JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

DEVELOPING A SELF-EFFICACY SCALE TOWARD PHYSICS SUBJECTS FOR LOWER-SECONDARY SCHOOL STUDENTS

Mustafa Fidan,
Meric Tuncel

Abstract. *Physics subjects or topics as a part of science education enable students to explore nature and natural events by using physics laws and scientific methods. In the lower-secondary school, physics is a subfield within the science curriculum developed holistically with the broad field curriculum design unlike the subject-centred curriculum in the upper-secondary education. As an important factor that directs the achievement, self-efficacy is one of the predecessors of these cognitive and affective skills. Accordingly, most of the scales which evaluate the students' cognitive or affective skills in the lower-secondary school are related to science course in a general context. This research aimed to develop a valid and reliable scale measuring the students' self-efficacy beliefs toward physics subjects for lower-secondary schools. The sample consists of 2737 students. The draft scale consisted of 52 items and was applied to 1882 students in the first stage. To construct validity of the scale, exploratory factor analysis was performed. The results showed that the scale consisted of single- factor with 28 items. To confirm its factor structure, the scale was applied to 785 students. The research findings indicate that the scale is a valid and reliable instrument to measure the self-efficacy beliefs towards physics subjects.*

Keywords: *lower-secondary school, physics subjects, scale development, self-efficacy belief*

Mustafa Fidan
Bartin University, Turkey
Meric Tuncel
Bolu Abant Izzet Baysal University, Turkey

Introduction

The term of self-efficacy is theoretically based on Social Learning Theory (Bandura, 1977). However, being formed in the light of cognitive processes, self-efficacy addresses to Social Cognitive Learning Theory in later times (Schunk & Parajes, 2009). Bandura (1997) stated self-efficacy as "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments". According to Zimmerman (1995), self-efficacy includes an individual's judgements about performing a task or an assignment rather than the physical or psychological characteristics owned by that individual. In other words, self-efficacy is not an observable skill that the individual owns. It is the individual's personal beliefs, expectations, or judgements about the answers that he or she gives to the question "What can I do?" in relation to a specific field, task, or situation (Bandura, 1997; Klassen & Usher, 2010).

Self-efficacy belief is related to an individual's ability to discover and manage his or her own abilities. As a specific domain-oriented term rather than a global and stable structure, self-efficacy belief occurs with direct or indirect experiences in a certain process (Bandura, 1997). Bandura (1997) has underlined the four principal sources of self-efficacy as follows: (a) mastery experiences (interpretations of actual performances, past accomplishments, or failures etc.) (b) vicarious experiences (observation of others' positive or negative situations) (c) verbal persuasion (supportive messages, encouragement of teachers etc.) (d) physiological and emotional situations (emotions, stress, happiness, concern etc.). The findings of some studies highlighted that these factors were power predictors of self-efficacy (Usher & Parajes, 2009). As a determinant of behaviour changes, self-efficacy belief also affects the task choice, effort, persistence in achieving resilience to difficult situations (Bandura, 1997).

In educational studies, self-efficacy is one of the critical variables in explaining the learning performance (Richardson et al., 2012; Schunk & Pajares, 2009). Accordingly, it has gained attraction from educators and researchers over the past decades (Britner & Pajares, 2006; Usher & Pajares, 2009). Self-efficacy has an important role on cognitive and affective outcomes such as learning achievement, motivation, attitude, self-regulation, and learning goals (Schunk & Pajares, 2009; Schunk & Usher, 2011). Actually, students with high

https://doi.org/10.33225/jbse/21.20.38

self-efficacy make more efforts when they face with difficulties, they are eager to learn and they tend to continue learning (Bandura, 1997). Conversely, there is considerable evidence that students with poor self-efficacy beliefs have a low level of course achievement and ability to deal with difficulties and that their desire and tendency to perform a task is low (Schunk, 1990). Therefore, students with low self-efficacy are less motivated to learn and do not make much effort to perform the assigned tasks (Bandura, 1997).

