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A multidimensional investigation of students' science self-efficacy: The role of gender

Merve Sezgintürk, *Middle East Technical University,* Turkey, *merve.sezginturk@metu.edu.tr*
ORCID: 0000-0001- 9203-7270
Semra Sungur, *Middle East Technical University,* Turkey, *ssungur@metu.edu.tr*
ORCID: 0000-0002-3372-6495

Abstract: The purpose of the current study was twofold: firstly, to examine gender difference in middle school students' science self-efficacy from a multidimensional perspective, and secondly, to explore the relationships among the science self-efficacy dimensions across gender. For these specified purposes, a questionnaire assessing science self-efficacy in terms of five dimensions, namely conceptual understanding, higher-order cognitive skills, practical work, everyday applications, and science communication, was validated for Turkish middle school students. Then, in order to examine the gender difference, the data obtained from the administration of the questionnaire to 461 middle school students (222 girls and 239 boys) were analyzed using Multivariate Analysis of Variance. According to the results, there was no statistical significant mean difference between boys and girls with respect to science self-efficacy dimensions. Both genders did not appear to be highly self- efficacious. Furthermore, path analyses results revealed that all the proposed relationships among the science self-efficacy dimensions were significant for both genders. However, strength of the relations appeared to vary across gender. Based on the results, it is suggested that, to enhance students' science self-efficacy for both genders, science teachers implement student-centered teaching methods in their classes

Keywords: Science self-efficacy, gender, scale adaptation

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INTRODUCTION

Self-efficacy, the central construct of Bandura's (1977) social cognitive theory, was defined as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1986, p. 391). In educational settings, students' self-efficacy beliefs influence their persistence, level of effort and choice of activities (Bandura, 1977; Schunk, Meece, & Pintrich, 2014). Indeed, to accomplish an educational task or activity, students with higher levels of self-efficacy beliefs are more likely to be involved in it whereas students with lower levels of self-efficacy are more likely to avoid engaging in it (Bandura, 1986; Schunk, et al. 2014; Liem, Lau & Nie, 2008). Accordingly, highly self-efficacious students tend to undertake more challenging tasks, work harder to perform successfully by using different learning strategies and persist longer when faced with difficulties; however, students who are in doubt about their capabilities tend to demonstrate unwillingness to try difficult tasks and tend to avoid exerting effort to complete them (Bandura, 1995; Hoy, 2004; Liem et al., 2008). Consistent with this situation, relevant literature demonstrates that students' self-efficacy is related to various adaptive outcomes such as effort, persistence, cognitive and metacognitive strategy use, and achievement (Sungur, 2007; Pamuk, Sungur, & Öztekin, 2017). Accordingly, examination of students' science learning self-efficacy is important because students' self-efficacy levels play a significant role in promoting their meaningful learning and enhancing their achievement.

According to Bandura (1995), one of the unique features of self-efficacy, being a context-specific rather than global construct, should be considered while measuring it. For instance, belief in students' capabilities to achieve goals or complete tasks for mathematics class may be different from the belief for English class (Bandura, 1995). In the science education field, by highlighting the domain specific nature of self-efficacy, researchers have given a great deal of their attention to examining students' science learning self-efficacy (e.g. Tuan, Chin & Shieh, 2005; Glynn, Taasoobshirazi & Brickman, 2009; Kiran & Sungur, 2012; Capa Aydın & Uzuntiryaki, 2009; Wang, Liang & Tsai, 2018). Along this line, to measure students' science learning self-efficacy, researchers have developed instruments which are mostly empirical self-report questionnaires such as Science Motivation Questionnaire (Glynn et al., 2009), and Students' Motivation Towards Science Learning (Tuan et al., 2009). However, in these early instruments, students' science learning self-efficacy is conceived as unidimensional, which may be inadequate to completely understand their science learning efficacy in science related tasks or goals. According to Bandura (1995), an adequate self-efficacy analysis requires multi-dimensional assessment methodology rather than singular (one-dimensional) scale, as a consequence of the domain-specific feature of self-efficacy. For this purpose, some researchers have recently initiated a development of multi-dimensional instruments to measure students' science learning self-efficacy (SLSE) (Baldwin, Ebert-May & Burns, 1999; Capa & Uzuntiryaki, 2009; Lin & Tsai, 2013; Uzuntiryaki & Capa Aydın, 2009). These instruments conceptualized students' SLSE in terms of different dimensions including conceptual understanding (Uzuntiryaki & Capa Aydin, 2009), higher-order cognitive skills (Baldwin et al., 1999; Uzuntiryaki & Capa Aydin, 2009), practical work (Baldwin et al., 1999; Capa Aydin & Uzuntiryaki, 2009; Uzuntiryaki & Capa Aydin, 2009), everyday applications (Baldwin et al., 1999; Uzuntiryaki & Capa Aydin, 2009), and science communication (Chang, Chen, Guo, Cheng, Lin & Jen, 2011). Based on this available literature, Lin and Tsai (2013) developed the Science Learning Self-Efficacy (SLSE) scale to measure students' beliefs in their capabilities to accomplish tasks or achieve goals while learning science concerning the abovementioned five dimensions. According to Wang et al, (2018), these five dimensions as measured by the SLSE scale belong to two main constructs, namely cognition and application. More specifically, the authors suggested that conceptual understanding and higher-order cognitive skills share something common that, both dimensions are related to cognition. On the other hand, remaining 3 dimensions (i.e. practical work, everyday applications, and science communication) concern with the people, events, or situations to which students can apply their scientific knowledge that they possess. Thus, these dimensions are related to practical application of the scientific knowledge in daily lives. The SLSE targeting these aspects of students' science learning self-efficacy was demonstrated to provide a valid and reliable measure of both elementary and high school students' science learning self-efficacy (Lin & Tsai, 2013; Wang, Liang & Tsai; 2018). Accordingly, the present study aimed to examine Turkish middle school students' science self-efficacy in terms of cognition (conceptual understanding and higher-order cognitive skills) and application (practical work, everyday applications, and science communication). For the specified purpose, firstly, the Science Learning Self-Efficacy scale was validated for Turkish middle school students. Then, the instrument was used to assess students' science learning self-efficacy across five validated dimensions. Because, in the relevant literature, gender appears play an important role in students' self-efficacy (e.g. Weisgram & Bigler, 2006), the current study explored students' science learning self-efficacy across gender. The role of gender in self-efficacy was elaborated in the following section.

