the proposed model should compare very well to, or exceed, a null model per the cut-off point ≥ .90, which indicates reasonable fit of the model (Kline, 1998; Schumacker & Lomax, 1996). The root mean square error of approximation
(RMSEA) and the standardized root mean square residual (SRMR) were used as absolute fit measures to assess the models under study in terms of badness-of-fit. RMSEA scores of .05, .08, and .10 have been suggested to represent the magnitude of population misfit, where lower values < .05 indicate close model fit and higher values between .05 and .10 indicate a sliding scale of increasing, yet reasonable error (Browne & Cudeck, 1993; Hu & Bentler, 1998). For the SRMR, desired cut-off values have been noted at the levels of .05, .08, and .10 as well (Garson, 2008). The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) were used as measures of comparative fit between the two estimated models, where the model with the lower index value is deemed the better of the two models in terms of data fit (Kenny, 2011).

One-Factor Model

Looking at Table 2, the one-factor model did not meet the suggested cut-off values (i.e., \( \geq .90 \)) for the IFI (.71) or the CFI (.71) as measures of incremental fit. For the absolute fit indices, the SRMR (.13) and the RMSEA (.14) values were well-above the suggested cut-off points of \( \leq .05, .08, \) and .10. For the comparative measures, the AIC (834.73) and the BIC (900.38) values were comparatively much higher than those from the two-factor model. Given this trend in results, it was concluded that the one-factor model, in totality, had varied problems with model misspecification and did not fit the data and, thus, would not be pursued as a viable, correctly-specified model.

Two-Factor Model

The two-factor model had incremental fit indices values for the IFI (.89) and the CFI (.89) that were a touch short of the suggested cut-off of \( \geq .90 \). The RMSEA value of .10 and the SRMR value of .09 were at or below the last of the suggested array of values of \( \leq .05, .08, \) or .10.
The AIC (480.94) and the BIC (546.59) values were nearly half of the size of the values found in the one-factor model.

Regarding the entire model findings, results from Table 2 suggested that the two-factor model fit the data reasonably well, when compared to the one-factor model, and should be pursued further with the current CFA analysis. To be sure, it was evident that most of the fit indices for the two-factor model were near to and/or at the suggested threshold values, which potentially signified a model that may incorporate some specification error. However, as is the case with some sets of guidelines provided in social science research, such as effect size measures, threshold values used with indicators of the goodness- or the badness-of-fit for a model serve as suggestions only and should be understood and evaluated as evidence of model fit, or lack thereof, within the context of the totality of data presented.

[Insert Table 2 about here]

**CFA**

A CFA with an oblique rotation, which was hypothesized as correlated factors and then verified via a correlational analysis, indicated that the attitudes and beliefs factors were statistically significantly related ($r = .503, p < .001$), and this was employed to examine the structure and loadings of the proposed two-factor model. Based on eigenvalue data, two interpretable factors emerged: attitudes toward science and beliefs about science. The attitudes factor accounted for 38.62% of item variance and the beliefs factor accounted for 12.94% of item variance or 51.56% for the entire two-factor solution. Eleven items comprised the attitudes factor while eight items constituted the beliefs factor (see Table 3). There was one item (question 20) associated with the original 20-item scale that was not retained as a viable measure affiliated
with the two-factor solution because its factor loading was extremely low (.12) and did not meet the \textit{a priori} threshold of $\geq .40$ for item salience (Ford, MacCallum, & Tait, 1986).

[Insert Table 3 about here]

With a model consisting of correlated factors, pattern (P) and structure (S) coefficients were examined (cf. Thompson, 1997). Data from Table 3 indicated that pattern coefficients, which measure the unique relationship between each factor and an item, for the two-factor solution, ranged from .45 to .89 with an average of .68. Additionally, structure coefficients, which are the correlations between factors and items, ranged from .44 to .86 with an average of .69. Comprehensively, 100\% of the ATS items had a coefficient $\geq .40$ for item salience (Costello & Osborne, 2005; Tabachnick & Fidell, 2001), which indicated that all of the scale’s items contributed, via a sufficient range of magnitude, to each of the two factors. There was evidence of convergent validity where correlated variables, meeting item salience, had sufficient factor coefficients on one factor and a minimal amount on the other factor. Based on the pattern coefficients by factor, the attitudes factor ranged from .45 to .89, with an average of .74, and the beliefs factor ranged from .46 to .77 with an average of .60. For the structure coefficients, the attitudes factor ranged from .44 to .86, with an average of .74, and the beliefs factor ranged from .44 to .82 with an average of .62. Thus, both of the factors in the oblique two-factor solution exhibited moderate to high pattern and structure coefficients.

