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REVIEW ARTICLE

# German Students' Environmental Literacy in Science Education Based on PISA Data

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## ABSTRACT

The main aim of this study was to determine the factors that affect the environmental literacy (EL) of 15-year-old students in Germany. The data were based on findings from the PISA 2015 of German students ($n$ = 6.504), which were published on the official PISA site (http://www.pisa.oecd.org). According to the results, there was a positive and meaningful relationship between EL and environmental optimism (EO) at a low level. There was a meaningful relationship between EL and socioeconomic characteristics (SEC). Moreover, SEC has a large effect on the EL. There was a significant relationship between both classic literature and books on art, music, or design that students have at home, number of musical instruments at home, and EL. There was, however, no significant relationship between both 'books of poetry' and 'books to help with school work that students have at home' and EL . Results show that there was a significant relationship between some of the selected teaching characteristics (frequency of adapting lessons, teachers' providing individual help, teachers' explanations of scientific ideas, and teacher changing the structure) and EL, while there was no significant relationship between EL and teachers continuing frequency of teaching. Recommendations for the promotion of EL in schools are discussed.

**KEY WORDS:** environmental education; environmental literacy; PISA; science education

## INTRODUCTION

In 2005, the UNESCO launched its Decade of Education for Sustainable Development (2005–2014). In this decade, educational institutions in Germany increased their efforts to educate students for a more sustainable future. In the PISA 2015, the scientific literacy of German students averaged 509 points, 16 points over the OECD average, while for PISA 2000, their average was 487 points, 13 points below the OECD average. Comparing these two outcomes raised the following idea about this positive change on science literacy. According to PISA data, it was determined that certain factors must have a positive and/or negative effect on environmental literacy (EL). Therefore, the purpose of this study was to determine the relationships between the environmental optimism (EO), socioeconomic characteristics (SEC) of the participating students, teaching characteristics (TC), and EL of 15-year-old students in Germany. The data were based on the German sample of PISA 2015. The following sections will discuss environmental education (EE) in Germany's educational system.

## EDUCATIONAL SYSTEM AND EE IN GERMANY

In our globalized world, social life is more and more determined by the natural sciences and the technologies. The task of science education (SE) is to educate citizens who are able to participate in a challenging world (Bybee and Fuchs, 2006). The goal of SE is not only to educate future scientists but also to teach scientific literacy to all students (Roberts, 2007). These considerations form the basis for the National Educational Standards for secondary level biology and the other natural sciences (KMK, 2005). These standards constitute a general recommendation that all schools help students to achieve a common level of learning (Barton, 2009). In 2003–2004, the Council of Ministers (KMK) developed the National Educational Standards for Science (biology, chemistry, and physics) for grades 9–10 in secondary school, and in 2007, additional standards for upper secondary school for all 16 German federal states (OECD, 2010).

An introduction to Germany's educational system will allow for a better understanding of the importance of national education standards. Therefore, the following section will discuss Germany's educational system.

Primary and secondary schools depend on local governments, and high schools (vocational schools) depend on state governments. The management and regulation of the educational system are the responsibility of the states (Bal and Basar, 2014). All children who are 6 years old are required to go Grundschule (primary school) for 4 years (Venter, 1987; Hainmüller, 2003). Germany's educational system is a bit complicated because the secondary level is divided into two levels (Hainmüller, 2003). Realschule is the lower secondary school, and the Gymnasium is an academic school that combines the lower and upper secondary levels (Halász et al., 2004). Gymnasium is the only type of school in Germany's

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otherwise very heterogeneous school system that is found in all 16 federal states (Pant et al., 2013).

In the Realschule, students are provided with the opportunity to learn about daily life and vocational life. At the Gymnasium, students are also given vocational training and are trained for academic careers (Kocak and Cobanogulları, 2016). In the Federal Republic of Germany, students are required to pass the Abitur examination to enter higher education institutions and graduate from the Gymnasium upper secondary level (Turan, 2005).

Each of the 16 federal states has its own individual school system, educational aims, and educational and administrative traditions; however, every educational administration is organized in a centralized way regarding school structure, kinds of school, and curriculum (Huber and Gördel, 2006). Eurydice (2010) mentions that teaching in schools in Germany is governed by regulations of various kinds laid down by the federal states. The proposed curriculum includes knowledge about the use of materials and various teaching approaches. Moreover, with the Education for Sustainable Development initiated by the UNESCO, curriculum, especially science curriculum, has been focused on educating more qualified environmental literate individuals.

In the last decade, educational institutions around the world to include German educational institutions have attempted to increase their efforts to educate students for a more sustainable future. For this reason, the term environmental sustainable development (ESD) has evolved out of EE (Filho, 2009), meaning that EE is linked to the concept of sustainable development (Brößkamp, 1994, as cited in Schleicher, 1995). ESD concerns lifestyles, participation, values, global, and individual responsibility, and patterns of consumption and production. ESD enables sustainable action and encourages readiness to accept responsibility for one's own actions (UNESCO, 2014). Since 1996, ESD has been a field of learning and action (Haan et al., 2007).

