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Assessing high school students' attitudes toward chemistry with a shortened semantic differential

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Abstract: Aims of science education are concerned not only with students' cognition but also with students' affect, an umbrella term for emotions, feelings, moods, and attitudes. Many studies have been conducted on student attitudes toward learning science in general; however, studies concerning attitudes toward chemistry are limited in number. The purpose of this research was to adapt and use the shortened version of Bauer's semantic differential, ASCIv2 (Attitude toward the Subject of Chemistry Inventory version 2), developed and validated by Xu and Lewis (2011). Following the translation and adaptation procedures, the inventory was administered to a total of 503 high school students at four public schools in Turkey. Factor analysis was conducted to explore the internal structure of the instrument and compare factors across cultures. The results showed that the two-factor structure of the ASCIv2 measuring intellectual and emotional attitudes was valid. The alpha values suggested strong internal consistency for the instrument. According to descriptive analyses, the students in the sample had average intellectual (M = 3.60, SD = 1.47) and emotional (M = 3.93, SD = 1.75) attitudes. Univariate analyses of variance demonstrated that former success in chemistry courses as well as achievement in middle school had effects on high school students' intellectual and emotional attitudes toward chemistry. This finding supports the pattern established by previous research, suggesting that attitude and achievement are related. Conducted in a culturally and linguistically different context, this research confirms and provides strong evidence that the instrument yields reliable scores in diverse settings.

Introduction

In many countries around the globe, national reports and research documents highlight low interest or declining numbers of young people choosing to pursue careers in science. For instance, it is reported that in the United States (U.S.) certain science and engineering fields (i.e., physical sciences) continue to receive lower attention from freshmen (National Science Board [NSB], 2012). On the other hand, a common alerting trend in European countries is that the more advanced a country is, the more negative attitudes its students have toward school science (Osborne & Dillon, 2008). A number of studies in science education provide empirical evidence that beliefs about consequences of pursuing science are important determinants of enrolling in science (i.e., Crawley & Black, 1992). One of these studies conducted in Denmark as longitudinal research reveal that students not choosing to pursue STEM (science, technology, engineering and mathematics) perceive these fields as rigid, fixed, and too narrow to allow for constructing a desirable identity (Holmegaard, Madsen, & Ulriksen, 2014). The researchers also draw attention to students choosing to pursue science, expressing their experiences as fixed and de-contextualized STEM education in their first year at university – hence their disappointment and risk of dropping out.

Potvin and Hasni (2014) have recently produced a comprehensive synthetic description of 228 research articles published between years 2000 and 2012 on interest, motivation and attitude of K-12 students towards science and technology. Among the many findings, the synthesis confirms that interest, motivation, and attitudes decline with school years, especially from elementary to middle school. This trend raises issues about how science and technology is taught in schools, suggesting that there may be a gap between what a school focuses on and what students prefer. In this vein, to explore possible shifts in attitudes towards and aspirations in science over the primary-secondary school divide, a large-sample study in England was conducted with over 9000 students in their last year in primary school and then again with the same cohort of students in their second year in secondary school (DeWitt, Archer, & Osborne, 2014). Findings from this research support Potvin and Hasni's observation to a certain degree in that students progressing to secondary school continue to hold low aspirations in science. Yet, this research reports that students' attitudes toward science remain positive in secondary school.

It is well recognized in the literature that affective components such as interest, attitude, and motivation play an important role in students' decisions of whether or not to engage in science. Research has also established that certain affective variables are influential in students' developing conceptual understanding over time (Nieswandt, 2007), and that affect plays a role even after controlling for cognition (Lewis, Shaw, Heitz, & Webster, 2009). Therefore, aims of science education are concerned not only with students' cognition but also with students' "affect," a key term usually used as a synonym to "emotions" (Reiss, 2005). One major finding in Potvin and Hasni's (2014) synthesis is that efforts to enhance interest, motivation, and attitudes in science usually produce desired results. In other words, many interventions are reported to positively influence students' affect.

Science educators consider interest, motivation, attitudes, beliefs, self-confidence and self-efficacy as constructs of the affective domain (Alsop, 2003). Of these, attitudes toward science have been the particular focus of research in science education concerning affect (Alsop, 2005). Based on earlier work of educational theorists, Nieswandt (2005) defines attitude as "a predisposition to respond positively or negatively to things, people, places or ideas" (pp. 41-42). As such, attitudes of students toward science involve students' predispositions to respond to science and scientists based on the views and images they develop as a result of relevant experiences (Ramsden, 1998).