Gender role in self-efficacy

Gender equity is an important issue in science education (Scantlebury & Baker, 2007) and relevant literature suggested that gender may play a role in various student related cognitive, affective, and behavioral outcomes in science including self-efficacy, achievement, or career choice (Huang, 2013; Lin & Tsai, 2018; Kıran & Sungur, 2012; Nisbett, 1993; Tindall & Hamill, 2004). According to the relevant research, the gender difference in science self- efficacy arises mostly from environmental factors rather than genetics. Indeed, Eccles (1987) suggested that the difference between self-efficacy levels of boys and girls can be to some extent explained by gender role stereotypes. Actually, Tindall and Hamill (2004) highlighted that starting from birth, the environmental conditions experienced by girls and boys differ: Boys tend to play with toys involving, for instance, construction of models, which are likely to enhance their science and mathematics abilities. On the other hand, girls tend to experience such play activities like sewing, drawing, playing house, and forming stories which are likely to enhance their verbal, interpersonal, or fine motor skills (Aldridge & Goldman, 2002; Tindall & Hamill, 2004). Additionally, girls are fostered to demonstrate nurturing and responsible behaviors (Lytton and Romney, 1991) and dependence to others, whereas boys are fostered to be creative and independent (Woolfolk, 1998). These different expectations from boys and girls can lead to male-dominated science classes where boys direct discussions and actively participate in various laboratory activities and tasks and girls remain passive and merely make observations, take notes, or record the obtained data (Guzzetti&Williams, 1996; Woolfolk, 1998). In addition, teachers tend to hold higher expectations for boys, provide them with higher order thinking questions and make corrective feedback more available for them (Guzzetti&Williams, 1996; Woolfolk, 1998). On the other hand, in an intervention study, Weisgram and Bigler (2006) demonstrated that girls in the intervention group engaging in hands-on science activities, being provided with the presentations by female scientists and presentations focusing on altruistic aspects of science careers had higher levels of self-efficacy compared to girls in the control group who did not experience such practices. This finding also supported the notion that the discrepancy between boys and girls concerning their science self-efficacy may be due to the differential socialization of boys and girls.

On the other hand, causal-comparative studies examining gender difference with respect to science achievement, in general, revealed no gender difference (Britner & Pajares, 2006; Kıran & Sungur, 2012). The reason for the non-significant gender difference may be that in these studies, self-efficacy was measured as a unidimensional construct. In a study, assessing self-efficacy as a multidimensional construct instead, boys appeared to be more self-efficacious in all dimensions including conceptual understanding, higher-order cognitive skills, practical work, everyday application, and science communication (Lin & Tsai, 2018). However, in the studies examining self-efficacy as a unidimensional construct, consistent with aforementioned literature, relative contribution of personal and environmental factors as sources of self-efficacy to students' self-efficacy appeared to differ across gender (e.g. Usher & Pajares, 2006). In the present study, students' self-efficacy will be assessed as a multidimensional construct and whether gender difference exists will be investigated. In addition, the relationships between these dimensions will be examined for each gender separately. Indeed, according to Wang et al. (2018), a limited research examined the relations among the science learning self-efficacy (SLSE) dimensions. They suggested that, as shown Figure 1, the dimensions which are related to cognition (i.e. self-efficacy for conceptual understanding and higher-order cognitive skills) can be predictors of the dimension related to application (i.e. self-efficacy for everyday applications, practical work, and science communication).