In 2003, the German Commission for UNESCO decided on the Hamburg Declaration. The Declaration invited governmental and non-governmental organizations in Germany to participate in an "alliance for learning sustainability." The purpose was to develop an action plan for the UN Decade. In 2005, the National Plan of Action was to establish the notion of sustainable development permanently in all stages of education (UNESCO, 2014). This plan was supplemented by over 60 specific educational policy measures. It includes necessary skills and competencies such as critical thinking, imagining future scenarios, and making decisions in a collaborative way. These competencies are necessary for environmentally literate individuals. In 2007, over 200 European and international representatives participated the conference "UN Decade of Education for Sustainable Development - the Contribution of Europe" in Berlin, Germany, during the German Presidency of the EU Council. The primary objective of the conference was to identify the European contribution to the UN Decade. 2 years later, in 2009, the "World Conference on Education for Sustainable Development" was held in Bonn, Germany. 700 participants from 150 countries agreed to the Bonn Declaration that was launched by the UNESCO and the German Federal Ministry of Education and Research. In 2014, the "World Conference on Education for Sustainable Development: Learning Today for a Sustainable Future" in Aichi-Nagoya, Japan, marked the end of the UN Decade. It celebrated its achievements and launched the Global Action Program on Education for Sustainable Development (2015–2019).

The following section will discuss the development of the purpose of this research.

## THE PURPOSE OF THE RESEARCH

Literacy, especially scientific literacy, is of paramount importance to PISA. However, although its scientific literacy tasks include items related to environmental issues, it does not evaluate EL directly. A literature review found international empirical research on students' EL (Fah and Sirisena, 2014; Spínola, 2015) and the EL of teachers and teacher candidates (Pe'er et al., 2007; Tuncer et al., 2009; Yavetz et al., 2009; Derman et al., 2016). Researchers have developed scales to assess EL (Ozsevgec et al., 2010; Atabek-Yigit et al., 2014). However, it seems that there is not enough research on EL using PISA data. In the future, PISA will provide an opportunity to survey EL in different nations. Moreover, Lin and Shi (2014) suggested that further investigations are needed to refine the understanding of socioeconomic influences on EL. Hollweg et al. (2011) believed that information about students' home situations, especially family SEC and school experience, may be relevant to understanding EL. For instance, one of the components of economic, social, and cultural status in PISA appears to be the index of home possessions that include variable of the number of books in the home (Recommendations to the National Center for Education Statistics, 2012). In this study, the relationship between the SEC and EL was investigated. SEC includes income as well as subjective perceptions of education level, financial security, social status, and social class (American Psychological Association, 2017). Therefore, in recent years, the number of books in the household was added to SEC indexes (OECD, 2004; Taylor and Yu, 2009; Zhao et al., 2012). Bearing this in mind, this empirical study examines EL in SE. The following sections will discuss scientific literacy as a main concept in PISA and framing the concept of EL.

## SCIENTIFIC LITERACY AS A MAIN CONCEPT IN PISA

Although the Paris-based Organization for Economic Cooperation and Development (OECD) sponsors PISA, both OECD members and non-OECD countries participate (Bybee and McCrae, 2011). PISA offers opportunities to improve and compare the performance of these nations' educational systems (OECD, 2003). The first PISA survey was launched in 2000,

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and this survey has been repeated with its focus shifting from mathematics to science to reading every 3 years (OECD, 2000b). Thus, PISA provides data on the specific knowledge and skills of students, schools, and nations about these forms of literacy (Dobrota et al., 2015). Scientific literacy was the main topic of PISA 2015. The international student assessments provide significant information about SE policies, programs, and practices in different nations (Bybee and McCrae, 2011). The most concrete example is the changing definition of scientific literacy. Scientific literacy was first defined by PISA 2000 as "The ability to employ scientific data, to determine questions, and to obtain evidence-based conclusions for comprehending and helping make decisions regarding the natural world and the alterations made to the natural world by human activities" (OECD, 2000a. p. 76; OECD, 2002a. p. 102). PISA 2000 added "The ability to use scientific knowledge, to identify science questions, to understand the nature of scientific investigation, to use scientific evidence, and to communicate these aspects of science are assessed as scientific literacy by PISA" (OECD, 2002b. p. 211). Therefore, distinctive features of science literate individuals are to understand scientific concepts, to have the ability to adopt a scientific perspective, and to think scientifically about evidence (OECD, 2004). In PISA 2006, science was assessed more comprehensively. The main difference was the distinction between knowledge of science and knowledge about science (OECD, 2009a). In 2006, the definition of scientific literacy was as follows:

The scientific competency of a person and employing that competency to determine questions, to learn new scientific details, to elaborate scientific elements, and to obtain evidence-based conclusions regarding scientific topics, comprehending the characteristics of science as a form of human knowledge and enquiry, awareness of how our material, and intellectual and cultural environments is formed by science and technology and willingness to play a role in scientific subjects as a reflective citizen with scientific ideas (OECD, 2006. p. 12; OECD. 2013. p. 17).

By the year 2015, scientific literacy was defined by PISA as: The ability to play a role in scientific matters as a reflective citizen with scientific ideas. A person with sufficient scientific competency is willing to take part in a reasoned and scientific and technological discourse requiring the scientific explanations of scientific matters, evaluation of scientific research and its design, and scientific interpretations of data and evidence (OECD, 2016. p. 20).

Ultimately, scientific literacy is constantly evolving. The necessity of scientific knowledge, especially the evidence-based knowledge in the definition of SL was foregrounded by PISA 2000. The importance and characteristics of science have become more specified in PISA 2006 and 2015. It is predicted that future discussions of SE, especially EL, will include environmental issues, their significance, and their components. For this reason, international assessment research will be able to evaluate EL and scientific literacy directly.