On the other hand, it is still under discussion among some researchers whether the variable of self-efficacy is peculiar to a general field or a more specific subject (Aypay, 2010). However, most of the researchers have emphasized that the concept of self-efficacy should be treated as being oriented to any assignments or tasks that are peculiar to a certain field (Bandura, 1997; Klassen & Usher, 2010). This means that it is more like a discipline, domain-specific or task-based content rather than a general construct. Therefore, students may have self-efficacy towards sub-disciplines such as geometry in mathematics course, grammar in language course or tasks and more specialized subjects like astronomy, anatomy in the field of science. In this context, the current study focused on the self-efficacy beliefs towards physics subjects of science course at lower-secondary schools.

As a part of science education, physics in a broad sense is concerned about the matters such as the history of science, movements and behaviours of nature, and earth and space sciences. It underlies other disciplines such as biology, astronomy, geology, and chemistry and directs to new inventions or technologies (MoNE, 2018). While students generally learn these subjects or concepts through physics curriculum in the secondary school, they learn them within context of science course at the lower-secondary shool level. Moreover, partly because of its abstract content or complexity, physics is critical for students to shape their knowledge, skills, and attitudes about science in the lower-secondary schools (Tuncel & Fidan, 2018). In the literature, the research on physics teaching-learning as a subfield of science education has started to increase over the past decades. Especially, the researchers have been interested in cognitive and affective features that predict the learning achievement in physics education (Kapucu, 2017; Tezer & Asiksoy, 2015). Self-efficacy belief can be described as the individual's belief in overcoming the tasks, difficulties or situations related to the field of science education by evaluating his or her own abilities (OECD, 2017).

Indeed, students with high self-efficacy beliefs in physics are willing to take risks and perform difficult tasks. Besides, they make more efforts to perform a behaviour related to learning and have higher levels of motivation and self-confidence (Tezer & Asiksoy, 2015). Therefore, the high level of self-efficacy beliefs held by the learners in physics may be an effective factor in the process of finding solutions to the problems they may face in the course. In contrast, the low level of self-efficacy belief in physics negatively affects motivation, learning behaviour, and expectations for future and performance (Lin et al., 2015).

Self-Efficacy Instruments in Physics

Recent studies have shown that self-efficacy regarding physics course is significantly correlated to students' learning achievement and motivation (Alpaslan & Isik, 2016; Kapucu, 2017). This means that the perception of self-efficacy in physics increases their learning performances and stimulates their actions. Considering the general objectives of physics curriculum (MoNE, 2013), self-efficacy belief is an important psychological construct about whether students can learn subjects and concepts in physics course or not. Also, it is included in the scope of science literacy as well as the attitudes, beliefs, values, and motivational orientations (OECD, 2017).

There are several measurement tools developed for measuring the self-efficacy belief in physics. For instance, Lin et al. (2015) attempted to develop the scale for physics self-efficacy belief of university students in a multi-dimensional sense. They adapted the self-efficacy scale which was developed for science learning by Lin and Tsai (2013) to physics learning. Its factors were as follows: conceptual understanding (structuring the physics concepts, principles etc.), higher-order cognitive skills (problem solving, critical thinking, or scientific inquiry regarding physics), practical work (performing laboratory activities regarding physics), everyday application (practicing the physics concepts regarding daily life), science communication (discussing the physics subjects with others or peers). Similarly, Alpaslan and Isik (2016) also adapted this scale developed by Lin and Tsai (2013) into Turkish to assess the physics self-efficacy of university students in Turkey. Selcuk et al. (2018) developed physics self-efficacy scale including two factors with 21 items for high school level. The first factor, self-efficacy belief towards physics achievement, is associated with problem solving and remembering necessary formulas in physics lesson while the second factor, self-efficacy belief towards the skill of using physics knowledge, is related to the ability to transfer physics concepts or subjects into daily life. However, these scales were developed for grades from upper-secondary school to higher education.