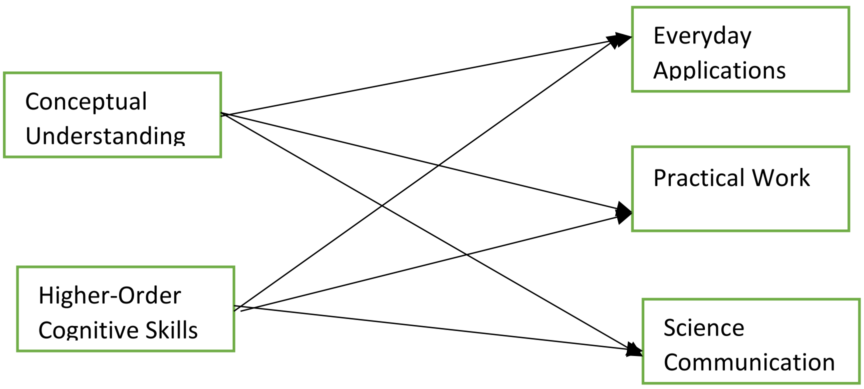

FIGURE 1. *Proposed relations among the SLSE dimensions*

In the current study, these hypothesized relations will be examined for each gender through path analyses because it is expected that due to the differences in their socializations, the relative contribution of each predictor (i.e. dimension related to the cognition) to the prediction of dimensions related to the application may differ across gender. For example, if girls are raised as dependent to others and provided with less opportunities to actively engage in science classes and laboratory works, the links between self-efficacy for higher-order cognitive skills and self-efficacy for everyday applications and practical work may be weaker: Even they find an opportunity to be involved in the activities and have a success, they may attribute this success to external causes such as luck. In fact, Schunk, et al., (2014) stated that, although there are no consistent results in the related literature, according to several studies, girls are likely to attribute their success to external factors including ease of task and luck, or unstable factors. Thus, in the present study, the path model proposed in Figure 1 will be tested for each gender separately. Result can provide specific implications for science education considering both genders. In fact, the newly updated Turkish science curriculum suggests that while learning science, students should be able to use their higher-order cognitive skills such as analytical skills or problem solving skills, apply scientific knowledge through laboratory activities and/or through daily life activities, and scientifically communicate through debates or discussions in science classrooms (MONE, 2018). To be able to achieve these goals, students should feel self-efficacious in all these aspects. Indeed, according to relevant literature, students' self-efficacy is related to various adaptive outcomes such as effort, persistence (Sungur, 2007), cognitive and metacognitive strategy use (Pintrich, Smith, Garcia & McKeachie, 1993; Sungur, 2007), and achievement in science (Pamuk, Sungur, & Öztekin, 2017). Relevant aspects were targeted by the Science Learning Self-Efficacy scale which assesses students' self-efficacy in terms of their conceptual understanding, higher-order cognitive skills, practical work, everyday application, and science communication Thus, administration of the Science Learning Self-Efficacy scale can provide valuable information concerning students' science learning self-efficacy levels: for example, if students are found less self-efficacious in some aspects, suggestions can be made for better classroom practices to improve their self-efficacy with the ultimate aim of achieving the goals of science curriculum. In addition, based on the results, suggestions can be made to science teachers, curriculum developers to promote the science self-efficacy equally for both genders.

Overall, based on the aforementioned literature, current study aims to address the following research questions:

1) Does Turkish version of the SLSE questionnaire provide a valid and reliable measure of Turkish middle school students' science self-efficacy in five dimensions, namely conceptual understanding, higher-order cognitive skills, practical work, everyday applications and science communication?

2) Is there a gender difference with respect science self-efficacy as measured by the SLSE?

3) Do the relationships among the SLSE sub-scales differ across gender?

METHOD

Participants

In this study, two different samples were utilized to validate the SLSE questionnaire for Turkish middle school students. Participants in both samples were middle school students selected via convenient sampling method. Students in each sample ranged in age from 11 to 14 years. They were from medium to high socioeconomic status families living in urban area, in Eskişehir. They all attended public schools. Sample 1 was used for the pilot study conducted as part of the validation of the SLSE. It consisted of 107 students (57 girls and 50 boys). Sample2 consisted of 461 students (222 girls and 239 boys). Data from the Sample 2 were used to examine psychometric properties of Turkish version of the SLSE in detail and address the second and the third research questions. All students in both the pilot and the main studies participated voluntarily.