## FRAMING THE CONCEPT OF EL

Human consumption, agriculture, and technology make life more comfortable and safe but also harm the environment (Polat et al., 2014). Therefore, deficient individual understanding of the fundamental environmental problem is often cited as a cause of environmental deterioration (Schneider, 1997). Currently, we face extremely important environmental problems such as increased air pollution (Ivanova and Roy, 2007), extinction of plants and animals (Patz et al., 2003), clearing forests (UNESCO-UNEP, 1992), water shortages (Goss, 2010), greenhouse gases (Chivian and Bernstein, 2010), genetically modified organisms (GMO) (Key et al., 2008; Hedrick, 2001), and acid rain (Likens and Bormann, 1974). These problems affect not only human beings but also all living things. Therefore, we need more environmentally literate individuals. We also need them to adapt to the changes and dynamics of environmental resources and systems (Scholz, 2011). EL is the capacity to recognize and understand the actual ecological situation and to take appropriate action to maintain, restore, and improve the health of environmental systems (Roth, 1992). EL as a part of the scientific literacy gives individuals the ability to engage with science-related issues and scientific ideas (PISA, 2013).

In 1990, the term of EL was clarified and redefined with the development of EE (Roth, 1992). However, researchers continue to present new definitions of this concept. One such definition is as follows:
A person competent in terms of the environment who spreads and implements primary ecological concepts and principles knows how human activities affect the environment from an ecological perspective, possesses the skills needed to define and investigate environment-related issues and alternative solutions, and adopts environmental values necessary for responsible use of environmental resources. (Subbarini, 1998. p. 245).

As the North American Association EE informs us, EL includes dispositions, knowledge, and competencies applied for the purpose of responsible environmental behavior (Daniš, 2013). Ultimately, people should be aware of nature's laws and sensitive to environmental problems and communicate with nature through EL (Kaya and Kazancı, 2009).

This research investigated the impact of environmental awareness (EA), environmental responsibility (ER), and EO on EL. The researchers reveal the basic framework for understanding EL in the light of the PISA 2015 data. One of the components, EA, is a basic level of EE (Coyle, 2005). Development of EA prepares students to become adults who have more knowledge and understanding of the environment (David, 1974). Environmentally literate individuals have social awareness about their own actions, as well as EA (Stoller-Patterson, 2012). Another component of EL and ER is defined as "an individual's responsible and moral approach to the prevention of environmental degradation, the solution of environmental issues and willingness to act in a positive

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manner for the environment" (Wenshun et al., 2011. p. 992). The last component, EO, has gained significance in the field of EE (Eryigit et al., 2011) because students' levels of EO as well as their EA affect their environmental concerns and this affects the global climate, the economy, and society (PISA, 2017). Finally, this research intends to contribute to a better understanding of EL by analyzing the effects of EA, ER, and EO in EE.

## RESEARCH QUESTIONS

The main aim of this research is to determine the factors that affect the EL of 15-year-old students in Germany. More specifically, its research questions were:

- Which factors affect EL of 15-year-old German students?
- What is the relationship between EL and SEC of the students (such as type of books and number of musical instruments at home)?
- What is the relationship between the EL and TC (such as explanations, individualized help, and the structure of lessons)?

## RESEARCH METHODS AND DESIGN

This study used the paradigm of descriptive research, and the surveys were used descriptively. In this study, the target population was 15-year-old German school students. The sample consists of the 6,504 students PISA 2015 data obtained from the official PISA website (http://www.pisa.oecd.org).

### Data Analysis

This section consists of two parts. The first describes the development of the scales. The second explains the analyses used in this study. The EL and EO scales were developed in two stages, first exploratory and then confirmatory factor analysis. Two different scales were developed by the researchers because the Likert-type items for EO differ from other factors.

### Developing the Scales

In the first part of the scale development, exploratory factor analysis (EFA) with the Statistical Package for the Social Sciences (SPSS) software (SPSS version 24) was used to examine the construct validity of the scale. In the second part, confirmatory factor analysis with analysis of moment structures (AMOS) software (AMOS version 18) revealed the relationships between the variables.

### EFA for EL

To determine whether or not to perform factor analysis, the Kaiser–Meyer–Olkin (KMO) Value and Bartlett's test of sphericity were calculated before the EFA. KMO values over 0.50 (KMO = 0.90, $\rho < 0.01$) indicate that factor analysis sampling was appropriate. Bartlett's test of sphericity was significant at 3,2061.74, $\rho < 0.01$, showing that the tool can be differentiated into factor structures. The t-test for the reliability of the meaningfulness of the median of top 27% and bottom 27% groups was done. The results are shown in Appendix 1, and the t-values are meaningful ($\rho < 0.01$). These results indicate that it is appropriate to perform a factor analysis. As Appendix 2 highlights, there are two important factors in the scale. While there are two factors in the graph with a high acceleration, the general trend of the graph in the third and subsequent factors is horizontal, and they have no significant declining trend. Thus, the contribution of the third and subsequent factors to the variance is very close to each other. According to EFA, it is seen that the 13-items were aggregated on the two factors, where eigenvalue is >1 (Appendix 2). The factor common variance, factor-1 load value, and the analysis of converted basic components are presented in Table 1.

