International Journal of Environmental & Science Education
(2014), *9*, 177-196

Modeling the Relationship between High School Students' Chemistry Self-efficacy and Metacognitive Awareness

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Received 17 July 2013; Accepted 4 January 2014

Doi:10.12973/ijese.2014.210a

In this study, the relationship between students' chemistry self-efficacy beliefs and metacognitive awareness was investigated utilizing a path model. There were 268 chemistry high school students (59% 10th grade and 41% 11th grade) participated in the study. The students took two-hour chemistry course in the 9th and 10th grade and three-hour chemistry course in the 11th grade. To measure students' self-efficacy toward chemistry, the High School Chemistry Self-efficacy Scale was used. Students' metacognition was assessed via Junior Metacognitive Awareness Inventory. The hypothesized model for the relationship between high school students' chemistry self-efficacy and metacognitive awareness was tested by conducting confirmatory factor analysis by using LISREL 9.1 for Windows with SIMPLIS command language. The results of this study showed that high efficacious students were more aware of knowledge about their cognitive abilities and their regulation of cognitive processes.

Keywords: metacognition; self-efficacy; path model; chemistry

Introduction

The origins of the concept of metacognition go far beyond to Plato and Aristotle. Brown (1987) stated that there are four historical roots of metacognition: verbal reports as data, executive control, self-regulation, and other regulation including Vygotsky's Psychological Development Theory. In the literature, the term "metacognition" was first emerged in 1970s by Flavell's metamemory study (Flavell, 1971). Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). There are also various definitions of metacognition in the literature. For example, according to Brown (1987), metacognition refers to "one's knowledge and control of own cognitive system" (p. 66). White (1988) described metacognition as "inner awareness or process, not an overt behavior" (p. 73). Due to the ambiguity in the conceptualization of metacognition and its different historical roots, metacognition was dubbed as “fuzzy” concept (Flavell, 1981; Hacker, 1998). Therefore, several researchers proposed different categorizations for metacognition. One of the first frameworks initiated by Flavell (1979) distinguished between metacognitive knowledge and metacognitive experience. Metacognitive knowledge includes “person”, “task”, and “strategy” variables. Metacognitive experience refers to cognitive or affective conscious experiences. Brown (1978) proposed another categorization for metacognition. Brown’s categorization includes two components of metacognition: knowledge of cognition and regulation of cognition. This categorization was improved by other researchers (Baker, 1991; Jacobs & Paris, 1987). Knowledge of cognition was described as the knowledge of learner about her/his own cognition. It involves three types of knowledge: declarative, procedural, and conditional knowledge. Regulation of cognition refers to metacognitive activities that a learner used to control her/his own learning and it includes three essential skills: planning, monitoring, and evaluation. In a similar vein, Pintrich, Wolters and Baxter (2000) made a distinction between three components of metacognition: metacognitive knowledge, metacognitive judgments and monitoring, and self-regulation and control of cognition. Pintrich et al.’s (2000) categorization of metacognitive knowledge was similar with Brown’s categorization in that it also includes declarative, procedural, and conditional knowledge. The second component of their categorization was metacognitive judgments and monitoring and they described it as “unlike the static nature of metacognitive knowledge, metacognitive judgments and monitoring are more process-related and reflect metacognitive awareness and ongoing metacognitive activities individuals may engage in as they perform a task” (p. 48). According to Pintrich et al. (2000), self-regulation and control of cognition could be divided into four subcategories: planning, strategy selection and use, resource allocation, and volitional control. Similar to Flavell (1979), Pintrich et al. (2000) also considered affective constructs as components of self-regulation and control of cognition.

Briefly, several researchers elaborated on the three components of metacognition: metacognitive knowledge/awareness, metacognitive monitoring and evaluation, and metacognitive regulation (e.g., Brown, 1978; Flavell, 1979; Pintrich et al., 2000). Metacognitive knowledge was divided into three components: person, task, and strategy (Flavell, 1979) or declarative, procedural, and conditional knowledge (Pintrich et al., 2000). Researchers also made a distinction between metacognitive knowledge and metacognitive awareness in that while metacognitive knowledge is stable and statable, metacognitive awareness is “on-line” experience. Affective constructs were also considered in the categorization of metacognition (Flavell, 1979; Pintrich et al., 2000). There is also growing literature investigating the relationship between metacognition and motivational constructs. Self-efficacy is one of the crucial motivational construct. The relationship between metacognition and self-efficacy was first noted by Flavell (1987). Paris and Winograd (1990) emphasized the importance of self-efficacy in the definition of metacognition.