Further, communalities ($h^2$), which are the proportion of each item explained by a factor, were computed and indicated typically observed magnitudes in social science research of between .40 to .70 per factor without marginal cross-loadings on the other factor (Costello & Osborne, 2005). The overall two-factor solution’s communalities ranged from .20 to .74 with an average of .52. The attitudes factor had $h^2$ values ranging from .20 to .74, with an average of .57,
and the beliefs factor had $h^2$ values ranging from .20 to .70 with an average of .44. Individually, item 19 had the highest $h^2$ value = .74 and both items 6 and 13 had the lowest $h^2 = .20$.

**Reliability**

Items from the ATS scale were examined by computing internal consistency estimates of reliability via Cronbach’s alpha coefficient ($\alpha$) with 95% confidence intervals (CI) (cf. Fan & Thompson, 2001). A recommended cut-off value for score reliability derive from survey research and/or used in applied settings is $\alpha \geq .80$ (Henson, 2001; Nunnally, 1978). The score reliability for the entire scale was $\alpha = .90$ (CI = .88, .92) and for the two subscales comprised of attitudes was $\alpha = .92$ (CI = .90, .93) and beliefs was $\alpha = .80$ (CI = .76, .84), which signified that there was high internal consistency and the items that comprised each factor shared a large percentage of the variance.

**Conclusions**

The present study determined, through a CFA, that the ATS scale assessed both high school science students’ attitudes toward and their beliefs about science. The results demonstrated that the ATS should not be considered unidimensional in terms of items’ content, but as a multidimensional structure consisting of two factors: attitudes toward science and beliefs about science. Because students’ attitudes toward science and beliefs about science represent distinct psychological variables, these constructs should be assessed independently. That is, the semantic meanings of scale items such as “I very much look forward to science lessons and activities in school,” and “Science is very important to the future of the U.S.” serve to trigger at least two independent notions in students’ minds (e.g., science in school as behavior, and the value of science for the society). Therefore, students’ responses tend to represent their evaluation of two distinct concepts. While the former concept measures their attitudes toward the science-
related activities they experience at school, the latter measures their beliefs about the nature and value of science in general.

The findings derived from this study are consistent with Fishbein and Ajzen’s (1975) expectancy-value model of attitudes. An expectancy-value model assumes that when an individual has to make a behavioral choice, he or she will select the alternative that has the highest subjective expected value. Additionally, this model choice explains the beliefs-attitudes relationship in the sense that a student’s attitude toward an object is a function of his or her belief about the object’s attributes and evaluation of those attributes. According to the current study’s two factor model, students’ attitudes toward science appeared to be influenced by their beliefs that evaluate the nature and value of science in society. The results of the present study, however, suggest that students with positive beliefs about science are likely to have positive attitudes toward science learning. Thus, it may be desirable for science educators to attempt to instill strong positive beliefs about science among students. Such positive beliefs may then yield more positive attitudes toward science. As a result of holding more positive attitudes, students’ motivation to learn science may be enhanced and their subsequent achievement improved.

Additionally, the present investigation has implications for studying and understanding students’ beliefs regarding science. Researchers and educators should direct their attention to students’ beliefs about science. This is important because beliefs represent, in part, students’ knowledge about the subject as well as their opinions related to the importance of the topic. Hopefully, science instruction conveys to students that science is important to understand. Further, examining the relationships between students’ beliefs about science and their academic achievement in this area, as well as their likelihood of pursuing a science major in college and a science-based career, is important because beliefs may highly correlate with students’ behaviors.
That is, students may elect to pursue science-based careers because they believe that science is an important endeavor to undertake (Bryan, Glynn, & Kittleson, 2011; Menis, 1989).

In connection to the current research, a number of studies have assessed secondary school-level students’ beliefs about science in the very recent past related to various domains. Some investigations have focused on students’ epistemological beliefs and science learning (Conley, Pintrich, Vekiri, & Harrison, 2004; Sandoval, 2003). Other studies have assessed students’ content knowledge in science (Stein & Goetz, 2008); students’ level of involvement in science as a transformative experience (i.e., engagement) encompassing the cognitive, affective, and behavioral domains (Pugh, Linnenbrink-Garcia, Koskey, Stewart, Manzey, 2010); curricular re-design predicated on the employment of project-based applications and discussions with students studying science (Alozie, Moje, & Krajcik, 2010); and the positive relationship between science students’ self-efficacy, as a motivational factor to learn science, and their overall science achievement as measured via Advanced Placement (Bryan et al., 2011). Thus, from the recent scholarly literature in this area as well as the results from the current study, it is becoming clearer that educational programs and practices, which highly correlate with students’ beliefs about science either by design or unintentionally, might bear greater scrutiny to determine how these programs and practices may affect changes in students’ beliefs, serve to confirm students’ beliefs, or debunk and disconfirm students’ misconceptions.