According to the results of EFA, it was obtained that 13-items were loaded on the two factors labeled. Whole factors explained 55.2% of the total variance. Through factor analysis, an attempt was made to bring together variables that measure the same structure with a small number of factors (Büyüköztürk, 2009). Item loads larger than 0.52 were chosen for inclusion in the scale. No items were excluded from the scale because they were not disassociated. As shown in Table 1, the item loads for each factor were organized from the high value to low value. The total variance was 55.2%. The variances of environmental awareness (EA) and environmental responsibility (ER) were found to be 29.2% and 25.9%, respectively. Analysis of factors-1 and -2 found Cronbach's alpha internal consistency coefficients of 0.85 for EA and 0.84 for ER. As Appendix 3 shows, there seems to be a positive and meaningful relationship between EA, ER, and EL ($\rho < 0.01$).

### EFA for EO

A KMO value over 0.50 (KMO = 0.81, $\rho < 0.01$) indicates that factor analysis sampling was appropriate. Bartlett's test of sphericity was significant at 8,370.62, $\rho < 0.01$, which shows that the tool can be differentiated into factor structures. The *t*-tests for the reliability of the meaningfulness of the median of top 27% and bottom 27% groups were done (Appendix 4). Appendix 4 shows that the t-values were meaningful ($\rho < 0.01$) except for item 5, which was excluded in the scale. According to the eigenvalue, the number of important factors in the scale was one (Appendix 5). According to EFA, it was seen that the 6-items were made on the 1 factor, where eigenvalue is >1 (Appendix 5). the factor common variance, factor-1 load value, and the analysis of converted basic components are presented in Table 2.

According to the result of EFA, it is obtained that six items were loaded on the factor-1 labeled. Whole factors explained 45.9% of the total variance. Those item loads larger than 0.55 were chosen and included in the scale. No items were excluded from the scale because they were not disassociated. The Cronbach's alpha internal consistency coefficient was 0.77 for factor-1.

## CONFIRMATORY FACTOR ANALYSIS FOR EL AND EO

Structural validity was tested by confirmatory factor analysis as described above. The initial results obtained by confirmatory factor analysis indicated that some of the values were not within

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**Table 1: Factor analysis of converted basic components**

| Factor | | Item | Factor common variance | Factor-1 load value | Analysis of converted basic components | |
|---|---|---|---|---|---|---|
| | | | | | Factor-1 | Factor-2 |
| Environmental responsibility | 1 | How informed are you about this environmental issue? Air pollution | 0.67 | 0.68 | 0.81 | |
| | 2 | How informed are you about this environmental issue? Extinction of plants and animals | 0.62 | 0.66 | 0.78 | |
| | 3 | How informed are you about this environmental issue? The consequences of clearing forests\ other land use | 0.63 | 0.68 | 0.78 | |
| | 4 | How informed are you about this environmental issue? Water shortage | 0.56 | 0.64 | 0.74 | |
| | 5 | How informed are you about this environmental issue? Nuclear waste | 0.54 | 0.64 | 0.72 | |
| | 6 | How informed are you about this environmental issue? The increase of greenhouse gases in the atmosphere | 0.49 | 0.64 | 0.67 | |
| | 7 | How informed are you about this environmental issue? The use of GMO | 0.33 | 0.56 | 0.52 | |
| Environmental awareness | 8 | Identify the science question associated with the disposal of garbage | 0.63 | 0.62 | | 0.78 |
| | 9 | Interpret the scientific information provided on the labeling of food items | 0.60 | 0.58 | | 0.77 |
| | 10 | Predict how changes to an environment will affect the survival of certain species | 0.56 | 0.61 | | 0.72 |
| | 11 | Recognize the science question that underlies a newspaper report on a health issue | 0.53 | 0.57 | | 0.71 |
| | 12 | Identify the better of two explanations for the formation of acid rain | 0.15 | 0.55 | | 0.70 |
| | 13 | Describe the role of antibiotics in the treatment of disease | 0.51 | 0.57 | | 0.69 |

Explained variance total 55.2%, factor-1: 29.2%, factor-2: 25.9%, Cronbach's $alpha_{EA}$=0.85, Cronbach's $alpha_{ER}$=0.84, GMO: Genetically modified organisms

the acceptable limits. For this reason, covariance was created between the error terms of the items within each latent variable in the model. These findings are shown in Table 3. Each correction should be based on a theoretical basis (Meydan and Sesen, 2015; Karagoz, 2016). Therefore, the error terms of the items in each factor were associated (Karagoz, 2016). Then, confirmatory factor analysis was performed again. Corrected confirmatory factor analysis seems to have good fit in general. Good fit and acceptable fit have different value ranges. Furthermore, it is possible that a model may fit the data, although one or more fit measures may suggest bad fit (Schermelleh-Engel et al., 2003).

As Table 3 shows, the significance value was found to be 0.00. Moreover, the ρ-values and most of the other values may be interpreted as indicating good fit.

### Findings

The results of the analysis are displayed in the tables according to whether they are statistically significant or not. Cohen's d (for *t*-test) and Cohen's f (for ANOVA) effect sizes were used to calculate effect size. The findings are discussed in three sections: Factors in EL, SEC, and TC that influence EL.

## FINDINGS ABOUT THE FACTORS IN EL

In this research, exploratory and confirmatory analyses were used to evaluate the data derived from the analysis of quantitative data. As Appendix 6 shows, the students had high EO (X=2.46/4.00), while EA (X=2.86/4.00) and ER (X=2.28/4.00) were low. Appendix 7 indicates that there seems to be a positive and meaningful relationship between EL and EO at a low level ($r = 0.16$, $\rho < 0.01$). As Appendix 8 highlights, there was a positive correlation between the EL of students and EA, ER, and EO. An increase in one of these three factors affects EL positively.