Self-efficacy beliefs play a crucial role in science education. Rooted in social cognitive theory, self-efficacy was defined as “beliefs in one’s capabilities to organize and execute courses of action required to produce given attainments” (Bandura, 1997, p. 3). Bandura (1986, 1997) posited that students form their self-efficacy beliefs based on four sources: Mastery experiences, vicarious experiences, verbal and social persuasion, and physiological state. Mastery experience or students’ prior experiences on a task is the most influential source in the formation of self-efficacy beliefs. Students also form self-efficacy beliefs through vicarious experience of observing others performing tasks. In addition, social persuasion, which includes judgments from others, and students’ physiological states such as anxiety, stress, and mood contribute to their self-efficacy beliefs. In terms of the measurement of self-efficacy, Bandura (1997, 2006) indicated that self-efficacy beliefs should have been measured at the optimal level of specificity within a specific domain. Chemistry self-efficacy beliefs were one of the focuses of this study. Chemistry self-efficacy was defined by Capa Aydin and Uzuntiryaki (2009) as the “beliefs in one's ability to accomplish tasks related to chemistry" (p. 3) and Capa Aydin and Uzuntiryaki developed a high school chemistry self-efficacy scale considering the optimal level of domain specificity of self-efficacy. In this study, to assess high school students' self-efficacy toward chemistry, the high school chemistry self-efficacy scale of Capa Aydin and Uzuntiryaki (2009) was used. Self-efficacy beliefs influence the effort students expend on activities and the perseverance they show when face with difficulties (Bandura, 1997; Pajares, 1996). Researchers reported that students high in self-efficacy mastered academic tasks better than the students low in self-efficacy (Bandura, 1997; Britner, 2008; Kupermintz, 2002; Schunk, 1996). Also, it was established that self-efficacy was a better predictor of science-related career choices (Gwilliam & Betz, 2001). Albeit the crucial role of self-efficacy in science education, it has been reported that there was an increase in the number of students who lacked confidence and interest in science (Pell & Jarvis, 2001). Therefore, it is important to find the ways to increase students' self-efficacy. In the literature, there are studies reporting the relationship between students' use of metacognitive strategies and their self-efficacy beliefs of their performance in a course (Anderson & Nashon, 2007; Gourgey, 2001; Kleitman & Stankov, 2007; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991; Sungur, 2007). For example, Gourgey (2001) stated that "metacognitive development might benefit not only their achievement, but their self-efficacy and motivation to learn as well" (p. 31). Kleitman and Stankov (2007) studied with psychology students to examine the relationship between self-confidence and cognitive, metacognitive, and personality measures. A battery of cognitive tests which include confidence scores and Metacognitive Awareness Inventory developed by Schraw and Dennison (1994) were given to the students. They found a strong relationship between confidence scores and Metacognitive Awareness Inventory scores. In Sungur's (2007) study, the participants were the high school students. She modeled the relationships among motivational beliefs, metacognitive strategy use, and effort regulation in science courses by using The Motivated Strategies for Learning Questionnaire developed by Pintrich, Smith, Garcia and Mckeachie (1991). All these studies focused on the relationship between self-efficacy and metacognition in a domain-general manner. However, Bandura (1997) posited that self-efficacy is a domain-specific construct and it should be measured at the optimal level of specificity within a specific domain. When the importance of self-efficacy in science education was considered, the need for the studies to reveal the relationship between self-efficacy and metacognition could be easily understood. Accordingly, the present study seeks to address these gaps in the literature by aiming at investigating the relationship between students' chemistry self-efficacy beliefs and metacognition. To measure students' self-efficacy toward chemistry, the High School Chemistry Self-efficacy Scale (HCSS) of Capa Aydin and Uzuntiryaki (2009) was used. And to assess students' metacognition, Junior Metacognitive Awareness Inventory (MAI) developed by Sperling, Howard, Staley and Murphy (2002) based on Brown's (1978) categorization of metacognition (knowledge of cognition and regulation of cognition) and adapted into Turkish by Aydin and Ubuz (2010) was used. It was hypothesized that students' chemistry self-efficacy beliefs were related to their metacognitive awareness. The hypothesized model includes two main components: self-efficacy beliefs in chemistry and metacognitive awareness. Self-efficacy beliefs in chemistry and metacognitive awareness are represented by a number of subcomponents in the model. Self-efficacy beliefs in chemistry include chemistry self-efficacy for cognitive skills and self-efficacy for chemistry laboratory. Metacognitive awareness is characterized by knowledge of cognition and regulation of cognition. In other words, students who are more aware about their knowledge of cognition and regulation of cognition are the high self-efficacious students. Taking the importance of investigating the relationship between chemistry self-efficacy beliefs and metacognition in a domain-specific manner into consideration, the current study addressed the following research question:

- What is the relationship between students' chemistry self-efficacy beliefs and their metacognition?

Method

In this study, high school chemistry students were surveyed in order to examine the relationship between students' chemistry self-efficacy beliefs and their metacognition. The students were administered the HCSS and Junior MAI. Exploratory factor analyses were performed to specify the factor structure of the instruments. The factor structures were also confirmed by performing confirmatory factor analyses. In order to test if the hypothesized model fitted the sample data, confirmatory factor analysis by using LISREL 9.1 for Windows with SIMPLIS command language, a statistical procedure used to examine the patterns of relationships among variables, was employed.

Sample

The sample of this study consisted of 268 chemistry students (45% females and 55% males) in grades 10 and 11 (59% 10th grade and 41% 11th grade) from three public high schools in Ankara-Turkey. The students took two-hour chemistry course in the 9th and 10th grade and three-hour chemistry course in the 11th grade. The Development of Chemistry, Compounds, Chemical Changes, Mixtures, and Chemistry in Life were the subjects of the 9th grade chemistry, while the Structure of Atoms, Periodic Table, Chemical Bonding, States of Matter, and Mixtures were the subjects of the 10th grade chemistry. In this study, 10th grade students completed the subjects of the 9th grade chemistry and while collecting the data, they were given the first subject (Structure of Atoms) of the 10th grade chemistry. The students in grade 11 completed the subjects of the 9th and 10th grade chemistry and while this study took place, they were given the first subject (Chemical Reactions) of the 11th grade chemistry. The ages of the students participated in this study were ranged from 16 to 17. Most of the students' socio-economic status, including the educational level of their parents, their family income and social life standards were middle.

Instrument

Two instruments were used in this study. One of them was High School Chemistry Self-efficacy Scale (HCSS) developed by Capa Aydin and Uzuntiryaki (2009) and the other was Junior Metacognitive Awareness Inventory (MAI) developed by Sperling et al. (2002) and adapted into Turkish by Aydin and Ubuz (2010). The students were completed these two instruments in 35 minutes. It should be noted that the author is aware of the difference between principal component analysis and factor analysis in terms of the variance that is analyzed. As a common term in the literature, the term "factor" was used to represent both for the component and factor.

High School Chemistry Self-efficacy Scale

The HCSS was developed by Capa Aydin and Uzuntiryaki (2009) to assess high school students' self-efficacy beliefs in chemistry. It consisted of 16 items in a 9-point scale ranging from very poorly to very well. In a 9-point scale, very poorly was graded as 1 point and very well was graded as 9 points. The possible scores of the scale raged from 16 to 144. Low scores indicate that students' chemistry self-efficacy is low, while high scores indicate that students had high chemistry self-efficacy. In order to explore the factorial structure of the scale, Capa Aydin and Uzuntiryaki (2009) conducted exploratory factor analysis with principal axis factoring and direct oblimin rotation. They reported that the HCSS had two-factor structure: chemistry self-efficacy for cognitive skills (CSCS) and self-efficacy for chemistry laboratory (SCL). The CSCS was described as "students' beliefs in their ability to use intellectual skills in chemistry" and the SCL was defined as "students' beliefs in their ability to accomplish laboratory tasks including skills in both cognitive and psychomotor domain" (Capa Aydin & Uzuntiryaki, 2009, p. 872). The CSCS consisted of 10 items (items 1, 2, 5, 6, 8, 9, 10, 11, 13, and 14) and the SCL consisted of six items