Limitations

The present study had some limitations. First, generalization of these results to the larger secondary school population throughout the United States should be done with caution because the study’s sample was derived from schools within Illinois, which may not be entirely representative of the rest of the U.S. Second, attitudes and beliefs were not observed directly;
instead, they were gathered as self-reports through surveys, which can lend itself to perceptual bias and possibly threaten the validity of the data. Lastly, the sample employed was unbalanced in terms of the proportionality between sub-samples of freshman, sophomores, juniors, and seniors, which may have influenced, at some level, the response data garnered.

**Future Research**

Further research examining the within-and out-of-school factors that influence both student’s attitudes toward and beliefs about science is warranted. It is recommended that science educators and researchers investigate students’ beliefs about science as distinct from their attitudes toward science. Students’ beliefs about science have been neglected somewhat in the literature as more studies have focused on science teachers’ beliefs (Atwater, Gardner, & Kight, 1991; Bryan & Atwater, 2002; Gess-Newsome, 1999; Lumpe, Haney, & Czeniak, 2000). Studies should also investigate factors that relate to students’ beliefs about science, as well as their attitudes toward science, and how these factors may differentially influence and/or predict science achievement and desire to pursue science as a career. Reid (2011), for example, notes that there is no evidence that poor attitudes toward science are causing students to turn away from studying science. He suggests, rather, that negative attitudes toward science result from the ways science is presented at school. Inadequate curricula, poorly prepared teachers, and inappropriate assessments may be culprits in students’ poor attitudes. Finally, Reid also suggests that researchers should examine how students’ beliefs about science, attitudes toward science, and their intention to perform science-related behaviors are related to their science achievement. The findings of such investigations could help us better understand students’ actions regarding science learning and predict their science-related behaviors.
References


Table 1

Descriptive Statistics of Items on the ATS Scale

<table>
<thead>
<tr>
<th>Item</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Science has ruined the environment*</td>
<td>3.14</td>
<td>0.66</td>
<td>-0.33</td>
<td>-0.76</td>
</tr>
<tr>
<td>2. Science that is taught in school is fun and interesting</td>
<td>2.62</td>
<td>0.74</td>
<td>-0.47</td>
<td>-0.12</td>
</tr>
<tr>
<td>3. Science is relevant to everyday life</td>
<td>3.03</td>
<td>0.77</td>
<td>-0.67</td>
<td>0.10</td>
</tr>
<tr>
<td>4. Working in a science lab would be an interesting job for me</td>
<td>2.22</td>
<td>0.93</td>
<td>-0.22</td>
<td>0.47</td>
</tr>
<tr>
<td>5. Science is very important to the future of the U.S.</td>
<td>3.26</td>
<td>0.70</td>
<td>-1.04</td>
<td>1.13</td>
</tr>
<tr>
<td>6. Science is difficult subject for me to learn*</td>
<td>2.52</td>
<td>0.85</td>
<td>-0.07</td>
<td>-0.66</td>
</tr>
<tr>
<td>7. Money spent on science is well worth spending</td>
<td>2.77</td>
<td>0.70</td>
<td>-0.49</td>
<td>0.20</td>
</tr>
<tr>
<td>8. I’d like to understand more about scientific explanation for things</td>
<td>2.51</td>
<td>0.86</td>
<td>-0.17</td>
<td>-0.81</td>
</tr>
<tr>
<td>9. In my future career, I’d like to use the science I am learning in school</td>
<td>2.04</td>
<td>0.83</td>
<td>0.31</td>
<td>-0.95</td>
</tr>
<tr>
<td>10. Studying science in school is something that I love to do</td>
<td>1.94</td>
<td>0.96</td>
<td>-0.72</td>
<td>4.72</td>
</tr>
<tr>
<td>11. Science will help to make the world a better place in the future</td>
<td>3.02</td>
<td>0.69</td>
<td>-0.58</td>
<td>0.36</td>
</tr>
<tr>
<td>12. I very much look forward to science lessons and activities in school</td>
<td>2.18</td>
<td>0.83</td>
<td>0.12</td>
<td>-0.90</td>
</tr>
<tr>
<td>13. Science discoveries do more harm than good*</td>
<td>2.96</td>
<td>0.64</td>
<td>-0.38</td>
<td>0.12</td>
</tr>
<tr>
<td>14. I don’t have much interest in science*</td>
<td>2.49</td>
<td>0.94</td>
<td>-0.13</td>
<td>-1.03</td>
</tr>
<tr>
<td>15. Science and technology are the cause of many of the world’s problems*</td>
<td>2.83</td>
<td>0.68</td>
<td>-0.12</td>
<td>-0.05</td>
</tr>
<tr>
<td>16. Science is a school subject that I enjoy</td>
<td>2.34</td>
<td>0.88</td>
<td>-0.13</td>
<td>-1.00</td>
</tr>
<tr>
<td>17. The U.S. needs to have many more scientists</td>
<td>2.73</td>
<td>0.71</td>
<td>-0.13</td>
<td>-0.41</td>
</tr>
<tr>
<td>18. I’d seriously consider becoming a scientist when I finish school</td>
<td>1.57</td>
<td>0.67</td>
<td>1.03</td>
<td>0.29</td>
</tr>
<tr>
<td>19. I would like to study science more deeply than I do now</td>
<td>1.86</td>
<td>0.82</td>
<td>0.60</td>
<td>-0.64</td>
</tr>
<tr>
<td>20. Science is difficult for me when it involves doing math*</td>
<td>2.82</td>
<td>1.00</td>
<td>-0.46</td>
<td>-0.98</td>
</tr>
</tbody>
</table>