https://doi.org/10.33225/jbse/21.20.38

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

On the other hand, the researchers integrally developed several instruments for measuring self-efficacy belief in science education including physics in the lower-secondary school level (Aslam & Ali, 2017; Lin & Tsai, 2013; Tatar et al., 2009). Some researchers have also used the self-efficacy as a sub-dimension of motivation on their scales (Glynn et al., 2009; Tuan et al., 2005). These instruments focus on a general perspective oriented to the overall course, field or discipline unlike specific subjects, themes, or tasks in the context of science discipline. In addition, in the literature, most of the research on scale development has focused on high or undergraduate school level rather than primary or middle school level. Specifically, the field of science education lacks an adequate instrument that enables understanding students' self-efficacy beliefs towards physics subjects. In recent years, the scale development studies regarding the specific domain, theme or task features have begun to draw attention of science researchers. For instance, Ilhan and Cicek (2017) have developed a self-efficacy scale for acid-base subjects by focusing on a more specific subject in the field of science and examined students' perceptions of self-efficacy in chemistry. At the end of the research process, they approached the self-efficacy belief in two aspects as associating it with daily life and as making scientific explanations about the subject. Similarly, in his research on prospective teachers, Demirci (2017) has developed a self-efficacy belief scale for teaching astronomy subjects and discussed it in three sub-dimensions as "student outcomes through astronomy teaching", "astronomy teaching strategies", and "difficulty in teaching astronomy subjects". Alternatively, there is a need to develop specific measurement tools to make educationally valid and reliable inferences about the concept of self-efficacy that has such a critical role in learning. Actually, these and similar measurement tools can provide important evidence for the factors affecting the science achievements and affective characteristics of the students who have difficulty in learning.

Importantly, the impact of self-efficacy beliefs on students' abilities to deal with the difficulties that they experience in their learning of physics subjects and to resist to such situations is significant. Indeed, since the students with high self-efficacy towards the field of physics are more aware of their own abilities, they can overcome difficult, complex, and abstract issues more easily and their motivation for the course is also high (Yelgun, 2009). At this point, examining the concept of self-efficacy with a more specific approach in such aspects as subject, theme, sub-discipline, and task may contribute to making important inferences about the whole of science course. Even though the students have high self-efficacy levels towards the sub-disciplines or a particular subject of science, their general self-efficacy level towards the whole field of science may be low. For instance, a student with a high self-efficacy about biology, chemistry or a specific subject can have low self-efficacy belief in science in the general sense only because physics subjects are difficult, and they have negative tendencies towards physics. Moreover, self-efficacy towards physics subjects not only may reveal an interrelation view with other factors affecting the learning, but also may take on a mediation role between science learning and the conceptions of science.

In the light of all this information, the lower-secondary school science curriculum (learning areas, units) was taken into consideration in the present research, and the focus was set on self-efficacy belief towards school physics subjects in lower-secondary schools. In order to address these gaps in the field of science, this research focused on the development of a valid and reliable scale to measure the self-efficacy belief level towards physics subjects in science education. The scale may be a valuable tool for researchers or educators to assess the self-efficacy beliefs of students at lower-secondary school level. As being one of the pioneer studies, this research may allow for educational implications or directions regarding self-efficacy as a crucial predictor of learning achievement and motivation in terms of science course. Therefore, the present research aimed to develop a valid and reliable scale measuring the self-efficacy beliefs towards physics subjects within the context of science course for lower-secondary schools.

Research Methodology

General Background

This scale development research was conducted by using the scanning model in quantitative methodology. The scanning model refers to "a research approach describing an existing or a previous situation as it is" (Karasar, 2012, p. 79). Data is generally collected from a large population in this model. Ethical approval for this research was obtained from Ethics Committee of the Bolu Abant Izzet Baysal University in Turkey. The official permission to perform the research was also taken from the Directorate of National Education. This section outlines the detailed information about the participants, procedures, data collection, and data analysis. The scale development process proposed by Anderson (1988) was taken into consideration in this research.