Student Attitudes toward Chemistry

Numerous studies have been conducted on student attitudes toward learning science in general; however, there are a limited number of studies focusing on attitudes toward chemistry. Among pioneering research in the topic is the study conducted by Hofstein, Ben-Zvi, Samuel, and Tamir (1977) with Israeli high-school students (ages 16-18). In this comparative study, the researchers found that students held more positive attitudes toward chemistry than physics. The researchers also concluded that chemistry was considered less masculine than physics and that girls had at least as positive attitudes toward chemistry as boys. Another study conducted recently with high-school students (ages 16-19) in Hong Kong revealed that students were only marginally positive about chemistry lessons (Cheung, 2009). Cheung's gender-related findings about chemistry attitudes were dependent on grade level. In other words, females' and males' attitudes from junior to senior grades changed in a different manner. For example, in earlier grades, male students liked theory lessons more than females but gender differences decreased as students progressed through secondary schooling.

Research conducted in Greece examined Greek high school students' (ages 16-17) attitudes toward the difficulty, the interest, the usefulness of chemistry courses, and the importance of chemistry in the students' life (Salta & Tzougraki, 2004). The findings suggested that Greek students had neutral attitudes regarding the difficulty of and interest in chemistry courses, that they did not find chemistry as useful for their future career but recognized its importance in everyday life. Lang, Wong, and Fraser (2005), in their study about gifted and non-gifted high school students' (average age of 15-16 years) attitudes toward chemistry in Singapore, reported associations between open-ended chemistry laboratory environments, dynamic teacher-student interactions, and enhanced student attitudes toward chemistry, especially for the gifted groups.

A limited number of experimental studies also report the effect of interventions on students' chemistry attitudes. For instance, Sarantopoulos and Tsaparlis (2004) found that using analogies in chemistry teaching helped to improve high school students' (10^{th} and 11^{th} grade) views toward chemistry as well as their achievement. Furthermore, students at the concrete developmental level were found to benefit more from the analogies and to develop more positive opinions. In their study with first-year college students, Brandriet, Xu, Bretz, and Lewis (2011) suggested that there was a statistically significant attitude change after a one-semester inquiry-based learning pedagogy implemented in general chemistry courses, and that this change was in favor of low-achieving students. The researchers also found that, in general, females had less favorable attitudes towards chemistry than males.

Assessment of Chemistry Attitudes

Diagnostic assessment in chemistry education is an assessment approach that encourages chemistry teachers and educators to act like "learning doctors" who could diagnose and respond to student ideas that might interfere with intended learning (Taber, 2002). Concerned with student misconceptions, or ideas that do not align well with commonly accepted scientific understandings, diagnostic assessment has been often attributed to the cognitive domain. However, Brandriet, et al. (2011) argue that "attitudinal assessments can also be valuable in the diagnostic sense" (p. 271).

There exists a wide range of attitudinal assessment measures toward science in general. Most commonly, science attitudes are measured through questionnaires consisting of Likert-scale items that require students to respond based on five options such as "strongly agree/agree/not sure/disagree/strongly disagree" (Osborne, Simon, & Collins, 2003). Given the limited number of studies that focus on student attitudes toward chemistry, in particular, the measures specific to chemistry attitudes are also scarce. Of the available measures, nearly all are Likert-scale instruments. For instance, the Chemistry Attitude Scale (CAS) used by Hofstein et al. (1977) is a 76-item five-point Likert-scale instrument. Similarly, the Questionnaire on Chemistry-Related Attitudes (QOCRA), a shortened and modified version of the Test of Science-Related Attitudes (TOSRA) originally developed by Fraser (1981), consists of 30 Likert-scale items (Lang, et al., 2005). Another 30-item Likert-scale instrument is the questionnaire developed in the Greek language by Salta and Tzougraki (2004), which requires respondents to rate the items based on a five-point scale. The Attitude Toward Chemistry Lessons Scale (ATCLS) developed by Cheung (2007) in Chinese is a Likert-scale measure consisting of seven-point 12 items.

A less-widely used format known as semantic differential in attitude research requires respondents to express their attitude relative to two opposite adjectives. In general, this format of assessment includes fewer items and requires shorter time to respond as compared to a typical Likert-scale measurement. Among researchers, there are different views about the appropriateness of attitude measures. Some find that Likert scales produce the highest reliability among other formats (Simpson & Oliver, 1990), and others suggest that a semantic differential format may effectively reduce acquiescence bias when measuring positive psychological constructs (Friborg, Martinussen, & Rosenvinge, 2006). Brandriet et al. (2011) argue that it is important to use instruments that avoid redundancy and assessment fatigue in order to obtain quality data. Furthermore, it could especially become critical to use shorter assessments with high school students who may experience fatigue in reading and responding to long questionnaire items more often than adults. As long as the measurements are reliable and valid, shorter instruments could also be useful in terms of being administered in a minimal amount of time.