Instrumentation

Science learning self-efficacy questionnaire (SLSE)

The SLSE was developed by Wang, Liang and Tsai (2018), for multidimensional assessment of students' self-efficacy in science learning. The SLSE is a 22-item self-report instrument on a 5-

point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). It consists of five dimensions: (1) Conceptual Understanding (CU, e.g. “I can choose an appropriate formula to solve a science problem”, n=4 items), which addresses students’ self-efficacy to employ comprehension skills in understanding the definitions of basic science concepts, laws, and theories; (2) Higher-Order Cognitive Skills (HCS, e.g. “I am able to critically evaluate the solutions of scientific problems”, n=6 items), which evaluates students’ self-efficacy to use higher-order cognitive skills such as problem solving, critical thinking, and scientific inquiry skills; (3) Practical Work (PW, e.g. “I know how to set up equipment for laboratory experiments” n=4 items), which assesses students’ self-efficacy to successfully complete laboratory activities in terms of cognitive and psychomotor skills; (4) Everyday Applications (EA, e.g. “I am able to use scientific methods to solve problems in everyday life” n=4 items), which evaluates students’ self-efficacy to practice science related concepts or skills in their daily life events; (5) Science Communication (SC, e.g. “In science classes, I can clearly express my opinions” n=4 items), which assesses students’ self-efficacy to communicate about science concepts. All the items in the questionnaire were positively stated statements.

For the present study, after taking permissions from the developers, the SLSE questionnaire was initially translated into Turkish by the researchers. Then, the Turkish version of the instrument was examined in terms of its content validity, grammar structure and clarity of the translated items by 6 experts in the field of science education, Turkish Language, and English Language. In addition, middle school students’ opinions about the items regarding to what extent the meanings are clearly communicated were taken. Based on the experts’ and students’ comments some revisions were made in the items. Then, psychometric properties of the translated instrument were examined using Sample 1 and Sample 2, as detailed in the results section.

Procedure

In this study, before the data collection, necessary permissions were obtained firstly from METU Ethics Committee, and then Ministry of Education. After getting the required permissions, the study was conducted in the middle of the spring semester in 2018. During data collection, all participants were ensured that their participation is voluntary and the data obtained from them will be kept confidential. The participants completed the questionnaire nearly in twenty minutes.

This study consisted of two main phases. In the first phase, the SLSE was validated for Turkish middle school students to assess their science self-efficacy in five dimensions. In the second phase, adapted instrument was used to examine whether there are gender differences with respect to the five dimensions conducting multivariate analysis of variance (MANOVA). In addition, relationships among the SLSE dimensions were examined for each gender conducting two separate path analyses in order to make comparisons concerning these relations.

RESULTS

Adaptation of the SLSE

Pilot Study

In order to address the first research question, firstly, a pilot study was conducted. As part of the pilot study, the Turkish version of the SLSE was administrated to 107 middle school students. By using collected data, confirmatory factor analyses (CFA) were conducted through LISREL 8.80 (Jöreskog & Sörbom, 2007). The CFA results showed that the model was marginally adequate ($\chi 2/df = 1.95$; RMSEA = .09; SRMR = .09; CFI = .94; and NNFI = .93). Examination of completely standardized Lambda-X estimates (pattern coefficients) revealed that factor loadings of all items were high enough exceeding .50 except for the item "I can write a laboratory report to summarize the main findings", from Practical Work dimension. When this item was deleted, there was an improvement in the model fit ($\chi 2/df = 1.65$; RMSEA = .08; SRMR = .08; CFI = .96; and NNFI = .95). In addition, investigation of the item-total correlations showed that when the item was removed, the mean inter-item correlation increased from .44 to .53 for the Practical Work dimension. Accordingly, this item was decided to be modified making it more understandable.

In the pilot study, when all items were included in the SLSE, reliability coefficients were found to be .69 for conceptual understanding, .87 for higher-order cognitive skills, .76 for practical work, .80 for everyday applications, and .74 for science communications dimensions.

The Main Study

After revising the SLSE, it was administered to 461 middle school students (Sample 2) to further examine its psychometric properties. The CFA results showed that there was a good model-to-data fit ($\chi 2/df = 3.08$; RMSEA = .07; SRMR = .05; CFI = .97; and NNFI = .96). All pattern coefficients were found to exceed .50 providing evidence for convergent validity (Hair, Black, Babin, & Anderson, 2010). Moreover, average variance extracted (AVE) values calculated for each dimension demonstrated that average pattern coefficients for the dimensions were between .39 to .46. Additionally, reliability coefficients that can be utilized as indicator of convergent validity (Hair et al., 2010), were found to be sufficiently high: Coefficient alpha values were .70 for conceptual understanding, .84 for higher-order cognitive skills, .77 for practical work, .73 for everyday applications, and .74 for science communications dimensions. Mean inter-item correlations ranging from .38 to .46 provided an exemplary evidence for internal consistency (Robinson, Shaver, & Wrightsman, 1991).