As Appendix 9 shows, when the factors related to the EO of the German students were examined, the factor of the extinction

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**Table 2: Factor analysis**

| Factor | | Item | Factor common variance | Factor-1 load value |
|---|---|---|---|---|
| Environmental optimism | 1 | This issue will improve or get worse over next 20 years? Extinction of plants and animals | 0.49 | 0.70 |
| | 2 | This issue will improve or get worse over next 20 years? The increase of greenhouse gases in the atmosphere | 0.58 | 0.76 |
| | 3 | This issue will improve or get worse over next 20 years? Clearing of forests for other land use | 0.52 | 0.72 |
| | 4 | This issue will improve or get worse over next 20 years? Air pollution | 0.39 | 0.62 |
| | 5 | This issue will improve or get worse over next 20 years? The use of GMO | 0.49 | 0.70 |
| | 6 | This issue will improve or get worse over next 20 years? Nuclear waste | 0.30 | 0.55 |

Explained variance total 45.9%, Cronbach's alpha 0.77, GMO: Genetically modified organisms

**Table 3: Fit criteria (Schermelleh-Engel et al., 2003) and model fit measures**

| Model Fit Summary | Good fit | Acceptable fit | EL model fit | EO model fit |
|---|---|---|---|---|
| c2/sd | 0d/²/sd dd | 2dd²/sd dd | 8.83 | 28.22 |
| ρ | 0.05≤ρ ≤1 | 0.012ρ ≤0.012 | 0.00 | 0.00 |
| Root mean square error of approximation | 0rror of app | 0.05r of approx | 0.04 | 0.07 |
| Normed fit index | 0.95indexappr | 0.90indexappr | 0.99 | 0.99 |
| Tucker-Lewis index | 0.95×r-Lewis | 0.90×r-Lewis o | 0.98 | 0.95 |
| Comparative fit index | 0.97indexve | 0.95indexve | 0.99 | 0.99 |
| Relative fit index | 0.90<RFI<1.00 | 0.85<RFI<0.90 | 0.98 | 0.95 |

of plants and animals with a coefficient of 1.67 had the highest factor value in PISA 2015. The students seemed to perceive EO as air pollution, clearing forests, and greenhouse gases. The last item is GMO with a coefficient of 1.00. Moreover, this research argues that students should be more informed and encouraged to take responsibility for environmental issues, particularly, GMO and water shortages.

## FINDINGS ABOUT THE SEC THAT INFLUENCE EL

This section includes analyses of the students' SEC. Parametric tests, ANOVA, and the *t*-test were used to evaluate the data derived from the analysis of quantitative data (Table 4).

There was a significant relationship between both classic literature and books on art, music, or design that students have at home and EL ($t_{Classic\ Literature}$ (5.500) = 3.86. $t_{Art,}$ music or design (5.544) = 3.31, ρ < 0.01). However, there was no significant relationship between both books of poetry and books to help with school work that students have at home and EL ($t_{Poetry}$ (5.554) = 2.06, $t_{School\ Work}$ (5.621) = 1.35, ρ > 0.01). Those who have these types of books at home ($X_{Classic\ L.}$ = 2.59, $X_{Poetry}$ = 2.58, $X_{BAMD}$ = 2.59, and $X_{BHSW}$ = 2.58) had a higher average EL than those who did not ($X_{Classic\ L.}$ =2.56, $X_{Poetry}$ = 2.56, $X_{BAMD}$ = 2.56, and $X_{BHSW}$ = 2.56) (Table 5).

There was a meaningful relationship between EL and number of musical instruments at home (F [3, 5,669]=7.43, ρ < 0.01). According to the results of the Scheffe test, the EL of students who had 3 or more musical instruments (d) (X = 2.60) was more positive than those who had only a single musical instrument (b) (X = 2.56) and those who had none (a) (X = 2.56) (Table 6).

As Table 6 shows, there was a meaningful relationship between EL and SEC (t (5.673) = 5.55, ρ < 0.01). Students' SEC affects their EL. Thus, it can be said that as the SEC increases, EL increases. These results show that SEC has a large effect on the EL ($\eta^2$ = 0.18).

## FINDINGS ABOUT THE TC THAT INFLUENCE EL

This section includes analyses of TC. ANOVA was used to evaluate the data derived from the analysis of quantitative data.

As Table 7 indicates, there is a meaningful relationship between EL and teachers' frequency of adapting the lesson to class needs and knowledge (F [3, 4,120] = 7.18, ρ < 0.01). According to the results of the Scheffe test, students' EL was higher for students whose teachers adapted lessons to their needs in every lesson or almost every lesson by the teacher (d) (X = 2.61) and lower for those whose lessons were adapted sometimes (b) (X = 2.55) or never or almost never (a) (X = 2.55).

