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Does Science Literacy Affect Self-Efficacy in Science Teaching? An Analysis with Structural Equation Modelling

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Abstract. It is well known that, for all civilizations' good and successful future, science and people with scientific skills have a key role. So, at the center of scientific skills, teaching science is an important topic. Maybe two of important components of science teaching are scientific literacy and self-efficacy. So, it has to be known if there is a correlation between them. The main aim of the study is to research correlation between self-efficacy beliefs towards science teaching and the level for science literacy of primary school teachers. For this aim data were collected with two instruments (basic science literacy test and the self-efficacy belief in science teaching scale) and gained data was analyzed with SEM (structural equation modelling). The sample of the study consist 506 primary school teachers. After data collection the theoretical model was tested that does science literacy affect or not the self-efficacy in science teaching with SEM. After data analysis it was found that the self-efficacy belief in science teaching affected positively and significantly by the science literacy levels. Considering that teachers with high self-efficacy in teaching science have more successful outcomes, it is believed that it would be beneficial to organize in-service training in which teachers can make a deep sense of their self-efficacy beliefs, literacy concepts and make self-evaluations.

Keywords: *literacy, self-efficacy towards science teaching, primary school teachers, SEM.*

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Introduction

Mankind tried to understand nature, use nature for his own benefit, and control events to ensure the safety and comfort of their lives since ancient times. As a result, these efforts have evolved into today's technology over time (Demirci Güler, 2017). Countries that want to keep up with technology and developments gave importance to science education and developed science education policies independent of political agendas (Ministry of National Education, 2013).

Science education is a long-term process that includes teaching the use and applications of scientific ideas in exploring and explaining how nature works (Asoko, 2002). Effective management of this process is directly related to the development of countries (Demirci Güler, 2017). The "Science Curriculum" published in Turkey in 2018 mentions the aim of raising individuals who are able to keep up with the rapid changes experienced by technology and science, capable of generating knowledge, able to use the knowledge they produce in a functional way in their daily lives, think critically, have developed problem-solving skills, and have skills such as entrepreneurship and determination (Ministry of National Education, 2018). These individuals are defined as "scientifically literate individuals" within the specific subjects of the program and in the science field. The concept of literacy has always been important since people began to express themselves with shapes and letters. When writing is used to express concepts, literate individuals start to have better places in society compared to those who are illiterate. Therefore, although the concept of literacy has survived to the present-day experience modifications in terms of its meaning, it still maintains its importance in terms of its effectiveness in society. With this thought, it is important to educate students and let them be prepared for life as literate individuals in all respects.

Raising literate individuals is strongly related to the teachers who are literate in their fields and have strong professional skills. Rapid developments in scientific and technological issues in recent years have increased the importance of raising scientifically literate individuals. Science literacy should include becoming familiar with the basic concepts of science, using these concepts in life skills and scientific thinking capacity (American Association for the Advancement of Science, 1989). Based on this thought, the determination of science literacy levels, which is one of the professional

competence indicators, of teachers, who are in the role of trainers and guides of science, becomes important.

A scientifically literate individual understands and explains some scientific concepts and facts at basic level, follows technological developments, and can use them in their lives (Duban, 2010). In the process of raising scientifically literate individuals in Turkey, the role of the teacher is described as encouraging, guiding, and also guiding students in the integration of technology, engineering, math, and science skills so that students reach the level of high-level thinking skills, invention, innovation, and product development (Ministry of National Education, 2018). Therefore, teachers, who can carry out this entire process, should be individuals who have sufficient professional skills and are scientifically literate. One of the important requirements for teachers to effectively manage the science education process is being a scientifically literate individual and adequately trained in this field (Duban, 2010). In this respect, revealing science literacy levels, determining the factors that determine the state of science literacy levels of teachers who are practitioners of science education is important in terms of revealing the quality and increasing efficiency of science education in Turkey (Özdemĭr, 2010). Considering the aforementioned statements, it is important that the teachers' science literacy levels closely affect student development, which is the product of the teaching profession, and thus, it is also important for teachers in terms of professional competence.