* These items were reverse coded
Table 2

*Fit Indices*

<table>
<thead>
<tr>
<th>Model</th>
<th>IFI</th>
<th>CFI</th>
<th>SRMR</th>
<th>RMSEA</th>
<th>AIC</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-Factor</td>
<td>.71</td>
<td>.71</td>
<td>.13</td>
<td>.14</td>
<td>834.73</td>
<td>900.38</td>
</tr>
<tr>
<td>Two-Factor</td>
<td>.89</td>
<td>.89</td>
<td>.09</td>
<td>.10</td>
<td>480.94</td>
<td>546.59</td>
</tr>
</tbody>
</table>
Table 3

*Two-Factor Model Measures: Pattern Coefficients (P), Structure Coefficients (S), and Communalities (h²)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor</th>
<th>P</th>
<th>S</th>
<th>h²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Science has ruined the environment</td>
<td></td>
<td>.67</td>
<td>.63</td>
<td>.41</td>
</tr>
<tr>
<td>3. Science is relevant to everyday life</td>
<td></td>
<td>.46</td>
<td>.54</td>
<td>.38</td>
</tr>
<tr>
<td>5. Science is very important to the future of the USA</td>
<td></td>
<td>.64</td>
<td>.69</td>
<td>.50</td>
</tr>
<tr>
<td>7. Money spent on science is well worth spending</td>
<td></td>
<td>.64</td>
<td>.70</td>
<td>.52</td>
</tr>
<tr>
<td>11. Science will help to make the world a better place in the future</td>
<td></td>
<td>.77</td>
<td>.82</td>
<td>.70</td>
</tr>
<tr>
<td>13. Science discoveries do more harm than good</td>
<td></td>
<td>.47</td>
<td>.44</td>
<td>.20</td>
</tr>
<tr>
<td>15. Science and technology are the cause of many of the world’s problems</td>
<td></td>
<td>.62</td>
<td>.57</td>
<td>.35</td>
</tr>
<tr>
<td>17. The United States needs to have many more scientists</td>
<td></td>
<td>.52</td>
<td>.60</td>
<td>.46</td>
</tr>
<tr>
<td>Attitudes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Science that is taught in school is fun and interesting</td>
<td></td>
<td>.61</td>
<td>.66</td>
<td>.46</td>
</tr>
<tr>
<td>4. Working in a science lab would be an interesting job for me</td>
<td></td>
<td>.71</td>
<td>.70</td>
<td>.49</td>
</tr>
<tr>
<td>6. Science is difficult subject for me to learn</td>
<td></td>
<td>.45</td>
<td>.44</td>
<td>.20</td>
</tr>
<tr>
<td>8. I’d like to understand more about scientific explanation for things</td>
<td></td>
<td>.67</td>
<td>.72</td>
<td>.55</td>
</tr>
<tr>
<td>9. In my future career, I’d like to use the science I am learning in school</td>
<td></td>
<td>.80</td>
<td>.80</td>
<td>.64</td>
</tr>
<tr>
<td>10. Studying science in school is something that I love to do</td>
<td></td>
<td>.76</td>
<td>.76</td>
<td>.58</td>
</tr>
<tr>
<td>12. I very much look forward to science lessons and activities in school</td>
<td></td>
<td>.85</td>
<td>.85</td>
<td>.73</td>
</tr>
<tr>
<td>14. I don’t have much interest in science</td>
<td></td>
<td>.74</td>
<td>.74</td>
<td>.54</td>
</tr>
<tr>
<td>16. Science is a school subject that I enjoy</td>
<td></td>
<td>.84</td>
<td>.86</td>
<td>.73</td>
</tr>
<tr>
<td>18. I’d seriously consider becoming a scientist when I finish school</td>
<td></td>
<td>.80</td>
<td>.77</td>
<td>.60</td>
</tr>
<tr>
<td>19. I would like to study science more deeply than I do now</td>
<td></td>
<td>.89</td>
<td>.85</td>
<td>.74</td>
</tr>
</tbody>
</table>