Examination of the pattern and structure coefficients also reveals that although all items correlate with their designated factors strongly, they correlate with their non-designated factors as well but to a less extent. To explore, if the correlations with non-designated factors create a threat to discriminant validity, confidence intervals around phi coefficients were calculated. Results showed that all the intervals (±2 standard errors) around the phi coefficients did not contain 1. This finding was an evidence for discriminant validity (Anderson & Gerbing, 1988). In fact, the highest phi coefficient was .90 with a confidence interval of .85 to .95.

Overall, results provided validity evidences for the Turkish version of the SLSE. In addition, reliability coefficients were found to be high enough. Accordingly, after ensuring that Turkish version of the SLSE provides a valid and reliable measure of students' self-efficacy in five dimensions, it was used to address the second and the third research questions.

Examination of Gender Difference concerning Science Self-efficacy

Descriptive Statistics

During the data analysis, firstly, as part of descriptive statistics, means and standard deviations were calculated for each dimension across gender (see Table 1). As shown in Table 1, the means appeared to be comparable for boys and girls. In general, boys were found to have slightly higher mean scores on conceptual understanding and everyday applications, while girls were found to have slightly higher mean scores on higher-order cognitive skills and science communication dimensions. In order to determine whether these observed mean differences between boys and girls are statistically significant, MANOVA was conducted, as detailed in the next section.

Inferential Statistics

In order to address the second research question, MANOVA was conducted. Prior to the analysis, multivariate normality, absence of multivariate outliers, linearity, multicollinearity, and homogeneity of variance-covariance matrices assumptions were checked and it was ensured that all the underlying assumptions were satisfied. According to the MANOVA results, there was no statistically significant gender difference with respect to collective dependent variables of self-efficacy for conceptual understanding, higher-order cognitive skills, practical work, everyday applications and science communication, (λ =.987, $F(5,454)= 1.20$, $p = .308$). The eta-squared value of .013 suggested that only 1.3 % of the variance in collective dependent variables can be explained by gender.

Table 1. *Descriptive statistics across gender*

Variables	Girls		Boys	
	M	SD	M	SD
Conceptual Understanding	3.54	.86	3.62	.84
Higher-Order Cognitive Skills	3.22	.95	3.19	.86
Practical Work	3.07	.99	3.07	1.00
Everyday Applications	3.37	.89	3.40	.93
Science Communication	3.64	.94	3.56	.85

Path analyses were conducted to address the third research question. More specifically, the relationships among the SLSE dimensions for each gender were investigated conducting two separate path analyses. There were good model fit for both boys ($\chi 2/df$ = 8.39; SRMR = .04; CFI = .97; and NNFI = .91) and girls ($\chi 2/df$ = .46; SRMR = .001; CFI = 1.00; and NNFI = 1.00). However, although, all the proposed relations were found to be positive and statistically significant for both genders, strength of the relations appeared to be different (see Table 2).

With regard to the self-efficacy for everyday applications, the amount variance explained by self-efficacy for conceptual understanding and higher-order cognitive skills appeared to be higher for girls (61 %) compared to boys (52 %). When the standardized coefficients were compared, it was seen that the association of self-efficacy for conceptual understanding with everyday applications appeared to be comparable for both genders. On the other hand, the link between self-efficacy for higher-order cognitive skills and everyday applications seemed to be stronger for girls.

Concerning self-efficacy for practical work, while the girls' self-efficacy for conceptual understanding and higher-order cognitive skills accounted for 58 % of the variance in this outcome variable, the corresponding percentage was 45 % for boys. Concerning the strength of the relationships, the relations of self-efficacy for conceptual understanding and self-efficacy for higher-order cognitive skills with self-efficacy for practical work appeared to be stronger for girls.

Table 2. *Direct effects on application related self-efficacy dimensions*

	Girls				*Boys*			
Effect	*Standardized Coefficient*	*Standard Errors of the Estimates*	*t*	*R^2*	*Standardized Coefficient*	*Standard Errors of the Estimates*	*t*	*R^2*
On Everyday				.61				.52
of Conceptual	.32	.06	5.82		.30	.07	4.92	
of Higher-Order	.54	.05	9.87		.48	.06	7.93	
On Practical Work				.58				.45
of Conceptual	.21	.07	3.71		.15	.08	2.36	
of Higher-Order	.61	.06	10.84		.55	.08	8.47	
On Science				.44				.40
of Conceptual	.32	.07	4.88		.40	.08	5.94	
of Higher-Order	.42	.06	6.39		.29	.07	4.25	

Regarding self-efficacy for science communication, path analysis results showed that the percent of variance explained by self-efficacy for conceptual understanding and higher-order cognitive skills were slightly higher for girls (44 %) compared to boys (40 %). In addition, the strength of the relationship between self-efficacy for conceptual understanding and self-efficacy for science communication appeared to be stronger for boys. On the other hand, the relation of self-efficacy for higher-order cognitive skills with self-efficacy for science communication was seemed to be stronger for girls as indicated by the standardized coefficients presented in Table 2. .