Another important aspect of education is teachers' self-efficacy belief. The concept of self-efficacy belief, which was first introduced by Bandura (1977) and took a very important place in the literature, is one of the two important basic expectations that affect the successful of individuals in realizing their intended behavior and achieving the desired result. Another factor affecting the professional competence and success of teachers is the concept of self-efficacy (Hazır-Bıkmaz, 2004). The teacher's ability to apply professional competencies by realizing permanent and qualified learning is related to self-efficacy (Huyugüzel Çavaş & Kesercioğlu, 2009). Teachers with high self-efficacy beliefs know how to cope with the difficulties he will face and will make an effort (Yıldız Duban & Gökçakan, 2012). When these aforementioned facts are considered together, in the context of professional competence, the concept of self-efficacy is an important issue to consider. If the teacher has sufficient self-efficacy beliefs in a particular field, he can set high goals in this field, face difficulties, do not give up easily, try different solutions, and have a positive perspective (Mutlu & Aydoğdu, 2003).

Individuals with low self-efficacy beliefs suffer difficulties in their profession, an increase in anxiety and stress levels, and narrowed positive perspectives on solving a problem (Kandemir, 2018). Based on the fact, it can be said that, teachers having high self-efficacy beliefs contribute to increasing their professional success and to be more resistant to the difficulties they will experience.

According to Bandura (1977), there are two basic expectations that play an active role for individuals to perform any behavior and to get the desired result. One of them is self-efficacy belief and the other is outcome expectation. The concept of self-efficacy belief was first introduced by Bandura (1986) and defined as individuals' beliefs about their ability to perform and organize the actions necessary to perform any behavior. The self-efficacy of teachers is the belief that the teacher can exhibit the performance expected of him and he can positively affect the performance of his students (Hazır-Bıkmaz, 2002). The self-efficacy for science teaching is the teacher's own judgment of his capacity to teach science (Riggs & Enochs, 1989).

Research Focus and Aim

In some cases, the knowledge and skills of the individual may not be sufficient on their own to perform the necessary behaviors (Bandura, 1995). Therefore, self-efficacy belief affects the use of knowledge and skills. Although there is often an incongruous correlation between the self-efficacy belief and the actual situation, it is believed that self-efficacy can motivate individuals (Pajares, 2002). This is why, it is believed that examining the correlation between self-efficacy beliefs towards science teaching and literacy levels of teachers, who are expected to be science literate, is important in terms of contributing to the literature.

And also, as mentioned above, one of the important factors effecting the professional competencies and scientific literacy levels of teachers, who are the practitioners of the process of raising scientifically literate individuals, which is important in the development of society, is the concept of self-efficacy (Hazır-Bıkmaz, 2004). Studies revealed that teachers with low self-efficacy beliefs have more difficulty in the profession and their burnout level is high (Sökmen, 2018). People with high self-efficacy beliefs can be more productive during challenging work while people with low self-efficacy beliefs experience more difficulties in their work than in reality (Kandemir, 2018). In this context, it is revealed that the self-efficacy beliefs of teachers should be high in teaching science to raise science-literate individuals more effectively. In present study, it is thought that determining how the

correlation between classroom teachers' science literacy levels and their self-efficacy beliefs towards science teaching, shaped within the scope of teacher qualifications, is important in terms of understanding the teaching competencies and field knowledge of classroom teachers.

Research Question

Based on this thought, "Is there a relationship between primary school teachers' basic science literacy levels and science teaching self-efficacy?" question form constitutes the research problem of the research.

Research Methodology

General Background

The aim of the study was to research the correlation between teachers' basic science literacy levels and self-efficacy beliefs towards science teaching. For this aim, Structural Equation Modelling (SEM) was used. SEM allows to test models with a comprehensive statistical approach. It is especially effective in cases where the causal and correlational correlation between observable and latent variables exists at the same time. Additionally, it allows researchers to study the correlation between one or more dependent and independent variables (Anagün, 2011; Yılmaz, et al., 2006). We need to measure certain observed variables to explain them since there is no direct measurement of the variables, which is capable of effecting self-efficacy. It can also calculate the predicted variable values with better precision because using implicit variables let us to determine the error in these variables (Şimşek, 2007). Furthermore, SEM allows researchers to process the path analysis for latent variable models and confirmatory factor analysis used in the measurements of the models (Jöreskog & Sörbom, 1996). It is worth noting that path analysis also let us estimate the relations between latent variables.

Sample

The sample of the study consists of 506 classroom teachers who answered the scales. The 66.6% (337) of teachers were female and 33.4% (169) were male. Their experiences in profession are, 86 (17%) less than 5 years, 104 (20.6%) between 6-10 years, 106 (20.9%) between 11-15 years, 69 (13.6%) between 16-20 years and lastly 141 (27.9%) more than 20 years. In the research, the data collected by authors at first hand so for sampling "convenience sampling" was used. Because it allows to select sample by availability (McIntyre, 2005, p. 106).