In chemistry education, Dalgety, Coll and Jones (2003) used a semantic differential format to develop items to measure attitudes toward chemistry and chemistry self-efficacy as part of their Chemistry Attitudes and Experiences Questionnaire (CAEQ). Appropriate for use at the tertiary school level, the attitude subscale includes 21, and the self-efficacy subscale includes 17 polar adjectives to be rated on a seven-point semantic differential scale. The Attitude Toward the Subject of Chemistry Inventory (ASCI) developed by Bauer (2008) to measure student attitudes toward chemistry as a discipline has also a semantic differential format and includes 20 adjective pairs. This initial version of the ASCI was recently used to quantify chemistry attitudes of college level students in the Pacific Islands (Brown et al., 2014). In 2011, the ASCI was refined by Xu and Lewis by reducing the number of items and conducting reliability and validity work. The revised version of the ASCI is referred to as ASCIv2 (Attitude toward the Subject of Chemistry Inventory version 2) and includes eight adjective pairs.

Purpose of Research

The present study is concerned with high school students' attitudes toward chemistry. Given the value of using shorter measures at the high school level requiring minimal administration time and avoiding assessment fatigue, the ASCIv2 instrument was considered to be an appropriate tool to accomplish the research purposes. Bauer (2008) also indicates that the vocabulary and the reading level of the instrument may be appropriate for upper secondary level students. The ASCIv2 is composed of polar adjectives, and it is thought that the adjectives could be understandable by a high school age population. The goals of this research study were (1) to adapt and further validate the shortened version of Bauer's semantic differential, ASCIv2, and to evaluate its quality for the high school student sample, and (2) to examine high school students' attitudes toward chemistry.

Methods

The Instrument

The ASCIv2 includes eight items that consist of pairs of polar adjectives on a seven-point semantic differential scale. For example, students are asked to indicate whether they think chemistry is easy (position 1), hard (position 7), or somewhere in between. The adjectives and the position choices are placed on the same line, with some of the positive adjectives on the left side and some on the right side. This, according to Bauer (2008), reduces the risk of falling into a pattern of acquiescence. In the directions section above the items, students are asked to express their attitudes toward chemistry as a body of knowledge and not their feelings about their chemistry teachers or particular chemistry courses.

In the study by Xu and Lewis (2011), the ASCIv2 was shortened from its original 20-item form and five latent constructs to eight items in two factors. Each of the factors, "Intellectual Accessibility" and "Emotional Satisfaction," includes four items (Table 1). Both the original and the shortened instrument were developed and validated with college chemistry students, who were enrolled in general chemistry or general chemistry laboratory courses in different universities in the United States (Bauer, 2008; Brandriet, et al., 2011; Xu & Lewis, 2011).

Table 1. *Items under the factors Intellectual Accessibility and Emotional Satisfaction of the original ASCIv2*

Intellectual Accessibility	**Emotional Satisfaction**
Hard-Easy	Uncomfortable-Comfortable
Complicated-Simple	Frustrating-Satisfying
Confusing-Clear	Unpleasant-Pleasant
Challenging-Unchallenging	Chaotic-Organized

To adapt the instrument to Turkish context, translation of the adjective pairs was undertaken by language teaching experts who were fluent in both English and Turkish languages. A total of three Turkish language teaching experts and four English language teaching experts, who were all faculty members, worked to translate the adjectives to best match their meaning in the Turkish language. Two of the English language teaching experts were also experienced in attitude research. The author, a chemistry educator, worked on the final form of the instrument, based on the experts' translations ensuring that the adjectives could be used in describing chemistry. Including instructions, the survey form was given its final shape based on the physical design features suggested by Bauer (2008).

Participants

The ASCIv2 was administered to a total of 503 high school students in Grades 10-12 (ages 16-18) at four public schools in an urban area in northwestern Turkey. One of the schools was a science high school, a type of high school where science and mathematics education is given emphasis and students are prepared for higher education in STEM fields. This high school was the only one of its type in the province. Science high schools in Turkey, not many in number, are known for their success in the national university entrance examinations. The other three schools in the sample were Anatolian high schools with student populations of varying achievement levels. Table 2 shows the frequency distribution of students' demographic characteristics in the sample.