DISCUSSION and CONCLUSION

Adaptation of the SLSE

In this current study, firstly, the SLSE scale was validated for Turkish middle school students in order to measure their science learning self-efficacy in five dimensions. As part of the validation process, a pilot study was conducted with 107 middle school students, CFA results demonstrated that all items except for one of the items in Practical Work dimension had sufficiently high pattern coefficients exceeding .50. In addition, reliability coefficients ranging from .69 to .87 indicated that internal consistencies were high enough. However, deletion of the item PW3 was found to improve the internal consistency in the related dimension. Also, the overall model fit was better in the absence of this item. Thus, this item was decided to be revised to make it more concise and understandable. After this revision, the main study was conducted with 461 middle school students. According to the CFA results, there was a good model fit. The lowest pattern coefficient found as .56 provided an evidence for convergent validity (Hair et al., 2010). In fact, the AVE values ranging from .39 to .46 suggested that the average pattern coefficients were between .62 to .68. In addition, Cronbach's alpha reliability coefficients providing a measure of internal consistency were found range from .70 to .84. Mean inter-item correlations also indicted an exemplary internal consistency evidence. Concerning, discriminant validity, confidence interval around phi-coefficients were examined. Results suggested an evidence for discriminant validity. Overall, according to the results, Turkish version of the SLSE appears to provide a valid and reliable measure of middle schools students' science self-efficacy in five dimensions. As Bandura stated (1997), self-efficacy beliefs have a future-oriented feature. Therefore, it operates before students engage in a specific task and so it consequently affects their performance. Consistent with this idea, since students' self-efficacy is found to be highly correlated with adaptive outcomes such as effort, persistence (Sungur, 2007), and achievement in science (Pamuk, Sungur, & Öztekin, 2017), the data from this instrument can be used as diagnostic tool to improve such student related outcomes in science by teachers, schools, and curriculum developers at the primary and secondary levels.

Examination of Gender Difference concerning Science Self-efficacy

Current results showed that there is no significant difference between boys and girls with respect to the dimensions of science self-efficacy as measured by the SLSE. Majority of the previous studies examining self-efficacy as a unidimensional construct also revealed non-significant results concerning gender difference (e.g. Kıran & Sungur, 2012). However, in the study which explored self-efficacy from a multidimensional perspective, Lin and Tsai (2018) found that boys feel more self-efficacious in all dimensions of self-efficacy compared to girls. In the present study, descriptive statistics suggested that, although it is not statistically significant, boys are likely to feel slightly more self-efficacious for conceptual understanding and everyday applications compared to girls. Considering these descriptive findings future studies can examine whether this difference, although not significant, arise from differential access of boys and girls to science activities, or different roles assigned to them during these activities in science classes. In order to do this, interviews can be conducted with teachers and students to examine their beliefs regarding gender roles and students' self-efficacy in relation to these beliefs. In addition, classroom observations can be made to explore the impact of contextual factors on the self-efficacy. Moreover, to uncover the role of socialization in students' self-efficacy, parents can also be interviewed.

At this point it is important to note that mean scores in all dimensions were not high for both boys and girls: Although the maximum possible mean score was 5, the mean scores ranged from 3.07 to 3.64. The lowest mean was obtained by both genders on the Practical Work (PW) dimension while the highest mean was obtained by girls on the Science Communication (SC) dimension. In general, mean scores were the lowest on the Practical Work and Higher-order Cognitive Skills (HCS) dimensions for both genders. This finding may reflect that activities which involve active student engagement are not emphasized in science classes. In fact, according to both previous national literature (Dindar & Yangın 2007; Özmen, 2003) science teachers appear to create teacher-centered learning environments transferring knowledge to students rather than implementing student-centered activities in their classes. Actually, in the present study, only 14.8 % of the students strongly agreed with the statement in the HCS dimension that they can design experiments to test their hypotheses. Similarly, only 16.1 % of the participants strongly agreed with the statement in the PW dimension that they can write a laboratory report summarizing the findings from the science experiments. However, according to the relevant literature, in order to enhance students' self-efficacy, various student-centered teaching methods such as learning cycle, problem based learning, project based learning and argumentation can be integrated to instruction (Bircan & Sungur, 2016). Such inquiry-based methods can help students realize the link between their efforts and successes improving their beliefs in their abilities to be successful in science classes (Brtiner & Pajares, 2006).