Instrument and Procedures

In this study, the Basic Science Literacy Test (hereafter BSLT) and Classroom Teachers' Self-Efficacy Belief Scale in Science Teaching (hereafter SBS) were used.

Basic Science Literacy Test: In the study, the Turkish translation (Duruk, 2012) of 1996 publication "Science for All Americans" by Lauksch and Spargo and the "Basic Science Literacy Test", whose validity and reliability tests were carried out, was used to measure the science literacy levels of classroom teachers. The test consists of 49 knowledge items. Participants respond to the items by choosing one of the "True - False - I don't know" options. The test includes three sub-dimensions as Knowledge of Scientific Content (coded as "bib" for statistical programmes in Turkish abbreviation, 33), Nature of Science (coded as "bd", 9), and Science-Technology and Society (coded as "ftt", 7). The evaluation of the test was performed as follows: correct answers were given "1 point" and incorrect and blank answers were given "0 point". The BSLT was translated from English to Turkish by Duruk (2012) and the sentence structure of the question items has not been changed to prevent the articles from losing their meaning. There are 33 items in the scientific content knowledge sub-field and 22 of these items are correct and 11 of them are incorrect. In the sub-field of the nature of science, out of 9 questions, 1 is wrong, and 8 of them are correct. There are 7 items in the science-technology society sub-field and 4 of these items are correct and 3 are incorrect (Duruk, 2012). The reliability coefficient of the test performed by the researcher was calculated as 0.82. The test was also used in the study named "Investigation of the relationship between pre-service science teachers' science teaching skills, science literacy and attitudes towards socioscientific issues" by Yolagiden (2017). In the aforementioned study, the test was applied to a total of 432 teacher candidates, 199 science candidates and 233 classroom teacher candidates, the reliability coefficient of test was calculated as 0.80. For present study, the Cronbach Alpha's reliability coefficient for the BSLT scale has calculated as 0.712.

Self-Efficacy Belief Scale in Science Teaching: SBS was developed by Enochs and Riggs (1990) and adapted into teachers' mother language by Hazır Bıkmaz (2004), was used to examine the classroom teachers' self-efficacy beliefs towards science teaching. It has two sub-dimensions as "Efficacy Belief (coded as "oi" for statistical programmes in Turkish abbreviation)" and "Outcome Expectation (coded as "sb")" and consists of a total of 20 items. The test was structured in a Likert type with 5 options,

ranging from "strongly disagree (1)" to "strongly agree (5)". The instrument was first translated into Turkish by the researcher and opinions were received from seven faculty members who are experts in their fields to determine the suitability of the translation in terms of meaning, compatibility with Turkish, content, and technical aspects. The scale was applied to 234 classroom teachers working in various provinces of Turkey and the reliability coefficient of the outcome expectation, efficacy belief, and the whole scale was calculated as 0.60, 0.78, and 0.71, respectively. In present study, the Cronbach alpha's for the SBS scale was found as 0.766.