(items 3, 4, 7, 12, 15, and 16). The following items are the sample items from the HCSS for each factor:

1. How well can you describe the structure of an atom? (CSCS)
2. How well can you explain the particle nature of matter? (CSCS)
3. How well can you collect data during a chemistry laboratory? (SCL)
4. How well can you interpret data collected during laboratory sessions? (SCL)

After that, Capa Aydin and Uzuntiryaki (2009) conducted confirmatory factor analysis (CFA) with the data obtained from 362 10th grade high school students to test the two-factor structure of the HCSS. They showed that there was a satisfactory fit to the data (NNFI = .97; CFI = .98; RMSEA = .09; 90% CI = .09, .10). This means that the HCSS consisted of two-factor structure- the CSCS and the SCL. They also noted that Cronbach alpha coefficients for the CSCS and SCL scores were .90 and .92, respectively.

Junior Metacognitive Awareness Inventory

The original version of Junior MAI including 18 items on a 5-point Likert-type scale ranging from “1-never” to “5-always” was developed by Sperling et al. (2002). It was applied to the students in grades six through nine to measure students’ metacognition. Sperling et al. (2002) used Brown’s (1978) categorization of metacognition in Junior MAI. They assessed students’ metacognition in two constructs: knowledge of cognition and regulation of cognition. The Junior MAI was adapted into Turkish by Aydin and Ubuz (2010). The adapted version of Junior MAI included 17 of 18 items in the original version of Junior MAI. The possible scores of the inventory raged from 17 to 85. Low scores indicate that students have low metacognitive awareness, while high scores indicate that students have high metacognitive awareness. Aydin and Ubuz (2010) conducted exploratory factor analysis with principal component and direct oblimin rotation to determine the factor structure of Junior MAI. They reported two-factor with 17 items: knowledge of cognition (KNOW; items 1, 2, 3, 4, 5, 11, 12, and 13) and regulation of cognition (REG; items 6, 7, 8, 9, 10, 14, 15, 16, and 17). They described the KNOW as “individual’s knowledge about her/his own capabilities, beliefs, cognitive activities, and processes” and the REG as “individual’s knowledge about her/his own control processes during the execution of a task” (p. 36). Aydin and Ubuz (2010) also supported the two-factor solution of the inventory by confirmatory factor analysis. The two-factor model explaining that Junior MAI consisted of the KNOW and the REG factors showed a satisfactory fit to the data ($\chi 2/df = 2.88$, RMR = .05, GFI = .94, AGFI = .92, RMSEA = .05, and CFI = .91). They also reported Cronbach alpha coefficients for the KNOW and the REG scores as .75 and .79, respectively. The sample items for each factor are shown below:

1. I am a good judge of how well I understand something. (KNOW)
2. I learn best when I already know something about the topic. (KNOW)
3. I draw pictures or diagrams to help me understand while learning. (REG)
4. I think about what I really need to learn before I begin a task. (REG)

Results

High School Chemistry Self-efficacy Scale

Exploratory factor analysis with principal component and direct oblimin rotation was conducted to investigate the factorial structure of the HCSS. Tabachnick and Fidell (2007) argued the selection of the rotation method based on the correlations among factors: “If correlations exceed .32, then there is 10% (or more) overlap in variance among factors, enough variance to warrant oblique rotation unless there are compelling reasons for orthogonal rotation" (p. 646). Since the correlation between the CSCS and the SCL was found to be .42, direct oblimin rotation was used. In this study, item distributions of the HCSS to the factors were found to be the same with the factorial structure of the HCSS as Capa Aydin and Uzuntiryaki (2009) reported.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found to be .89, which shows that the sampling adequacy is satisfactory to proceed factor analysis. Bartlett's test of sphericity (BTS) was significant ($\chi2(120) = 2484.54$, $p < .001$) indicating that the correlation matrix was not an identity matrix and the data approaches multivariate normality. In order to determine the number of factors retained two criteria were used: i) eigenvalues which are above 1 (Kaiser, as cited in Stevens, 2009) (see Table 1) and ii) the scree test (Cattell, as cited in Stevens, 2009) (see Figure 1). Table 1 shows that there are two factors whose eigenvalues are above 1. According to Table 1, two-factor structure explains 59% of the total variance. In scree test, the magnitude of the eigenvalues is plotted against all factors (Field, 2006). Figure 1 shows that there are only two factors whose eigenvalues in the sharp descend before the first one on the line where they appear to level off. Therefore, scree test also showed that there were two factors to be retained.

Table 1. Eigenvalues and total variance explained by factors for the HCSS

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.40	40.00	40.00	6.40	40.00	40.00
2	3.12	19.47	59.48	3.12	19.47	59.48
3	.91	5.68	65.16			
4	.76	4.78	69.93			
5	.67	4.19	74.13			
6	.62	3.89	78.02			
7	.61	3.79	81.81			
8	.51	3.18	84.99			
9	.47	2.96	87.94			
10	.42	2.59	90.53			
11	.34	2.13	92.67			
12	.31	1.91	94.57			
13	.30	1.85	96.42			
14	.21	1.31	97.74			
15	.21	1.28	99.02			
16	.16	.98	100.00			