As Table 8 highlights, there is a meaningful relationship between EL and the frequency of teachers providing individual help when students had difficulties (F [3, 4.091] = 5.08, ρ < 0.01). According to the results of the Scheffe test, the EL of the students who were provided individual help in every lesson or almost every lesson (d) (X = 2.62) was higher positive than

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**Table 4: The results of the *t*-test for EL and type of books at home**

| Type of books | Answer | N | $\bar{X}$ | sd | Df | t | ρ | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|
| Classic literature | Yes | 2.363 | 2.59 | 0.27 | 5.500 | 3.86 | 0.00 | 0.03 |
| | No | 3.139 | 2.56 | 0.29 | | | | |
| Poetry | Yes | 2.952 | 2.58 | 0.28 | 5.554 | 2.06 | 0.04 | 0.02 |
| | No | 2.604 | 2.56 | 0.29 | | | | |
| BAMD | Yes | 2.928 | 2.59 | 0.28 | 5.544 | 3.31 | 0.00 | 0.03 |
| | No | 2.618 | 2.56 | 0.28 | | | | |
| BHSW | Yes | 4.943 | 2.58 | 0.28 | 5.621 | 1.35 | 0.18 | 0.02 |
| | No | 680 | 2.56 | 0.28 | | | | |

MAMD: Books on art, music, or design, BHSW: Books to help with school work

**Table 5: The results of ANOVA for EL and number of musical instruments at home**

| Musical instruments | N | $\bar{X}$ | Source of variance | Df | Mean square | F | ρ | Sig. Dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| None (a) | 1.725 | 2.56 | Between groups | 3 | 0.59 | 7.43 | 0.00 | d-a, d-b | 0.06 |
| 1 (b) | 1.379 | 2.56 | Within groups | 5.669 | 0.08 | | | | |
| 2 (c) | 1.050 | 2.58 | Total | 5.672 | | | | | |
| 3 and more (d) | 1.519 | 2.60 | | | | | | | |

**Table 6: The results of the t-test for EL and SEC**

| SEC | Responses | N | $\bar{X}$ | Sd | Df | t | ρ | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|
| Number of books at home | 0–25 | 1.326 | 2.53 | 0.31 | 5.673 | 5.55 | 0.00 | 0.18 |
| | More than 25 | 4.349 | 2.58 | 0.27 | | | | |

**Table 7: The results of ANOVA according to EL and frequency of adapting lessons**

| Adapting lessons | N | $\bar{X}$ | Source of variance | df | Mean square | F | ρ | Sig. dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Never or almost never (a) | 795 | 2.55 | Between groups | 3 | 0.75 | 7.18 | 0.00 | d-a, d-b, c-a, c-b | 0.07 |
| Some lessons (b) | 1.548 | 2.55 | Within groups | 4.120 | 0.11 | | | | |
| Many lessons (c) | 1.175 | 2.59 | Total | 4.123 | | | | | |
| Every lesson or almost every lesson (d) | 606 | 2.61 | | | | | | | |

that of those who did so sometimes (b) (X = 2.55), or never or almost never (a) (X = 2.57).

As Table 9 shows, there is a meaningful significant relationship between EL and frequency of teachers explanations of scientific ideas (F [3, 4.227] = 10.91, $p < 0.01$). According to the results of the Scheffe test, the EL of the students whose teachers explained scientific ideas in every lesson or almost every lesson (d) (X = 2.60) was higher than those who did so sometimes (b) (X = 2.59) or never or almost never (a) (X = 2.52).

As Table 10 notes, there is no significant relationship between EL and frequency of teachers continuing to lecture (F [3, 4.227] = 0.98, $\rho > 0.01$). Accordingly, it can be said that as the frequency of teachers continuing to lecture increases, EL does not increase.

As Table 11 indicates, there is a meaningful relationship between EL and frequency of teacher changing the structure of lessons to suit class needs (F [3, 4.078] = 4.72, $\rho < 0.01$). According to the results of the Scheffe test, the EL of the students whose teachers changed the structure of lessons to suit class needs every lesson or almost every lesson (d) (X = 2.61) was higher than that of those whose teachers did so sometimes (b) (X = 2.55).

## CONCLUSION AND DISCUSSION

In this research, parametric tests, ANOVA, and the t-tests were used to evaluate the data derived from the analysis of quantitative data. In this section, the data obtained are discussed in two parts: SEC and TC that influence EL.

### Conclusion and Discussion about SEC that Influences EL

This study showed there was a significant relationship between EL and the number of musical instruments and books at home (SEC). Oral and McGivney (2013) mentioned that one of the factors thought to affect student achievement is having books

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**Table 8: The results of ANOVA for EL and the frequency of teachers' providing individual help**

| Individual Help | N | $\bar{X}$ | Source of variance | df | Mean square | F | ρ | Sig. dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Never or almost never (a) | 1.106 | 2.57 | Between groups | 3 | 0.53 | 5.08 | 0.00 | d-a, d-b | 0.06 |
| Some lessons (b) | 1.603 | 2.55 | Within groups | 4.091 | 0.11 | | | | |
| Many lessons (c) | 986 | 2.58 | Total | 4.094 | | | | | |
| Every lesson or almost every lesson (d) | 400 | 2.62 | | | | | | | |

**Table 9: The results of ANOVA for EL and the frequency of teachers' explanations of scientific ideas**

| Explanations of scientific ideas | N | $\bar{X}$ | Source of variance | df | Mean square | F | ρ | Sig. dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Never or almost never (a) | 550 | 2.52 | Between groups | 3 | 1.10 | 10.91 | 0.00 | d-a, d-b, c-a, c-b | 0.09 |
| Some lessons (b) | 1.573 | 2.56 | Within groups | 4.227 | 0.100 | | | | |
| any lessons (c) | 1.373 | 2.59 | Total | 4.230 | | | | | |
| Every lesson or almost every lesson (d) | 735 | 2.60 | | | | | | | |