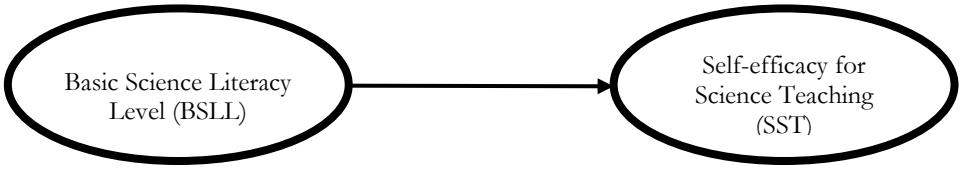
Data Analysis

The data gathered in the study were analyzed by LISREL program. When the results for validity and reliability studies of the scales are examined, it was deemed appropriate to include them in the model without the need for exploratory factor analysis. First, it was included all the variables one by one in our model and tested them with LISREL. After these tests, analyzed self-efficacy on learning strategies, classroom learning activities and the effects of attitude with the help of the SEM (structural equation modelling). SEM is famous for process the path analysis for latent variable models and confirmatory factor analysis used in the measurements of the models (Kelloway, 1998; Jöreskog & Sörbom, 1996). Additionally, path analysis also let us estimate relations between latent variables, which need to be estimated. In this regard, LISREL allows a holistic evaluation of the structural correlation quality in the variables. It was used the following indexes to examine the fitness between the empirical data and theoretical model. Below, you can find the acceptance ranges of the data and the accuracy of the established model that allows us to evaluate the compatibility (Schermelleh-Engel, et al., 2003 pp.52). As summary they said that if χ^2 value is between 0 and 2*df* the model has perfect fit, if between 2*df* - 3*df* model shows acceptable fit. Also *p* value is important for model's evaluation. It expected between .05 and 1 for perfect fit, and acceptable if between .01 and .05 range. If χ^2 /*df* value is between 0 to 2 model shows perfect fit, if between 2 to 3 model has acceptable fit. Lastly RMSEA index must between 0 to .05 for perfect fit and .05 to .08 for acceptable fit. There are other indexes that used for analyze the model like, AGFI=Adjusted Goodness-of-Fit-Index, CFI= Comparative Fit Index, GFI = Goodness-of-Fit Index, NFI = Normed Fit Index, NNFI=Nonnormed Fit Index, RMSEA=Root Mean Square Error of Approximation, SRMR= Standardized Root Mean Square Residual you can see in results.

Research Results

In this section of the study, structural equation modeling results about how and to what extent primary school teachers have science self-efficacy according to basic science literacy levels are included. The theoretic structural model and latent variable path models, are shown in Figure 1.

Figure 1 *Theoretic model*



Source: Author's own conception

As mentioned above, when the results of the reliability and validity studies of scales are examined, it was deemed appropriate to include them in the model without the need for exploratory factor analysis. In addition to this, the descriptive item statistics related to the items constituting the variables are included in the following table.

Table 1 *Descriptive item statistics of the BSLT and the SBS*

Variable	***Sub-dimension***	***Item codes***	***Factor load range***	***Cronbach's α Reliability Coefficient***	
BSLL coded as "TFOT")	Scientific content knowledge (coded as "bib")	bib_1 – bib_33	0.366 – 0.289	0.619	0.712
	Nature of Science (coded as "bd")	bd_34 – bd_42	0.395 – 0.270	0.470	
	Science-technology-society (coded as "ftt")	ftt_43 – ftt_49	0.402 – 0.216	0.478	
SST (coded as "FOI")	Self-efficacy belief (coded as "oi")	oi_1 – oi_13	0.623 – 0.311	0.673	0.766
	Outcome expectation (coded as "sb")	sb_14 – sb_20	0.643 – 0.317	0.692	

Source: Author's own conception

When examined table 1, it is seen that it is appropriate to test the collected data by taking the structural equation model. However, in model studies that latent variables used, every measurement tool should be tested one by one before the analysis (Byrne, 2009; Şimşek, 2007). Testing of tools

should be similar to CFA and any unconfirmed measurement model should not be included in the structural model (Çokluk, et al., 2010). Therefore, each sub-dimension (latent variable) in the study should be tested separately and its suitability with the structural model should be proven. The goodness of fit values (without exposure to any modification) obtained with LISREL for each variable are given in Table 2. As a result of the first goodness of fit trial for the variables, items coded bib_6, bib_11, bib_12, bib_13, bib_22, bd_36, oi_5, oi_7, and oi_11, whose *t* values were found to be insignificant, were excluded from the independent models and retested.