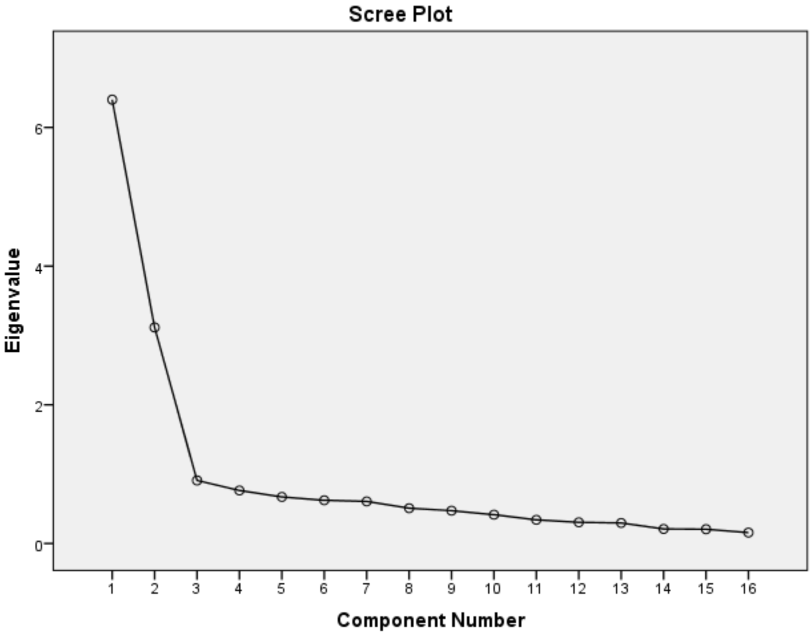

Figure 1. Scree Plot for the factorial structure of the HCSS

The two-factor solution was performed. Table 2 demonstrates factor pattern coefficients of the items for the two-factor solution. While deciding on number of variables per factor for interpretation, the following rule was used: "Factors with about 10 or more loadings about 0,40 in absolute value are reliable as long as sample size is greater than about 150" (Stevens, 2009, p. 332). It was found that the HCSS consisted of two-factor structure: The CSCS (items 1, 2, 5, 6, 8, 9, 10, 11, 13, and 14) and the SCL (items 3, 4, 7, 12, 15, and 16).

Table 2. Factor pattern coefficients of the items for the HCSS

Items	Factors	
	CSCS	SCL
8	.80	-.16
11	.79	-.05
10	.78	.02
13	.74	-.01
6	.74	-.05
2	.72	.06
9	.71	-.07
14	.62	.10
1	.61	.15
5	.54	.23
4	-.14	.92
3	-.11	.89
12	.02	.89
15	.08	.82
7	.15	.75
16	.11	.74

The internal consistencies of scores on the two factors were estimated by Cronbach alpha coefficient. Cronbach alpha reliability coefficients for the CSCS and the SCL scores were found to be .89 and .92, respectively which is consistent with the study of Capa Aydin and Uzuntiryaki (2009).

In order to test a two-factor structure comprising the CSCS and the SCL proposed by Capa Aydin and Uzuntiryaki (2009), Confirmatory Factor Analysis (CFA) was conducted by using LISREL 9.1 for Windows with SIMPLIS command language. Before performing the CFA, multivariate normality was checked by detecting univariate normality. Kline (1998) stated that unless the value of skewness exceeds 3 and the value of kurtosis exceeds 10, the distribution may not violate from univariate normality extremely. When the variables were inspected for univariate normality, it was found that the distributions are normal. Skewness values ranged from .02 to .20 and kurtosis values ranged from .12 to .74. The maximum likelihood estimation method was used in all the LISREL analyses. Normed Fit Index (NFI), Non-Normed Fit Index (NNFI), Comparative Fit Index (CFI), and The Root Mean Square Error of Approximation (RMSEA) were employed for the model data fit assessment. To evaluate model fit, two fit indexes named absolute and incremental can be used (Hu & Bentler, 1995). In this study, both fit indexes were employed. As an absolute fit index, which evaluates how well the model fit the sample data (Hu & Bentler, 1999), RMSEA with the 90% confidence interval was examined. CFI, NNFI, and NFI were the incremental fit indexes, which measures the improvement in fit by comparing the target model with the null model (Hu & Bentler, 1999), used in this study. Bentler (1992) proposed that CFI, NFI, and NNFI values greater than .90 indicated a well-fitting model. RMSEA values lower than .05 is representative of good fit (Browne & Cudeck, 1993); however, MacCallum, Browne and Sugawara (1996) specified cutoff points and noted that RMSEA values between .08 and .10 represented mediocre fit. In this study, it was found that fit indexes for the two-factor structure model of the HCSS was satisfactory (NFI = .95; NNFI = .96; CFI = .97; RMSEA = .08; 90% Confidence Interval for RMSEA = .07; .09).

Junior Metacognitive Awareness Inventory

In order to validate the factor structure of Junior MAI, exploratory factor analysis was conducted. The extraction method was the principal component and the rotation method was the direct oblimin. Taking Tabachnick and Fidell’s (2007) argument on correlated factors into consideration, direct oblimin rotation was used. The correlation between the factors was .42. Before the investigation of the results of the exploratory factor analysis, the KMO and BTS values were inspected. The KMO measure of sampling adequacy was found to be .89. The BTS value was found to be significant ($\chi 2(136) = 1206.27$, $p < .001$). These results showed that it was appropriate to proceed factor analysis. Exploratory factor analysis yielded three-factor structure for Junior MAI (see Table 3). Table 3 demonstrates that all the items loaded to the factors with at least .34 values.

However, when the scree plot (see Figure 2) and % of variances explained by factors (see Table 4) were examined, it was seen that two-factor solutions should be selected. Scree plot shows that there are only two factors whose eigenvalues in the sharp descend before the first one on the line where they appear to level off. Table 4 supported that the two-factor solution could be retained since the two of three factors (41%) explain most of the variance without third factor.

Table 3. Factor pattern coefficients of the items for the three-factor solution of Junior MAI

Items	Factors		
	1	2	3
16	.71	.11	.21
8	.69	.05	.08
15	.66	-.07	-.12
7	.64	-.09	-.15
6	.63	-.04	.03
10	.51	.11	-.15
13	.49	.04	-.21
14	.42	.05	-.25
12	-.11	.85	-.07
5	.18	.81	.14
11	.02	.52	-.37
2	.05	-.02	-.76
1	-.11	.19	-.68
9	.20	-.10	-.59
3	-.01	.04	-.58
4	.34	-.00	-.45
17	.25	.25	-.34