**Table 10: The results of ANOVA according to EL and frequency of teachers' continuing to lecture**

| Teachers' continuing to lecture | N | $\bar{X}$ | Source of variance | df | Mean square | F | ρ | Sig. dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Never or hardly ever (a) | 607 | 2.58 | Between groups | 3 | 0.095 | 0.98 | 0.40 | - | 0.02 |
| Some lessons (b) | 1.134 | 2.57 | Within groups | 4.447 | 0.097 | | | | |
| Most lessons (c) | 1.360 | 2.56 | Total | 4.450 | | | | | |
| Every lesson or almost every lesson (d) | 1.350 | 2.58 | | | | | | | |

**Table 11: The results of ANOVA for EL and frequency of changing the structure of lessons to suit class needs**

| Changing the structure of lessons | N | $\bar{X}$ | Source of variance | df | Mean square | F | ρ | Sig. dif. | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Never or almost never (a) | 1.337 | 2.56 | Between groups | 3 | 0.498 | 4.72 | 0.00 | d-b | 0.06 |
| Some lessons (b) | 1.433 | 2.55 | Within groups | 4,078 | 0.105 | | | | |
| Many lessons (c) | 925 | 2.59 | Total | 4.081 | | | | | |
| Every lesson or almost every lesson (d) | 387 | 2.61 | | | | | | | |

at home. Other similar studies have found that books have positive effects on scientific literacy (Ozer and Anil, 2011; Kaya and Dogan, 2016) and mathematics literacy (Ozer and Anil, 2011). In addition, this study showed that there was a significant relationship between both classic literature and books on art, music, or design that students had at home and EL. On the other hand, this study highlighted that there was no significant relationship between both books of poetry and books to help with school work at home. Furthermore, classic literature and books on art, music, or design that students had at home had greater positive effects on EL. Ozer and Anil (2011) claimed that there is a relationship between scientific literacy and educational materials that students have at home, but there was no relationship between mathematics literacy and educational materials. It can be stated that having books to help with school work at home does not affect EL since education is not examination oriented in Germany. Furthermore, as reported by Abdu-Raheem (2015), there is a relationship between the academic performance of students and the SEC of their families. This research also showed that there was a significant relationship between EL and SEC. A similar finding was mentioned by Erbas et al. (2012). Turkish students' responsibility toward the environment varies by SEC. In a similar vein, Lin and Shi (2014) mentioned that economic, social, and cultural status, internal student factors, seem to affect certain aspects of EL. This study found that students' SEC affected their EL, and as SEC increases, EL increases. Studies have indicated that SEC has a significant effect (Hattie, 2003) and its importance for teaching (Lotz and Lipowsky, 2015). Lotz and Lipowssky (2015) in an updated study of Hattie's (2003) study found the effect size between student achievement and SEC (such as family resources) was d = 0.52. Consequently, these results show that SEC is effective in both student achievement and EL.

### Conclusion and Discussion about TC that Influences EL

The link between students and teachers is important to the attainment of educational goals (Nembhard, 2005). An important part of the responsibility for strengthening this bond belongs to teachers. For this reason, raising the educational standards of teachers, who are schools' most important resource, is critical (OECD, 2009b). The instructional quality of the teacher has a powerful effect on achievement (Hattie, 2003). In particular, the teaching process should be supported to improve the quality of education. Thus, educators are exploring ways to create schools that improve the learning and performance of students in many parts of the world (Whole Schooling Research Project, 2000). The character of a teacher is also significant for effective teaching practices in enriched learning environments (Pennock and Moyers, 2012). This study's results provided evidence that there was a significant relationship between teachers adapting lessons to their students' needs and knowledge, changing the structure of their lessons, providing individual help when students have difficulties, and explaining science ideas in every lesson and EL. In fact, research has identified these characteristics as effective teacher skills. Sprague (2012) stated about effective teachers that "they can adapt or differentiate instruction for all students by using some basic problem-solving techniques that involve quickly identifying issues, generating alternative solutions, and trying one or two to see if they work" (p. 3).

On the other hand, this study's findings suggest that there was no meaningful relationship between teachers continuing to lecture in their science lessons and EL. The reason for this may be that students want a student-centered learning environment instead of a teacher-centered learning environment. In addition, various approaches can be used for student-centered learning, including case-based learning, project-based learning, and problem-based learning (Pederson and Liu, 2003). These environments focus on meaning formation, inquiry, and authentic activity, unlike traditional teaching (Garrett, 2008). These environments acknowledge each student can learn, research, and analyze current knowledge in a different way (Attard et al., 2010).

Ultimately, individual support given by teachers has a positive effect on EL. For this reason, teachers should create atmospheres where students are supported. Although lecturing does not affect EL, teachers' explanations of scientific ideas in science lessons increase EL. Adapting all lessons to the needs of the students and changing the structure of lessons accordingly can help students to increase their EL.

## DIDACTICAL RECOMMENDATIONS

According to the results, it might be concluded that the environmental literate individual needs awareness and responsibility toward the environment, as well as, to be optimistic toward the environment. Therefore, the knowledge and awareness levels of students should be increased to educate more environmentally literate individuals. The relationship between EL and EO is also positive and meaningful. However, it is also apparent that they are more concerned about environmental issues. Therefore, they should be encouraged to increase their knowledge and awareness about the environment as well as to develop positive emotions toward the environment to remove or reduce environmental concerns. Increasing their optimism about the environment will contribute to higher EL.