Table 2 *SEM indexes for goodness of the variables in the model*

Variable	AGFI	GFI	NFI	CFI	RMSEA	SRMR
BSLL	0.95	0.96	0.98	0.95	0.041	0.055
SST	0.90	0.93	0.92	0.90	0.064	0.057

Source: Author's own conception

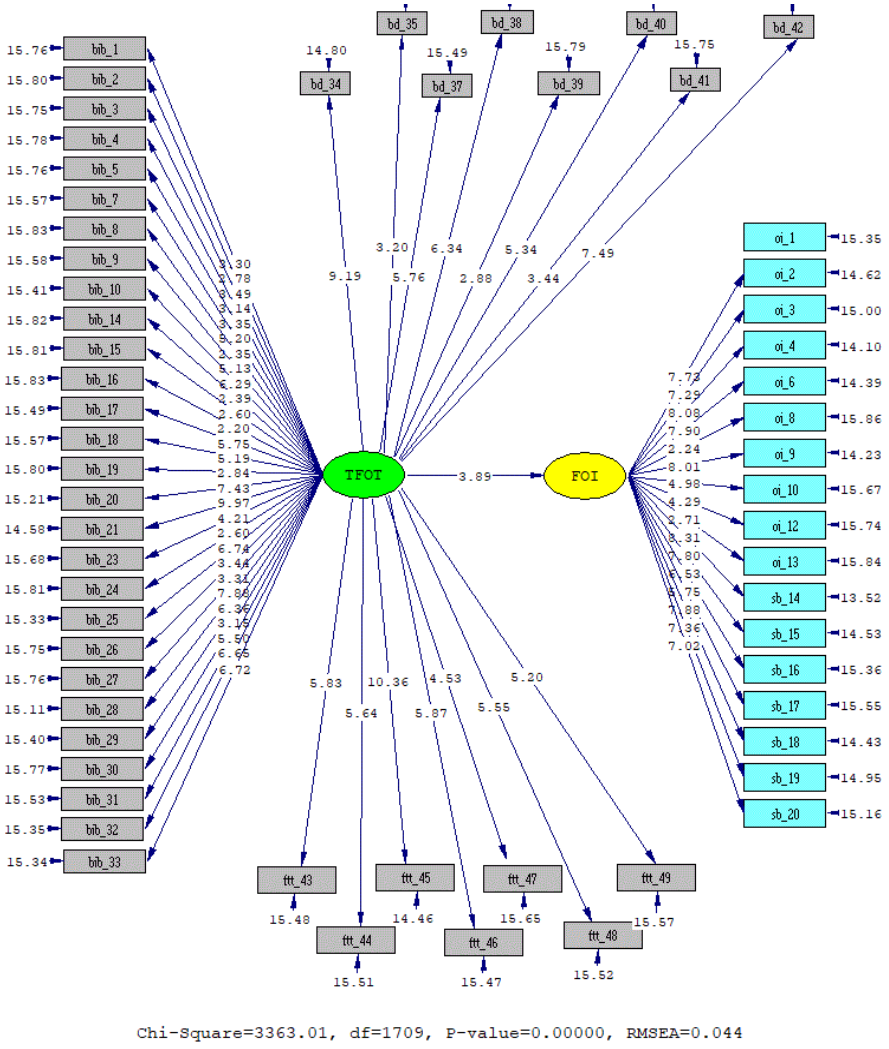
When we examine table 2, it can be seen that the goodness of fit values of the variables considered to be used in the model are within the limits of compliance available in text above for evaluation. Also, X^2=1703.25, *df*=860, and *p*=0.000 for BSLL, and the ratio χ2/df was calculated as 1.98. These values show that the model has a perfect fit for BSLL. For SST, χ2=346.74, *df*=119, and *p*<0.001, and the ratio χ2/df was calculated as 2.91, which means it was found to be at an acceptable level.

Therefore, it was decided that the data gathered from all variables was suitable for SEM analysis and included in the research model.

Later on, the theoretical model was tested to reveal the relationship between primary school teachers' basic science literacy levels and science teaching self-efficacy, in other words, finding out how much and in what direction BSLL predicts SST.

As a result of the test, it was found that χ2=3363.01, *df*=1709, and *p*<0.001. In addition to this, RMSEA was calculated as 0.044 and SRMR goodness of fit as 0.055 and X^2/df ratio found as 1.96, and these show that the model has perfect fit and is interpretable. Figures showing the *t* values and standardized path coefficients of the tested structural model are given below.