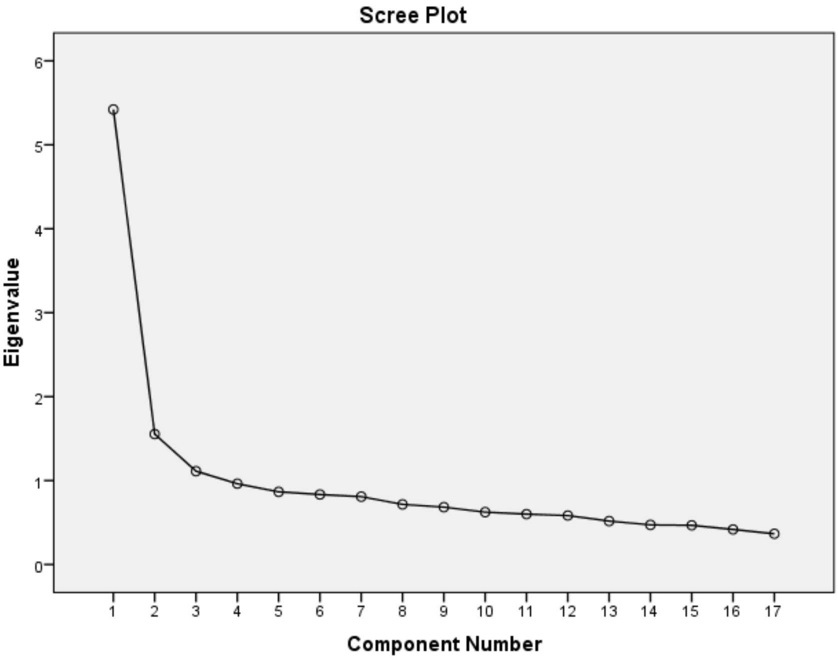

Figure 2. Scree Plot for the factorial structure of Junior MAI

Table 4. Eigenvalues and total variance explained by three-factor for Junior MAI

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.42	31.89	31.89	5.42	31.89	31.89
2	1.55	9.14	41.02	1.55	9.14	41.02
3	1.11	6.54	47.56	1.11	6.54	47.56
4	.96	5.66	53.22			
5	.87	5.09	58.31			
6	.83	4.91	63.22			
7	.81	4.75	67.97			
8	.72	4.21	72.18			
9	.68	4.02	76.20			
10	.62	3.67	79.87			
11	.60	3.53	83.40			
12	.58	3.43	86.83			
13	.52	3.04	89.87			
14	.47	2.78	92.65			
15	.47	2.75	95.39			
16	.42	2.46	97.85			
17	.37	2.15	100.00			

The second exploratory factor analysis with principal component and direct oblimin rotation was employed for the two-factor solution. Table 5 demonstrates factor pattern coefficients of the items for the two-factor solution. All factor loadings are above .36. The two-factor structure of Junior MAI is consisted of the KNOW (items 1, 2, 3, 5, 11, 12, and 17) and the REG (items 4, 6, 7, 8, 9, 10, 13, 14, 15, and 16). The results of the exploratory factor analysis fairly replicated Aydin and Ubuz's (2010) study. In the study of Aydin and Ubuz (2010), items 4 and 13 were loaded to KNOW and item 17 was loaded to REG. The internal consistencies of scores on the two factors were estimated by Cronbach alpha coefficient. Cronbach alpha reliability coefficients for the KNOW and the REG scores were found to be .75 and .82, respectively. These reliability values are consistent with the study of Aydin and Ubuz (2010).

Confirmatory factor analysis using LISREL 9.1 for Windows with SIMPLIS command language was conducted in order to test the two-factor structure of Junior MAI. The maximum likelihood estimation method was used in all the LISREL analyses. Multivariate normality was checked by detecting univariate normality. Skewness and kurtosis values were checked for univariate normality. Skewness values ranged from .00 to 2.34 and kurtosis values ranged from .03 to 2.87. Kline (1998) stated that unless the value of skewness exceeds 3 and the value of kurtosis exceeds 10, the distribution may not violate from univariate normality extremely. Therefore, the distributions are normal. The results of the confirmatory factor analysis showed a satisfactory fit to the data (NFI = .92; NNFI = .94; CFI = .95; RMSEA = .07; 90% Confidence Interval for RMSEA = .06; .08). This means that the Junior MAI had two-factor structure comprising the KNOW and the REG.

Table 5. Factor pattern coefficients of the items for the two-factor solution of Junior MAI

Items	Factors	
	REG	KNOW
15	.72	-.06
7	.72	-.05
8	.66	-.06
6	.63	-.11
16	.61	-.09
13	.57	.11
10	.55	.14
4	.52	.22
14	.51	.15
9	.45	.23
12	-.24	.84
11	.07	.70
5	-.02	.66
1	.13	.58
2	.35	.41
17	.34	.41
3	.22	.37

Results of the Model Testing

The hypothesized model for the relationship between high school students' chemistry self-efficacy and metacognitive awareness was tested by using LISREL 9.1 for Windows with SIMPLIS command language (see appendix for the covariance matrix including variable means and standard deviations). The observed and latent variables used in this study are shown in Table 6. The maximum likelihood estimation method was used in all the LISREL analyses. The results demonstrated a good fit to the data (NFI = .91; NNFI = .94; CFI = .95; RMSEA = .07; 90% Confidence Interval for RMSEA = .06; .07).

When the significance of the paths was examined with respect to the t-values, it was found that all the paths had significant t-values ranging from .00 to 16.86. This means that all variables contribute to the model significantly.

The path analytic model with standardized solution is shown in Figure 3. This model is respecified model. Modifications were made one by one according to the maximum decrease in Chi-Square (Kline, 1998). Model respecification included correlated errors. Byrne (2006) conferred that respondent and item characteristics of the instruments could cause correlated errors. In this study, social desirability bias could occur. There are also overlaps in the item contents of the instruments used in the study. For example, item 9 in Junior MAI is "I think about what I need to learn before I start working", while item 17 is "I decide what I need to get done before I start a task".

As seen from Figure 3, the correlation coefficients changed between .37 and .50. Cohen (1988) made some suggestions about interpretations of the absolute magnitudes of correlation coefficients. According to Cohen, the values of correlation coefficients less than .10 may indicate a small effect; whereas values around .30 indicate a medium effect and values above .50 indicate a large effect. With respect to these criteria, the correlation coefficient from the CSCS to KNOW (.50) indicates a large effect. The correlation coefficients from the CSCS to the REG (.45), from the SCL to REG (.41), and from the SCL to KNOW (.37) indicate medium effect. In the model fitted, it can be said that as the students' self-efficacy belief scores increase, their metacognitive awareness scores also increase.