Table 2. *Frequency distribution of student demographic characteristics*

	f	%	Valid %	Cumulative %
Gender				
Female	242	48.1	50.9	50.9
Male	233	46.3	49.1	100.0
Total	475	94.4	100.0	
Missing	28	5.6		
Grade Level				
10	176	35.0	35.8	35.8
11	162	32.2	33.0	68.8
12	153	30.4	31.2	100.0
Total	491	97.6	100.0	
Missing	12	2.4		
School Type				
Science H.S.	208	41.4	41.4	41.4
Anatolian H.S.	295	58.6	58.6	100.0
Total	503	100.0	100.0	

Anatolian high schools and science high schools in Turkey are two among six types of non-vocational high schools (science, social science, Anatolian, Anatolian teacher, sports, fine arts) (Milli Eğitim Bakanlığı-Ortaöğretim Genel Müdürlüğü [MEB-OGM], n.d.). Social science and Anatolian teacher high schools are schools where emphasis is placed on social sciences and teacher preparation, respectively. Sports high schools and fine arts high schools accept students via performance evaluation and interviews. Thus, these four types of high schools were not included in the study. Admission to both science high schools and Anatolian high schools are based on scores that students get from centralized examinations conducted nationwide. In

Anatolian high schools, students decide to pursue science-mathematics or non-science-mathematics tracks upon completion of Grade 9. Thus, Anatolian high school students in Grades 10-12 who had decided for science-mathematics tracks were included in the study. Data analysis was planned to include investigation of the effect of school type (science or Anatolian high school) on attitudinal variables.

Data Collection

Prior to the study being conducted, all documentation required by the Provincial Directorate of National Education was submitted, and permission was obtained to collect data in the high schools. A consent form was prepared in which the students were informed about the purpose of the research and the procedure to be followed to fill in responses. The consent form included a statement that participation was voluntary and that the students were not going to be asked for any personally identifiable information. The researcher's contact information was provided in case a question or problem arose.

With help of teachers, the inventory was given to intact classes in paper-and-pencil format during the fall semester of 2012. Students who volunteered to participate completed the survey in approximately 3 minutes by placing their responses on the sheet. Besides rating their feelings of chemistry on the semantic differential scale, the students were asked to mark their grade level and gender on given options as well as to provide their final course mark for chemistry in the previous year and the score they had obtained from the end-of year achievement test (AT)[1] upon completion of middle school (Grade 8). Students' names or other personal identity information were not asked. In total, on the survey there were four questions concerned with demographics and achievement (grade level, gender, previous year chemistry course mark, AT score) and a total of eight items in semantic differential format. Additionally, the school names were noted for further coding of the school type variable. The eight items in semantic differential format included two polar adjectives each, fair and understandable by students of high school age.

[1] The particular AT consists of multiple choice questions developed to measure skills and knowledge learned in Grade 8, which is the final year in middle school. The AT is conducted annually by the Ministry of Education nationwide, at the end of each school year. The AT scores are calculated in the 100-500 points range, and these scores contribute to a composite score used for admission to various high schools.

All students in the sample of grades 10-12 had a chemistry course in the previous year. Within the context of traditionally highly centralized Turkish education system, K-12 schools follow the same curricula, specific to each grade and each subject area. Thus, chemistry courses in the sample schools are based upon the same content within particular grades (e.g., grade 10 chemistry). Furthermore, teachers and students are provided with textbooks approved by the Turkish Ministry of National Education for use in each grade and subject area. The same scoring system is used in all schools. The final course mark is a score ranging from 1 to 5, with 5 representing the highest level of achievement in a course. In this context, the chemistry course content and marks appear to be sufficiently comparable across the different high schools.

Using students' self-reports of factual data, such as grade information, is a common practice in educational research because it is often impractical or impossible to obtain formal grade records for each student. However, caution is needed when relying on students to accurately self-report their former attainment because of the possibility of purposeful distortion or difficulties in memory retrieval (Cole & Gonyea, 2010). The students in this study were not asked to provide their personal information, so the possibility of students' motivation to present themselves favorably to their teachers or the researcher is eliminated from consideration. On the other hand, difficulties in memory retrieval of previous attainment should be minimal for Turkish students as they spend a significant amount of their school years in preparation to succeed in examinations conducted annually nationwide. These examinations are centralized and are important for high school and university admissions. Other than that, literature in this line suggests high correlations between self-reported and actual scores. For instance, Cole and Gonyea (2010) confirm previous research in reporting the overall high validity of self-reported test scores. In another study conducted with high school students (Schiel & Noble, 1991), it is found that self-reported grades appear to have sufficient accuracy for educational research concerning groups of students as opposed to their use for making crucial decisions about individuals.