Concerning the relationships among the SLSE dimensions across gender, results showed that the proposed relations were all significant for both genders. However, when the standardized path coefficients were examined, it appeared, for example, that the link between self-efficacy for higher-order cognitive skills and science communication was stronger for girls. This can be due to differential socialization of girls: Girls, during their childhood, tend to be involved in the games including role play, which require various verbal skills ranging from verbal establishment and determination of the rules to the communication during the role play (Perleth & Wilde, 2009). Such games can help students improve their communication skills. Thus, because boys are less likely to be involved in these games requiring verbal skills during their childhood, the weaker link found between the self-efficacy for higher-order cognitive skills and science communication in the present study seems to be not surprising. On the other hand, interestingly, the relation of self-efficacy for conceptual understanding and science communication appear to be stronger for boys. Thus, self-efficacy for conceptual understanding appears to be a better predictor of their science communication compared to girls. However, the relation of self-efficacy for conceptual understanding with remaining two application related self-efficacy dimensions (i.e., self-efficacy for everyday applications and practical work) were found to be weaker for boys. The possible explanation for the findings related to conceptual understanding may be that this dimension was measured by the items such as "I know the definitions of basic scientific concepts (for example, gravity, photosynthesis, etc.)" or "I can choose an appropriate formula to solve a science problem". As stated before, science teachers tend to use teacher-centered methods in their classes in Turkey. Accordingly, it is expected both gender have equal access to the opportunities to learn about concepts, definitions, relations among them and formulas taught by their teachers. Thus, the variability between the genders due to classroom environment may be less in this dimension. So, when such contextual factors are controlled, the relation between cognition related self-efficacy dimension (i.e. self-efficacy for conceptual understanding) and two of the application related self-efficacy dimensions (i.e. self-efficacy for higher-order cognitive skills and practical work) appeared to be stronger for girls.

Overall, current results revealed that there was no statistically significant difference between boys and girls with respect to dimensions of science self-efficacy. In addition, all the proposed relations among the dimension were significant for both genders. Though, strength of the relationships appeared to show differences across gender which can be explained by differential socialization of boys and girls. However, collection of the data only from administration of the SLSE as a self-report instrument can be considered as a limitation of this study. Self-report instruments allow researchers to obtain more generalizable results accessing larger samples but to be able to enrich current findings and to be able to provide better explanations, qualitative data collection methods can be integrated to the research design in the future studies. For example, observations can be made in the science classroom, and science teachers and their students can be interviewed to be able to uncover boys' and girls' multidimensional self-efficacy beliefs in relation to classroom practices and teacher behaviors and to determine whether there are gender biases in the science learning environments.

REFERENCES

Aldridge, J., & Goldman, R. (2002). Gender equity and education. In S. Dragin (Eds.), *Current issues and trends in education* (pp. 163-170). Boston: Allyn and Bacon.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin,103* (3), 411-423.

Baldwin, J., Ebert-May, D. & Burns, D. (1999). The development of a college biology self-efficacy instrument for non-majors. *Science Education*, 83, 397–408.

Bandura A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliff, NJ: Prentice-Hall.

Bandura A. (1977). *Social learning theory*. NewYork: General Learning Press.

Bandura, A. (Eds.). (1995). Self-efficacy in changing societies. New York, NY, US: Cambridge University Press.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W.H. Freeman and Company.

Bircan, H. & Sungur, S. (2016). The role of motivation and cognitive engagement in science achievement, *Science Education International, 27* (4), 509-529.

Britner SL, Pajares F (2006) Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43* (5), 485–499.

Capa Aydin, Y. & Uzuntiryaki, E. (2009). Development and psychometric evaluation of the high school chemistry self-efficacy scale. *Educational and Psychological Measurement*, *69* (5), 868–880.

Chang, H. P., Chen, C. C., Guo, G. J., Cheng, Y. J., Lin, C. Y., & Jen, T. H. (2011). The development of a competence scale for learning science: Inquiry and communication. *International Journal of Science and Mathematics Education*, *9* (5), 1213-1233.

Dindar, H., & Yangın, S. (2007). İlköğretim fen ve teknoloji dersi öğretim programına geçiş sürecinde öğretmenlerin bakış açılarının değerlendirilmesi. *Kastamonu Eğitim Dergisi*, *15* (1), 185-198.

Eccles J (1987) Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly, 11*, 135–172

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching, 46* (2), 127-146.