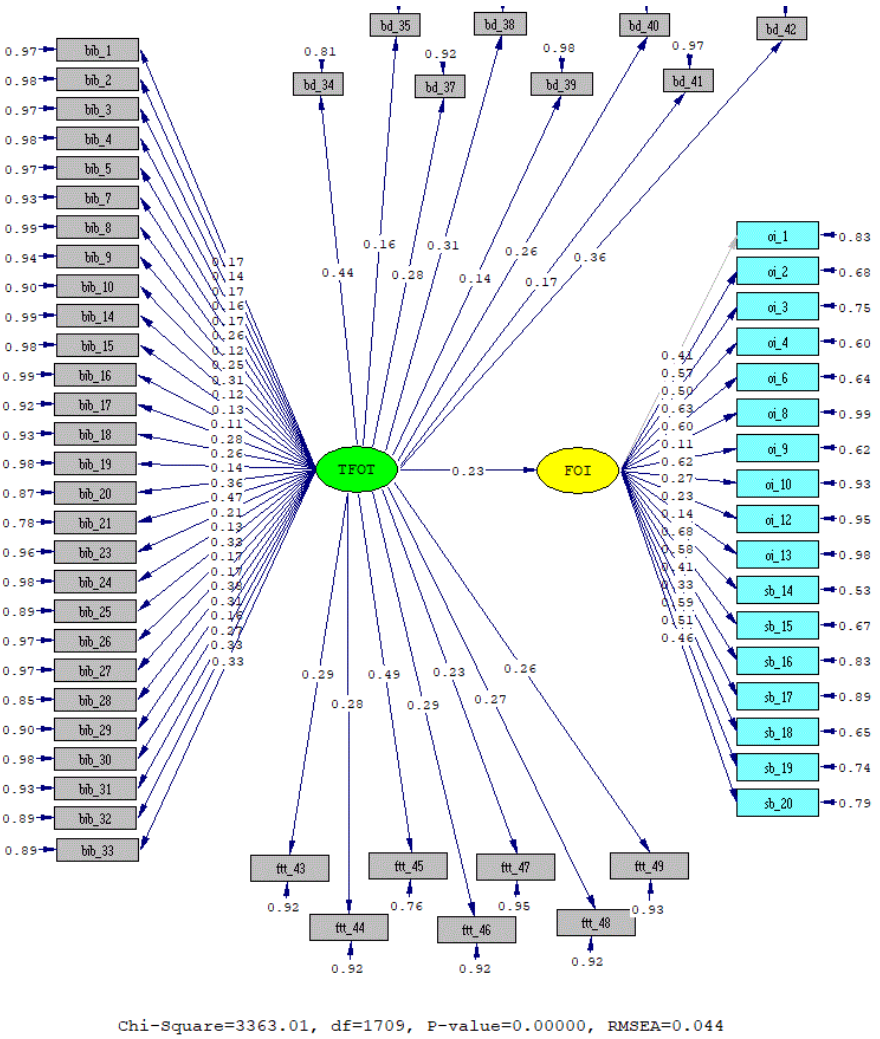
Figure 2 t values for the structural model



Source: Author's own conception

When examined Figure 2, it is seen that all paths are significant. The standardized values of the model of the research are given above.

Figure 3 The model shows the relationship between primary school teachers' science teaching self-efficacy and basic science literacy levels



Source: Author's own conception

When examined Figure 3, it is seen that basic science literacy levels of classroom teachers have a significant and positive effect on self-efficacy belief levels in science teaching. The correlation coefficient is 0.23 and this shows that this effect is moderate.

Discussion

When the results of the data on which the correlation between the science literacy levels of primary school teachers and their self-efficacy beliefs towards science teaching are tried to be determined are examined, it was revealed that science literacy level predicted self-efficacy beliefs towards science teaching in a positive and significant way. According to these results, a classroom teacher with a high level of science literacy has a higher self-efficacy belief towards science teaching. Similarly, a classroom teacher with a low level of science literacy will have a lower self-efficacy belief in managing the science teaching process and performing successful teaching.

The results of the research conducted by Uludüz (2017) with prospective classroom teachers and found that science literacy level and science teaching self-efficacy beliefs predict each other positively and significantly support these results. Also, these research results show similarity with the study of Akgün et al. (2014), in which they found that the level of science and technology literacy affects self-efficacy beliefs and attitude levels positively. In his study, Poluakan (2012) stated that teachers' science literacy levels strongly affect their success motivation. In another study examining the relationship between science literacy and self-efficacy of physics teachers, it is stated that there is a strong and positively significant relationship between science literacy and science teaching self-efficacy (Latifah et al., 2019). In the study conducted with 49 pre-service classroom teachers enrolled in the introductory and intermediate level "Advanced science teaching methods" course in the United States, a positive and significant relationship was found between science literacy and self-efficacy beliefs (Al Sultan et al., 2018). In his study, Flores (2019) examined the science literacy and science teaching self-efficacy of secondary school science teacher candidates and stated that high science literacy means high self-efficacy, and as science literacy increases, self-efficacy belief towards science teaching also increases.

When comparing the results of the study with literature and other researches, it is proved that important components of science teaching, for raising scientific literate individuals, self-efficacy beliefs and science literacy levels are affected each other. As mentioned above AAAS (1989) states for scientific literacy meaning, for becoming familiar with basic concepts of science and using them in life skills, the teachers must have enough self-

efficacy toward science teaching. So, with the help of these components help, the main focus for scientific literate individuals will be come true.

Conclusions and Implications

In this study, it was concluded that the level of science literacy affects self-efficacy beliefs about science teaching in a positive and significant way. Considering that teachers with high self-efficacy in teaching science will have more successful outcomes, it is believed that it would be beneficial to organize in-service training in which teachers can make a deep sense of their self-efficacy beliefs, literacy concepts and make self-evaluations.

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