Data Analysis

Collected data was coded, initially entered in Excel spreadsheet, and then transferred to SPSS 17.0 data editor for data analysis. For ease of analysis, five-level coding shown in Table 3 was used in grouping and designating the AT scores. The levels were set arbitrarily to increase in 50 points intervals (except Level 1), considering that students within a range would be alike in achievement. For instance, most science high schools in Turkey admit "high achievers" who get AT scores in the 450-500 points range (Level 5). As mentioned before, the AT scores range from 100 to 500 points. A student who answers all of the questions on the test correctly gets full 500 points.

Table 3. *Codes used for students' AT scores*

AT Score Range	Code
100-299	Level 1
300-349	Level 2
350-399	Level 3
400-449	Level 4
450-500	Level 5

Schools were also coded in two groups as science high school and Anatolian high school. Before the analysis, scores obtained from the adjective pairs that were placed in reverse order were recoded. Scores were calculated in SPSS's list-wise selection, resulting in 483 list-wise valid cases.

Examination of skewness and curtosis provided evidence for good normality of the item scores, as no item had skewness or curtosis values less than -1.000 or greater than +1.000. In order to explore the internal structure of the ASCIv2 and seek evidence for validation of the originally reported factor structure, exploratory factor analysis (EFA) was conducted via maximum likelihood extraction technique with direct oblimin rotation. Prince (2008) notes that "full criterion validation across cultures may be a chimera" (p. 218) and suggests reliability work as a basic approach to provide support for viability of measures in new cultural settings. The researcher further suggests that EFA is a method that can be used to compare factors and factor loadings across cultural settings. In the adaptation of developed scales for cross-cultural comparisons, the term construct equivalence appears to be of key importance and refers to different respondents from different cultures attaching the same meaning to the same construct (Welkenhuysen-Gybels & van de Vijver, 2001). Among several different methods, Welkenhuysen-Gybels & van de Vijver (2001) discuss the application of EFA as a relatively straightforward technique to assess construct equivalence. In this technique, invariance among the factor loadings of items from culturally different groups on the relevant factors is considered as indication of construct equivalence. There are a number of research studies that utilized EFA as a means of assessing construct validity of scales translated and adapted to different languages (e.g. Niclasen et al., 2012; Shearer, 2012). Similarly, in the current study, EFA was considered a suitable approach to factor analysis, as the ASCIv2 was being tested in a culturally different context.

Initially, data were analyzed in terms of suitability for factor analysis. Further, to decide the number of factors to extract, two criteria were used. The first criterion was a cut-off of eigenvalue equal to or greater than 1. Although the eigenvalues cut-off method is most widely used, Costello & Osborne (2005) suggest the scree test as the best method to decide for the number of factors to retain. As second criterion, the scree plot was examined and the factors with eigenvalues in the sharp descent prior to the line leveling off were retained. The threshold for significant factor loadings of the items was accepted as .50, a commonly used threshold value that indicates strong loading (i.e., Bauer, 2008; Costello & Osborne, 2005), although smaller loadings are acceptable for large sample sizes For example, in their guidelines for identifying significance of factor loadings, Hair, Anderson, Tatham, and Black (1998) suggest a minimum loading value of .30 for large samples sizes of over 350 participants (as in this study). Cronbach's alpha (α) coefficients were computed for each of the subscales for the internal consistency reliability analysis.

For descriptive analysis, mean values for the items with the highest factor loading in each of the subscales were examined. Further analyses concerning the ASCIv2 factors were performed by using estimated factor scores for each participant. Estimated factor scores for each factor were the weighted sum of products of scoring coefficients and the standardized z-scores on the variables. Scoring coefficients were calculated in SPSS by multiplying the inverse of the original simple correlation matrix by the factor loading matrix. Factor scores were obtained as SPSS outputs into the main data set and used in further analyzes.

Two univariate analyses of variance (ANOVA) tests were conducted to explore the effect of the independent variables (grade level, gender, school type, previous year final chemistry mark, AT score) on each of the attitude constructs of ASCIv2. The ANOVA analyses were executed in the

SPSS by designating the independent variables as fixed factors and the attitudinal subscales as the dependent variables.

Results

There were multiple sources of evidence for suitability for factor analysis. The matrix of bivariate correlations among items demonstrated significant and positive correlations (all in .37-.66 range), indicating that all items correlated fairly well and that factorability was reasonable (see Appendix). Also, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .89, above the recommended value of .60, and Bartlett's test of sphericity was significant (χ^2 (28) = 1702.808, $p < .05$). Both the KMO and Bartlett's test suggested that factor analysis was feasible.