Table 6. Descriptions of latent and observed variables

Latent Variables	Observed Variables
CSCS	SE1_1[1] SE2_1 SE5_1 SE6_1 SE8_1 SE9_1 SE10_1 SE11_1 SE13_1 SE14_1
SCL	SE3_1 SE4_1 SE7_1 SE12_1 SE15_1 SE16_1
KNOW	MA1_1[2] MA2_1 MA3_1 MA5_1 MA11_1 MA12_1 MA17_1
REG	MA4_1 MA6_1 MA7_1 MA8_1 MA9_1 MA10_1 MA13_1 MA14_1 MA15_1 MA16_1

[1] SE1_1 represents the HCSS items.

[2] MA1_1 represents Junior MAI items.

Discussion and Conclusions

This study modeled the relationship between high school chemistry students' self-efficacy beliefs and their metacognitive awareness. By this aim, two instruments were used: the HCSS and Turkish version of Junior MAI. The factor structure of the HCSS was the same with the study of Capa Aydin and Uzuntiryaki (2009). Although some variables were not loaded to hypothesized factors in the factor solution of Junior MAI, the results were fairly consistent with the adaptation study of Aydin and Ubuz (2010). The difference between the factor structures of Junior MAI could be resulted from various reasons. In the development of original Junior MAI, as Sperling et al. (2002) reported, significant correlations between the factors could cause this result. Also,

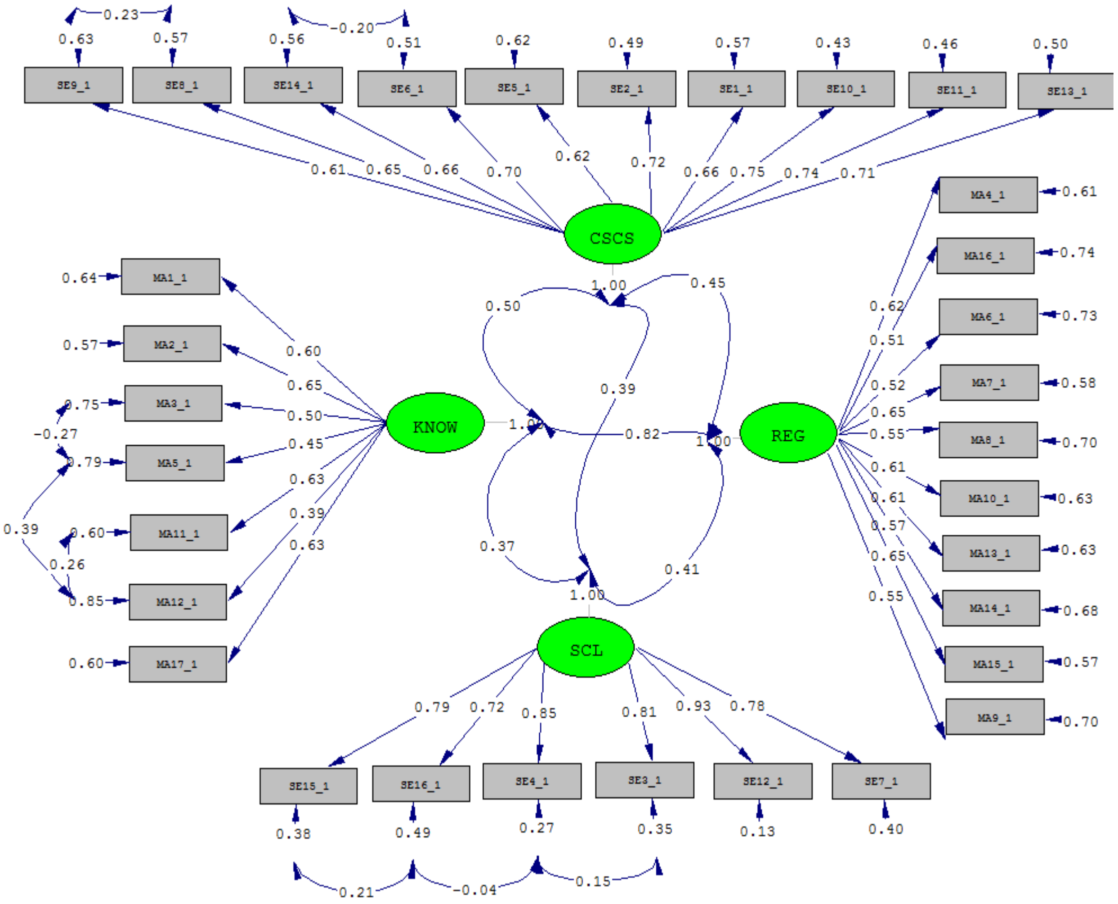

Figure 3. Path analytic model with standardized solutions

the differences in grade levels result in this outcome. Sperling et al. (2002) studied with students in grades three through nine and documented that the factor structure of Junior MAI was different for younger and older students.

In the literature, it was documented that self-efficacy beliefs affected students' effort on a challenging task, how resilient they were when facing with difficulties. High efficacious students involve in challenging tasks, put greater efforts on an activity, and resilient when dealing with hurdles. However, low efficacious students may not show persistence and resilience when confronting adverse situations (Pajares, 1996). In a similar vein, researchers reported that student self-efficacy was the better predictor of their academic achievement and career choice (Bandura, 1997; Britner, 2008; Gwilliam & Betz, 2001; Kupermintz, 2002; Schunk, 1996). However, there was a decrease in self-efficacy of students and interest in science courses (Pell & Jarvis, 2001). Therefore, it is important to find the ways to increase student self-efficacy. For example, Anderson and Nashon (2007) found that high efficacious students with low monitoring and controlling metacognitive skills were resistant to change their alternative conceptions, while low efficacious students with high metacognitive skills were willing to change their alternative conceptions.