https://doi.org/10.33225/jbse/21.20.38

Sampling

A total of 2737 students (aged from 11 to 16, *M* = 13.04, *SD* = 1.31) participated voluntarily in all phases of the research process from the lower-secondary schools in Turkey. They are randomly selected. In the first stage, the primary data were collected from 1918 students through Exploratory Factor Analysis (EFA) to determine the construct validity of the draft scale. Data from 36 students were excluded from the scale because of their incorrect or missing responses. Accordingly, the pilot sample was composed of 1882 students (902 males, 980 females) attending 6th (*n* = 599, 32.13%), 7th (*n* = 618, 32.84%), and 8th (*n* = 665, 35.33%) grades. MacCallum et al. (1996) reported that a larger sample increases the power of the model being examined and contributes to more reliable results regarding the measurement.

In the second stage, the secondary data were collected from 785 lower-secondary school students through Confirmatory Factor Analysis (CFA) to test the factor structure of the scale on a different sample. Importantly, it is a more appropriate approach that the sample for CFA may be different from EFA. Because of the fact that 21 students responded to the scale items incorrectly, the data obtained from these students were excluded. Accordingly, the sample two was composed of 764 students (366 males, 398 females) attending 6th (*n* = 204, 26.7%), 7th (*n* = 254, 33.2%), and 8th (*n* = 306, 40.1%) grades. In the final stage, 91 lower-secondary school students (41 females, 50 males) participated in the research of scale application on an independent sample to determine the test-retest reliability and internal consistency. The participants in all stages were independent of each other.

Instrument and Procedures

1. Item development and preparation of the item pool

In the preliminary stage, the instruments were examined on self-efficacy in science education in detail along with an extensive review of the literature on self-efficacy theories. The items related to self-efficacy towards the concepts or units of physics particularly focus on the subject area of "physical events" included for lower-secondary schools in the science curriculum. Firstly, an initial item pool was created with 52 items. Importantly, Bandura's (2006) criteria for developing the self-efficacy instrument were also taken into consideration to create the items. For example, the items included the phrase "can do" instead of "will do" to carry a positive connotation rather than negative.

2. Taking expert opinions

Prior to the pilot research of the scale, 14 experts with PhD degrees from "science education" (*n* = 6), "curriculum and instruction" (*n* = 5), and "assessment and evaluation" (*n* = 3) departments at universities commented on the scale items to ensure content (scope) and face validity. They judged the relevance of each item to the theoretical framework of self-efficacy. In addition, physics (*n* = 3), science (*n* = 4), and Turkish language (*n* = 2) teachers' views were also applied with regard to the clarity of items. An assessment form, rated on a 3-point scale ("essential", "useful, but not essential", "not necessary") for each item, was sent to these teachers via e-mail. In line with their feedback, the content validity ratio (CVR) of items was calculated as proposed by Lawshe (1975). This value for each item was evaluated by taking .57 as a reference for the expert sample size (*n* = 14) according to the CVR critical table prepared by Ayre and Scally (2014). The minimum expert size is supposed to be 5 to measure the values of CVR (Ayre & Scally, 2014).

3. Item reduction and revision

A total of 12 items were excluded from the scale and some items were revised for trial application in terms of conformity to the scale, expediency, spelling, and writing. Moreover, the criteria proposed by Oluwatayo (2012) were taken into account to ensure face validity in the research. The experts evaluated the scale in the light of these criteria (the clarity and unambiguity of items, the appropriateness of item difficulty level for the respondents, the correct spelling of difficult words etc.). Although face validity is considered within the scope of content validity, it is initially referenced as a validity type in the process of scale development.

https://doi.org/10.33225/jbse/21.20.38

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

4. Draft scale for pilot research

The pilot draft scale was ultimately composed of 40 items, on a 5-point Likert scale from "Strongly Disagree" (1) to "Strongly Agree" (5). There were no negative items in the scale. Before the pilot research, 12 students also read the scale items in terms of comprehensibility. Their feedback indicated that the items of the scale were not difficult to understand for pilot research.