The unrotated factor model suggested that there were two factor components satisfying the eigenvalue criterion. The line in the scree plot was observed to level off at the third component, confirming the two factor structure. In factor analysis, tables of total explained variance are important sources of information about the number of significant factors (Yong & Pearce, 2013). The first column in Table 4 lists all variables (the 8 items of the scale) as the initial number of factors. The second column "Initial Eigenvalues" shows the eigenvalues – in other words, the variances of these factors. In the next two sub-columns, the variances are shown as the percent variance and the cumulative percentage variance accounted for by the factors. The "Eigenvalues after Extraction" column contains the two factors retained, and their common variance is shown as eigenvalues, percent, and cumulative percent. Finally, the "Eigenvalues after Rotation" column represents the distribution of variance between the two factors after rotation, which is a method for optimizing the factor structure. Table 4 demonstrates that the analysis of the cumulative variance of the two factor model yielded 56.5%, an acceptable value for explained variance.

Table 4. *Total explained variance based on maximum likelihood extraction*

Component	Initial Eigenvalues			Eigenvalues after Extraction			Eigenvalues after Rotation*
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.341	54.259	54.259	3.907	48.836	48.836	3.604
2	1.024	12.800	67.059	.613	7.663	56.499	3.097

3	.575	7.190	74.249
4	.488	6.101	80.350
5	.477	5.965	86.315
6	.398	4.977	91.292
7	.383	4.790	96.082
8	.313	3.918	100.000

Extraction Method: Maximum Likelihood

* When components are correlated, eigenvalues cannot be added to obtain a total variance.

Social science researchers suggest that when case factors are correlated, using oblique rotation in factor analysis is a method that controls for shared variance between the factors, producing more accurate results (Beavers et al., 2013; Costello & Osborne, 2005). Research that used the ASCIv2 has shown that the two key components of the affective and cognitive components of attitude were highly correlated (Bauer, 2008; Brandriet, et al., 2011; Xu & Lewis, 2011). Therefore, an oblique rotation strategy, direct oblimin, was utilized as an extraction method. The pattern matrix demonstrated that all items had primary loadings over .50 and no cross-loadings above .25 (Table 5), yielding a clear factor structure. The Factor Correlation Matrix revealed a high correlation (r = .68) between the factors.

Table 5. *Factor loadings based on a maximum likelihood factor analysis with direct oblimin rotation for the ASCIv2 items (N = 483)*

ASCIv2 Item #		Intellectual Accessibility	Emotional Satisfaction
2	Complicated-Simple	.88	-.09
3	Confusing-Clear	.84	-.06
8	Chaotic-Organized	.70	.06
6	Challenging-Unchallenging	.60	.11
1r*	Hard-Easy	.52	.25
7r	Pleasant-Unpleasant	-.03	.81
5r	Satisfying-Frustrating	-.01	.76
4r	Comfortable-Uncomfortable	.14	.61

* r indicates recoding during analysis

The factor labels proposed by Xu and Lewis (2011) suited the extracted factors and were retained. One difference from the original scale was that item 8 (chaotic-organized) loaded strongly on the "intellectual accessibility" factor instead of its original factor "emotional satisfaction." Based on this model, items 1, 2, 3, 6, and 8 comprised the "intellectual accessibility" subscale, and items 4, 5, and 7 comprised the "emotional satisfaction" subscale. Internal consistency for each of the subscales was examined using Cronbach's alpha (α). The alpha values for "intellectual accessibility" and "emotional satisfaction" were .86 and .79, relatively, suggesting strong internal consistency for the instrument.

Descriptive statistics results based on the mean values of the items with the highest factor loading in each of the subscales are presented in Table 6.

Table 6. *Descriptive statistics for the two ASCIv2 factors (N = 483)*

	No. of items	*M* (*SD*)	Skewness	Kurtosis
Intellectual Accessibility	5	3.60 (1.47)	.03	-.43
Emotional Satisfaction	3	3.93 (1.75)	-.12	-.78

The mid-point in the scale is 4, and higher scores represent positive aspects of student attitudes. The mean values given in Table 6 indicate that the students had neither positive nor negative intellectual and emotional attitudes toward chemistry.