The results of this study could conclude that high efficacious chemistry students were more aware of knowledge about their cognitive abilities and their regulation of cognitive processes. The results of the current study also corroborated the earlier studies albeit they were carried out in a domain-general manner (Gourgey, 2001; Kleitman & Stankov, 2007; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991; Sungur, 2007). The findings of this study is important in that it suggests that teachers could create learning environments to develop metacognitive awareness of students in order to increase their students' self-efficacy beliefs. In the literature, various researchers documented that metacognition could be enhanced during schooling (Adey, Shayer & Yates, 1989; Baird & Northfield, 1992; Beeth, 1998; Georghiades, 2000). Metacognitively guided instruction to facilitate students' metacognitive knowledge and processes could be used while practicing metacognition in the chemistry classroom. This instruction can provide a student-centered learning environment in which students have opportunity to be more metacognitive and thus to be self-efficacious in chemistry. There is need for more studies to investigate the relationship between metacognition and self-efficacy beliefs in other areas and in different cultures. Also, further studies should be conducted on how to increase student metacognitive awareness.

There are some limitations of the current study. First, this study relied on the data obtained by the two questionnaires- the HCSS and Junior MAI. Questionnaires are the most efficient tools to gather data from a large sample in a very short period of time; however, it does not provide in-depth information about the students' thoughts or beliefs. Observations and/or in-depth interviews could be used as a complement to quantitative data. Although in this study, Structural Equation Modeling was used and this requires the data gathered from a large sample, relying on the results of the questionnaires is a weakness of the study. Second, the sample size of the results limits the generalizability of the results. Therefore, the generalizations should be made with caution. Third, in this study the same data set was used for the exploratory and confirmatory analyses. Another limitation is related to the data analysis itself. It should be known that Structural Equation Modeling does not give information about causation. In order to give causational relationship, experimental research should be conducted.

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Please cite as: Kirbulut, Z. D. (2014). Modeling the relationship between high school students' chemistry self-efficacy and metacognitive awareness. *International Journal of Environmental and Science Education, 9*(2), 177-196. doi: 10.12973/ijese.2014.210a

Appendix

Covariance Matrix with Variable Means and Standard Deviations

Total Sample Size(N) = 268
Covariance Matrix

```
SE1_1 SE2_1 SE3_1 SE4_1 SE5_1 SE6_1
------------------------------------------------
SE1_1 39.442
SE2_1 12.419 13.036
SE3_1 6.195 3.511 22.681
SE4_1 5.025 3.118 15.851 15.709
SE5_1 18.163 11.446 9.829 9.251 56.695
SE6_1 5.616 3.325 1.277 0.599 7.387 4.114
SE7_1 6.384 3.163 8.236 7.029 8.213 1.593
SE8_1 11.255 7.528. . 0.757 0.026. 15.2995. 526
E9_1 7.716 5.780 2.345 1.057 10.206 3.161
SE10_ 17.946 5.771 2.644 1.786 8.128 2.228
SE11_1 7.472 4.974 1.317 0.948 7.972 3.116
SE12_1 8.342 3.557 14.198 12.644 9.737 1.415
SE13_1 17.280 10.634 3.845 2.911 19.640 7.109
SE14_1 10.161 5.786 2.138 2.435 10.980 1.782
SE15_1 9.994 4.702 12.865 11.185 10.611 1.512
SE16_1 10.812 6.170 17.258 13.750 17.557 2.907
MA1_1 1.953 1.538 1.750 1.599 4.371 1.075
MA2_1 2.568 2.254 1.486 1.262 3.876 0.782
MA3_1 3.979 3.185 1.576 1.765 3.875 1.023
MA4_1 2.232 0.896 1.980 1.410 3.100 0.355
MA5_1 4.200 0.400 1.557 1.712 4.790 0.953
 MA6_1 2.351 0.574 1.313 1.188 2.538 0.365
 MA7_1 1.864 0.669 0.890 0.673 2.366 0.361
 MA8_1 1.359 0.877 0.897 0.954 3.490 0.310
 MA9_1 1.045 0.429 0.304 0.263 1.114 0.242
 MA10_1 2.024 0.600 1.255 1.267 2.905 0.537
 MA11_1 6.962 3.209 3.468 3.073 8.228 1.970
 MA12_1 3.231 0.262 -0.988 -0.121 2.216 0.729
 MA13_1 2.592 1.109 1.441 0.727 3.802 0.729
 MA14_1 1.625 1.508 1.554 1.554 3.190 0.435
 MA15_1 2.294 1.413 2.071 1.789 4.278 0.757
 MA16_1 2.632 0.528 1.693 1.248 2.892 0.139
 MA17_1 2.628 0.876 1.236 1.383 3.901 0.560
```