Guzzetti, B. J., & Wilhams, W. O. (1996). Changing the pattern of gendered discussion: Lessons from science classrooms. *Journal of Adolescent and Adult Literacy, 40* (1), 38-47.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). New York: Prentice Hall.

Hoy AW (2004) What do teachers know about self-efficacy? Paper presented at the annual meeting of the American Educational Research Association, San Diego.

Jöreskog, K., & Sörbom, D. (2007). *LISREL 8 user's guide*. Chicago: Scientific Software

Kıran, D. & Sungur, S. (2012). Middle school students' science self-efficacy and its sources: Examination of gender difference. *Journal of Science Education and Technology, 21,* 619-630.

Liem, A. D., Lau, S. & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology*, 33, 486–512.

Lin, T.-J., & Tsai, C.-C. (2013). A multi-dimensional instrument for evaluating Taiwanese high school students' science learning self-efficacy in relation to their approaches to learning science. *International Journal of Science and Mathematics Education, 11*(6), 1275–1301. doi:10.1007/s10763-012-9376-6

Lin, TJ. & Tsai, CC. (2018). Differentiating the sources of Taiwanese high school students' multidimensional science learning self-efficacy: An examination of gender differences, *Research in Science Education, 48,* 575-596.

Lytton, H., & Romney, D. M. (1991). Parents' differential socialization of boys and girls: A meta-analysis. *Psychological Bulletin, 109(2),* 267-296. http://dx.doi.org/10.1037/0033-2909.109.2.267

Ministry of National Education (2018). Elementary 3-8th Grades Science Education Curriculum. Ankara: Ministry of National Education Publications.

Nisbett, R.E. (1993). *Rules for reasoning.* Hillsdale, NJ: Lawrence Erlbaum.

Özmen, Ş. G. (2003). Fen Bilgisi Öğretmenlerinin Yapılandırmacı Öğrenme Yaklaşımına İlişkin Görüşlerinin İncelenmesi (Yayımlanmamış Yüksek Lisans Tezi). Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü, Ankara

Pamuk, S., Sungur, S. & Öztekin, C. (2017). A Multilevel Analysis of Students[1] Science Achievements in relation to their Self-Regulation, Epistemological Beliefs, Learning Environment Perceptions, and Teachers' Personal Characteristics, *International Journal of Science and Mathematics Education, 15,*1423-1440

Perleth, C., & Wilde, A. (2009). Developmental trajectories of giftedness in children. In L. V. Shavinina (Eds.), *International Handbook on Giftedness* (pp. 319–335). Amsterdam: Springer Science+Business Media B.V.
Pintrich, P. R., Smith, D. A., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, *53*(3), 801-813.
Robinson, J.P., Shaver, P.R. and Wrightsman, L.S. (1991) Criteria for Scale Selection and Evaluation. In: Robinson, J.P., Shaver, P.R. and Wrightsman, L.S., (Eds.), *Measures of Personality and Social Psychological Attitudes* (pp. 1-15). Academic Press, San Diego.
Scantlebury, K., & Baker, D. (2007). Gender issues in science education research: remembering where the difference lies. In S. Abell & N. Lederman (Eds.), *Handbook of research on science education* (pp. 257–286). Mahwah: Lawrence Erlbaum.
Schunk, D. H., Meece, J. L., & Pintrich, P. R. (2014). *Motivation in education: Theory, research and applications*. New Jersey: Pearson Education, Inc.
Sungur, S. (2007). Modeling the relationships among students' motivational beliefs, metacognitive strategy use, and effort regulation. *Scandinavian Journal of Educational Research, 51* (3), 315-326. doi:10.1080/00313 830701356166
Tindall, T. & Hamil, B. (2004). Gender disparity in science education: The causes consequences and solutions. *Education, 125* (2), 282-296.
Tuan, H. L., Chin, C. C., & Shieh, S. H. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, *27*(6), 639-654.
Usher EL, Pajares F (2006) Sources of academic and self-regulatory efficacy beliefs of entering middle school students. *Contemporary Educational Psychology, 31*(2), 125–141.
Uzuntiryaki, E. & Capa Aydin, Y. (2009). Development and validation of chemistry self-efficacy scale for college student. *Research in Science Education*, *39* (4), 539–551.
Wang, Y. L., Liang, J. C., & Tsai, C. C. (2018). Cross-cultural comparisons of university students' science learning self-efficacy: structural relationships among factors within science learning self-efficacy. *International Journal of Science Education*, *40* (6), 579-594.
Weisgram E.S., & Bigler R.S. (2006). Girls and science careers: the role of altruistic values and attitudes about specific tasks. *Journal of Applied Developmental Psychology, 27* (4), 326–348.
Woolfolk, A. E. (1998). *Educational psychology* (3rd ed.). Boston: Allyn and Bacon.