ANOVA results concerning the "intellectual accessibility" factor revealed that the effects of students' previous year chemistry mark and AT score were significant at the .05 level. The main effect of chemistry mark yielded an F ratio of $F(4, 333) = 7.480$, $p < .001$, $\eta^2 = .082$, and the main effect of the AT produced an F ratio of $F(4, 333) = 3.707$, $p = .006$, $\eta^2 = .043$. According to common guidelines (Cohen, 1988), the effect sizes (eta squared) reported indicate small to medium effects. The interaction effect of the two variables was non-significant, $F(9, 333) = 0.626$, $p > .05$. Students' grade level, gender, and school type also produced non-significant effects on students' intellectual attitudes ($p > .05$).

Post-hoc analyses were conducted in order to understand how students' intellectual attitudes varied in the different categories of chemistry mark and AT score levels. Hochberg's GT2 was chosen based on Field and Miles' (2010) recommendation of the procedure as being appropriate for comparing different sample sizes, as is the case in this study. According to the researchers, it is important to choose the best performing post hoc procedure for controlling Type I and Type II error rates, and the choice depends on the research situation. The post-hoc results indicated that, in general, "intellectual accessibility" attitudes were more positive for students with higher chemistry marks than students with lower chemistry marks ($p < .05$). However, intellectual attitudes did not differ significantly ($p > .05$) between students with the lowest chemistry mark (mark 1, $M = 3.09$, $SD = 2.51$) and students with marks 2, 3 or 4 (mark 2, $M = 2.60$, $SD = 1.50$; mark 3, $M = 3.37$, $SD = 1.56$; mark 4, $M = 3.38$, $SD = 1.28$). Similarly, "intellectual accessibility" attitudes were less positive for students with AT scores at level 2 than students with higher AT scores ($p < .05$). No significant differences were observed among other AT level groups ($p > .05$) with respect to intellectual attitudes.

Conduct of ANOVA concerning the "emotional satisfaction" factor yielded a main effect for chemistry mark, $F(4, 333) = 5.867$, $p < .001$, $\eta^2 = .066$, and grade level, $F(4, 333) = 3.193$, $p = .042$, $\eta^2 = .019$. These effect sizes illustrate small to medium effects (Cohen, 1988). The interaction effect of these two variables was non-significant, $F(8, 333) = 1.041$, $p > .05$. The effects of AT score, gender, and school type on emotional attitudes were also non-significant ($p > .05$).

Post-hoc analyses based on Hochberg's GT2 procedure were conducted to understand how students' emotional attitudes were different in the different categories of chemistry mark and grade level. The analyses indicated that, in general, "emotional satisfaction" attitudes were more positive for students with higher chemistry marks than students with lower chemistry marks ($p < .05$), but emotional attitudes did not differ significantly ($p > .05$) between students with mark 1 ($M = 2.36$, $SD = 1.96$) and mark 2 ($M = 2.40$, $SD = 1.26$), and students with mark 3 ($M = 3.64$, $SD = 1.92$) and mark 4 ($M = 3.76$, $SD = 1.55$). Comparisons of the different grade levels did not yield any significant differences in terms of emotional satisfaction means. This may be due to the variance among the groups not being large enough to make difference.

Discussion and Conclusions

In response to the first research question, the shortened version of Bauer's semantic differential, ASCIv2, was adapted for use in a different context and high school student population, unlike previous work that targeted college student populations. The results provide additional evidence for the validity and reliability of the ASCIv2, compared to the original two-factor structure that was established by the pioneering work of Xu and Lewis (2011). Though adapted to a different context and language, factor analysis results showed that the instrument was composed of two factors that fit to measure the two latent attitude variables, "intellectual accessibility" and "emotional satisfaction." The Cronbach's alpha (α) results suggest a strong internal consistency of the ASCIv2, which is supportive of Brandriet et al.'s (2011) work with different student populations. Conducted in a culturally and linguistically different context, this research confirms and provides strong evidence that the instrument yields reliable scores in diverse settings.

As observed in the Pattern Matrix, one item ("chaotic-organized") loaded on the "intellectual accessibility" factor as opposed to "emotional satisfaction." The most likely reason for this occurrence is the variance in meanings attributed to the adjectives in the translated language. Most notably, the translated version of the adjective "chaotic" appears to have evoked students' cognitive rather than emotional reactions. Experts were particularly challenged when adapting the word "chaotic" to the Turkish language, as no particular word appeared to match it in the context of a scientific discipline. The precise use of "chaotic" in Turkish is most common to descriptions related with life conditions. The adapted word for this adjective was closer in meaning to "complicated" in Item 2, which is part of the "intellectual accessibility" scale. This study also examined high school students' attitudes toward chemistry. The mean values, (3.60 and 3.93, respectively) found in this study indicating average intellectual and emotional attitudes toward chemistry were slightly greater than those (2.91 and 3.63, respectively) found by Xu and Lewis (2011) in their research with first year university chemistry students. On the other hand, the results indicate neither negative nor positive attitudes when compared with Cheung's (2009) findings that suggested the secondary school students in their sample had only marginally positive attitudes toward chemistry. The results are consistent with those of Salta and Tzougraki (2004), indicating that Greek students in Grade 11 consider chemistry neither difficult nor easy and demonstrate neutral interest attitudes. A limitation of the current study is that reported results are based on data collected from a convenient sample of high school students. These conclusions need to be verified with a representative sample in further research.