States and schools should be aware of the effect of SEC on EL. Governments should provide books to students of low socioeconomic status. Science teachers should also be aware of the effect of SEC on EL and enrich the teaching methods and materials used in their lessons. For instance, the use of musical instruments by science teachers during EE may increase EL levels.

Furthermore, the teaching profession starts with pre-service training and continues with in-service training (Kaya and Gödek, 2016; Kaya, 2011). Therefore, teacher training and practices should be developed to teach environmental issues in teacher education. Similarly, teachers should also be supported by in-service teacher education.

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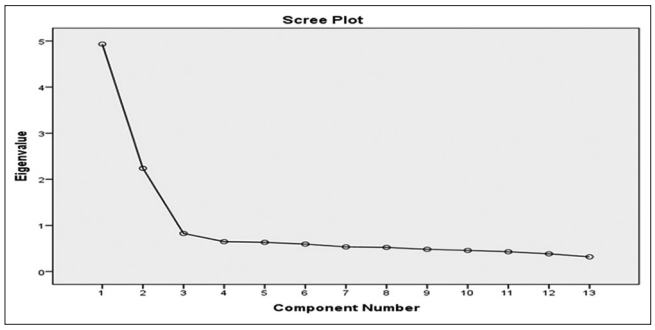
# APPENDICES

**Appendix 1: Analyses of item for EL scale**

| Item | T (bottom%27 - top%27)[1] |
|---|---|
| 1 | 25.37** |
| 2 | 20.14** |
| 3 | 29.57** |
| 4 | 30.63** |
| 5 | 31.56** |
| 6 | 30.69** |
| 7 | 30.54** |
| 8 | 16.22** |
| 9 | 16.21** |
| 10 | 17.71** |
| 11 | 14.18** |
| 12 | 20.17** |
| 13 | 18.18** |

[1]$n_1=n_2=1.756$, number of Items=13, **p<0.01




**Appendix 2:** Graphic of eigenvalues for EL scale

**Appendix 3: Correlation between EL and EO**

| | EA | ER | EL |
|---|---|---|---|
| EA | | | |
| R | 1 | | |
| P | | | |
| N | 6504 | | |
| ER | | | |
| R | −0.38** | 1 | |
| P | 0.00 | | |
| N | 6504 | 6504 | |
| EL | | | |
| R | 0.67** | 0.43** | 1 |
| P | 0.00 | 0.00 | |
| N | 6504 | 6504 | 6504 |

**Appendix 4: Analyses of item**

| Item | T (bottom%27 - top%27)[1] |
|---|---|
| 1 | 5.00** |
| 2 | 4.55** |
| 3 | 4.80** |
| 4 | 7.45** |
| 5 | 0.82 |
| 6 | 4.30** |
| 7 | 2.5** |

[1]$n_1=n_2=1.756$, number of items=13, **p<0.01

**Appendix 5:** Graphic of eigenvalues

**Appendix 6: Mean of factors**

| Statistics | EA | ER | EL | EO |
|---|---|---|---|---|
| Mean | 2.86 | 2.28 | 2.57 | 2.46 |
| Maximum value | 1.00 | 1.00 | 1.00 | 1.00 |
| Minimum value | 4.00 | 4.00 | 4.00 | 3.00 |

**Appendix 7: Correlation between EL and EO**

| | EL | EO |
|---|---|---|
| EL | | |
| R | | |
| P | | |
| N | | |
| EO | | |
| R | 0.16 | 1 |
| P | 0.00 | |
| N | 6504 | 6504 |

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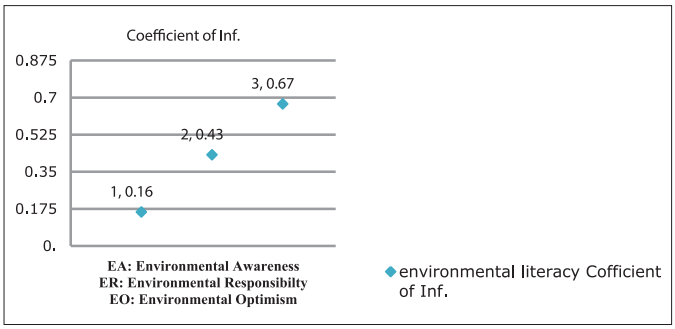
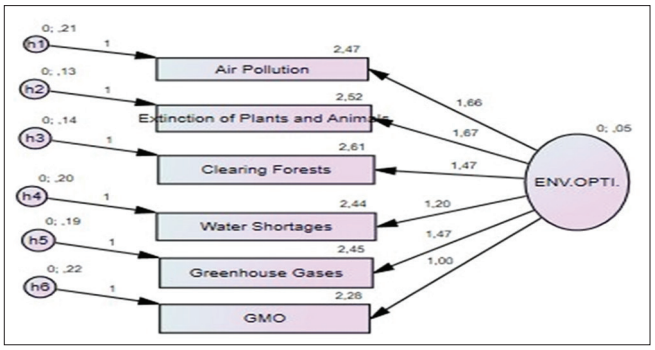



**Appendix 8:** Correlation coefficients




**Appendix 9:** Views on EO