Covariance Matrix

```
SE7_1 SE8_1 SE9_1 SE10_1 SE11_1 SE12_1
-------- -------- -------- -------- -------- --------
SE7_1 7.690
SE8_1 3.140 25.169
SE9_1 2.147 11.719 13.916
SE10_1 2.152 6.427 5.757 6.762
SE11_1 2.053 6.852 4.748 4.235 6.762
SE12_1 7.744 2.157 2.562 2.690 2.382 15.350
SE13_1 4.331 16.273 10.105 8.427 7.339 7.055
SE14_1 2.807 5.887 3.850 4.501 3.475 3.831
SE15_1 7.905 3.729 3.398 3.396 2.748 12.124
SE16_1 9.370 6.487 5.223 4.715 4.402 15.593
MA1_1 1.467 2.119 1.627 1.082 1.381 1.560
MA2_1 1.130 2.152 1.813 1.239 1.341 1.754
MA3_1 1.644 3.672 2.086 0.885 1.842 1.381
MA4_1 1.105 1.786 1.232 0.873 0.831 1.635
MA5_1 0.984 2.953 0.588 0.373 0.865 1.669
```

```
MA6_1 0.780 1.625 0.945 0.701 0.512 1.369
MA7_1 1.014 1.030 0.766 0.449 0.845 0.952
MA8_1 0.969 1.912 1.355 1.109 0.576 1.252
MA9_1 0.304 0.401 0.235 0.236 0.348 0.884
MA10_1 0.818 1.042 0.707 0.652 0.671 1.385
MA11_1 2.113 4.654 3.504 2.306 2.161 2.745
MA12_1 0.007 1.752 0.883 -0.142 -0.111 -0.387
MA13_1 1.309 2.420 1.650 0.510 1.073 1.405
MA14_1 1.128 1.869 1.328 0.982 0.597 1.739
MA15_1 1.306 3.281 1.617 1.047 1.413 1.999
MA16_1 0.809 1.331 0.298 0.880 0.697 1.776
MA17_1 1.253 2.406 1.226 0.558 1.094 1.813

Covariance Matrix

SE13_1 SE14_1 SE15_1 SE16_1 MA1_1 MA2_1
-------- -------- -------- -------- -------- --------
SE13_1 39.851
SE14_1 10.743 10.821
SE15_1 6.809 4.648 18.463
SE16_1 9.556 4.343 20.146 36.845
MA1_1 2.589 1.613 1.709 1.772 4.114
MA2_1 3.483 1.699 1.983 2.756 1.886 4.118
MA3_1 2.402 1.373 2.255 1.737 1.898 2.069
MA4_1 1.970 1.234 1.572 2.728 1.146 1.311
MA5_1 1.959 1.293 1.185 2.147 2.285 1.258
MA6_1 1.841 0.970 0.928 1.772 0.631 0.654
MA7_1 2.115 1.139 0.766 1.212 0.826 1.041
MA8_1 1.978 1.175 1.730 2.482 0.459 1.028
MA9_1 1.156 0.370 0.342 0.631 0.745 1.004
MA10_1 2.719 1.098 1.079 1.301 0.836 1.071
MA11_1 5.750 3.438 4.333 7.572 3.015 3.121
MA12_1 2.310 0.669 2.016 1.730 2.095 1.966
MA13_1 2.243 0.968 1.498 2.579 1.028 1.290
MA14_1 2.447 1.400 2.233 2.912 0.980 1.196
MA15_1 2.808 1.699 1.498 3.024 0.794 1.436
MA16_1 1.902 1.732 1.280 1.687 0.445 0.723
MA17_1 2.249 1.061 2.505 3.877 1.409 1.841

Covariance Matrix

MA3_1 MA4_1 MA5_1 MA6_1 MA7_1 MA8_1
-------- -------- -------- -------- -------- --------
MA3_1 8.469
MA4_1 1.176 2.574
MA5_1 -0.024 1.342 13.036
MA6_1 0.690 0.652 1.073 2.000
MA7_1 1.285 1.035 1.323 0.881 2.357
MA8_1 1.496 0.938 1.168 0.877 1.060 3.732
MA9_1 0.732 0.588 0.792 0.414 0.639 0.483
MA10_1 0.787 0.778 1.329 0.619 1.005 0.652
MA11_1 3.386 2.448 5.141 0.855 1.374 1.625
MA12_1 3.053 0.788 7.830 0.223 0.464 0.620
MA13_1 0.926 0.956 1.255 0.599 0.911 0.935
MA14_1 1.308 1.035 1.113 0.675 0.715 1.428
MA15_1 1.018 1.205 1.551 1.041 1.349 1.727
MA16_1 1.131 0.703 1.365 0.727 0.980 1.294
MA17_1 1.802 1.562 2.854 0.789 1.242 1.300

Covariance Matrix

MA9_1 MA10_1 MA11_1 MA12_1 MA13_1 MA14_1
```

```
-------- -------- -------- -------- -------- --------
MA9_1 1.190
MA10_1 0.528 1.997
MA11_1 0.983 1.620 14.555
MA12_1 0.605 1.704 7.836 14.555
MA13_1 0.642 0.992 1.913 1.120 2.734
MA14_1 0.444 0.698 1.702 1.346 0.790 2.556
MA15_1 0.894 1.184 2.362 0.303 1.447 1.164
MA16_1 0.319 0.895 1.650 0.447 1.033 0.700
MA17_1 1.229 0.768 3.315 2.457 1.438 1.058

Covariance Matrix

MA15_1 MA16_1 MA17_1
-------- -------- --------
MA15_1 4.217
MA16_1 1.184 3.133
MA17_1 1.452 1.188 4.950

Total Variance = 423.593 Generalized Variance = 0.443502D+22

Largest Eigenvalue = 152.434 Smallest Eigenvalue = 0.489

Condition Number = 17.649

Means

SE1_1 SE2_1 SE3_1 SE4_1 SE5_1 SE6_1
-------- -------- -------- -------- -------- --------
11.196 8.245 4.046 3.815 13.783 4.937

Means

SE7_1 SE8_1 SE9_1 SE10_1 SE11_1 SE12_1
-------- -------- -------- -------- -------- --------
3.319 10.447 7.486 5.415 5.415 3.329

Means

SE13_1 SE14_1 SE15_1 SE16_1 MA1_1 MA2_1
-------- -------- -------- -------- -------- --------
12.254 6.022 4.537 4.608 4.937 4.226

Means

MA3_1 MA4_1 MA5_1 MA6_1 MA7_1 MA8_1
-------- -------- -------- -------- -------- --------
6.060 2.860 8.245 1.614 1.698 3.008

Means

MA9_1 MA10_1 MA11_1 MA12_1 MA13_1 MA14_1
-------- -------- -------- -------- -------- --------
2.491 2.201 9.287 9.287 2.948 2.714

Means

MA15_1 MA16_1 MA17_1
-------- -------- --------
3.135 1.898 4.465

Standard Deviations
```

```
SE1_1 SE2_1 SE3_1 SE4_1 SE5_1 SE6_1
-------- -------- -------- -------- -------- --------
6.280 3.611 4.762 3.963 7.530 2.028

Standard Deviations

SE7_1 SE8_1 SE9_1 SE10_1 SE11_1 SE12_1
-------- -------- -------- -------- -------- --------
2.773 5.017 3.730 2.600 2.600 3.918

Standard Deviations

SE13_1 SE14_1 SE15_1 SE16_1 MA1_1 MA2_1
-------- -------- -------- -------- -------- --------
6.313 3.290 4.297 6.070 2.028 2.029

Standard Deviations

MA3_1 MA4_1 MA5_1 MA6_1 MA7_1 MA8_1
-------- -------- -------- -------- -------- --------
2.910 1.604 3.611 1.414 1.535 1.932

Standard Deviations

MA9_1 MA10_1 MA11_1 MA12_1 MA13_1 MA14_1
-------- -------- -------- -------- -------- --------
1.091 1.413 3.815 3.815 1.654 1.599

Standard Deviations

MA15_1 MA16_1 MA17_1
-------- -------- --------
2.054 1.770 2.225
```