Gender differences in chemistry attitudes were not observed in the present study. Published literature on attitudes towards chemistry and gender relations with attitudes provide mixed, sometimes contradictory and complicated results. Some studies report more positive chemistry attitudes for boys, while others find more positive attitudes for girls. Furthermore, Brandriet et al. (2011) found that gender differences existed only in the low-achieving group of students in their sample. Cheung (2009) reported varying results concerning gender across different grade levels. On the other hand, Kahveci (in press) argues that chemistry is a physical science that is less likely to generate differential gender effects when compared to physics, and the current research adds to this perspective.

This study also demonstrated that previous chemistry course success and achievement in middle school affected high school students' intellectual and emotional attitudes toward chemistry. This finding supports the pattern established by previous research (i.e., Brandriet, et al., 2011; Narmadha & Chamundeswari, 2013; Xu & Lewis, 2011), suggesting that attitude and achievement are related. Support of this pattern indicates additional evidence for the construct validity of the adapted ASCIv2.

As an expected result, higher achieving students thought that chemistry was more intellectually accessible than lower achieving students. Uncommonly, students in the lowest range of achievement appeared to feel about intellectual accessibility of chemistry in a similar way to their higher achieving counterparts. With that being said, the large standard deviation signifies that students in this group varied greatly in their responses. Despite positive attitudes, other factors may play a key role in hindering achievement in the lowest scoring group, and this needs further investigation. On the other hand, emotional satisfaction increased with increasing former chemistry success, as might be expected. Although these results are significant both in a statistical and practical sense, small effect sizes of former student achievement are a limitation of this study. Methods such as convenient sampling and the use of ordinal data may have contributed to this effect.

While this research does not reveal a cause-effect relationship, it provides evidence that chemistry course achievement and both intellectual and emotional attitudes are interrelated for high school students. Based on this relationship, it is possible to say that achievement would enhance a positive attitude toward chemistry, and a positive attitude would bring about higher levels of success. In this sense, further experimental research which investigates the effect of attitudes on achievement may prove useful in better understanding this relationship. In similar studies, the ASCIv2 is a practical instrument that can be used in a diagnostic sense. For instance, the instrument could be used as a research tool to compare students' initial and final attitudes or to compare different student groups. In this way, chemistry courses or other educational practices may be evaluated in light of students' attitudinal outcomes.

According to the findings of this research, achievement which affects the intellectual component of attitudes is achievement-specific to chemistry as well as school achievement in a more general sense. Thus, it is important that aims of teaching chemistry, as well as other subjects, are concerned not only with students' cognition but also with students' affect. Curriculum development and teaching practices that are sensibly tailored to enhancing students' attitudes may serve as catalysts for future success. Efforts to enhance affect may also help to reverse the alerting trend of the low attention paid by students to enrolling in science.

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Appendix: Correlation Matrix for the ASCIv2 Items

	i1 (Hard-Easy)	i4 (Comfortable-Uncomfortable)	i5 (Satisfying-Frustrating)	i7 (Pleasant-Unpleasant)	i2 (Complicated-Simple)	i3 (Confusing-Clear)	i6 (Challenging-Unchallenging)	i8 (Chaotic-Organized)
i1 (Hard-Easy)	1.000	.452	.418	.482	.551	.510	.544	.520
i4 (Comfortable-Uncomfortable)	.452	1.000	.551	.545	.434	.450	.371	.401
i5 (Satisfying-Frustrating)	.418	.551	1.000	.586	.366	.391	.377	.401
i7 (Pleasant-Unpleasant)	.482	.545	.586	1.000	.380	.365	.409	.413
i2 (Complicated-Simple)	.551	.434	.366	.380	1.000	.664	.508	.612
i3 (Confusing-Clear)	.510	.450	.391	.365	.664	1.000	.560	.575
i6 (Challenging-Unchallenging)	.544	.371	.377	.409	.508	.560	1.000	.499
i8 (Chaotic-Organized)	.520	.401	.401	.413	.612	.575	.499	1.000