5. Data collecting

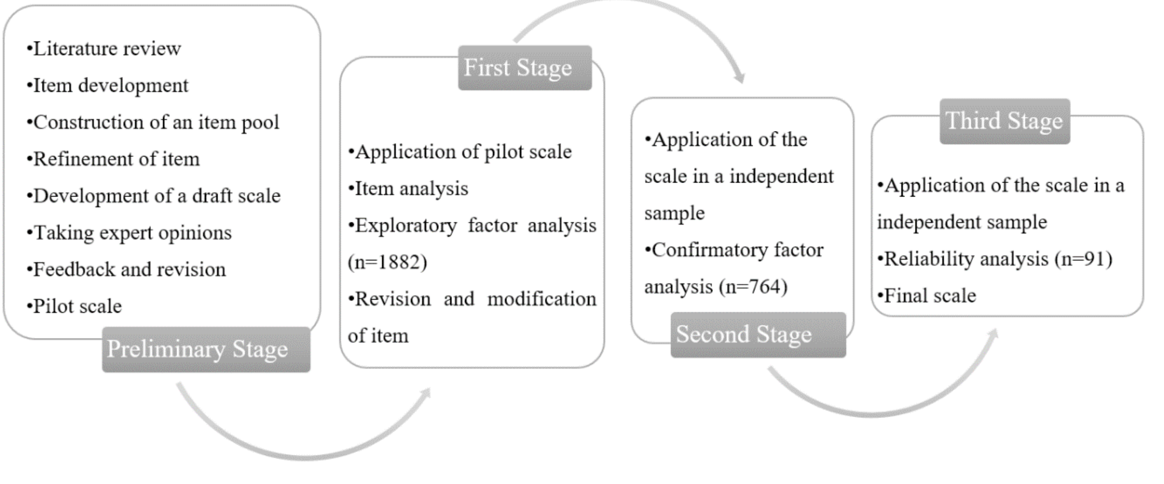
The data were collected during the fall semester of 2017-2018 academic year. Prior to the application of the scale, the students were informed about the purpose of this research. The students completed the scales in groups at certain periods in the classroom setting. To complete the scale, the process lasted approximately 10-15 minutes.

Data Analysis

In this research, both EFA and CFA were conducted to reveal the construct validity of the scale. Prior to these analyses, missing and outlier data, the normality of the data set, the number of the sample and its relevance were controlled for these analyses. The normality of the data distribution was checked by using Kolmogorov-Smirnov test ($p > .05$). The histogram graphics, Q-Q plots, and skewness and kurtosis values (+2, -2) were also examined (Kline, 2016). In addition, there is no consensus on the number of samples in the factor analysis studies. The sample size should be at least 5-10 times higher than the number of items for scale development and contain at least 300 cases (Tabachnick & Fidell, 2013). According to Kline (2016), although a sample of 200 people is enough for reliable findings in factor analysis, still it may be more suitable to research in larger samples. Comrey and Lee (1992) expressed that 100 as poor sample size, 300 as good and 1000 as excellent. In this context, the sample size is quite enough for the reliability of the present research. After the items were tested for the multicollinearity problem, in other words for the high-level correlation ($r > .90$) of item pairs, it was seen that there was not such a problem for the analysis.

In the first stage, the data obtained from the pilot application to determine the factor structure of self-efficacy belief variable were analysed with EFA by using SPSS 21.0 software. The new latent factors are discovered meaningfully by clustering the variables associated with each other through the EFA (Tabachnick & Fidell, 2013). Importantly, Kline (2016) emphasized that the construct validity is an umbrella term that includes the other types of validity. During the EFA, the principal component analysis was employed in this research. For the item analysis, independent samples *t* test was also used to determine whether there is a significant discrimination between the scores of lower and upper groups (27 % in each group). Next, item-total correlation coefficient (*r*) was calculated

Figure 1
The Process of the Scale Development in this Research



https://doi.org/10.33225/jbse/21.20.38

to determine item's discrimination feature in this research. It means the relationship between each item and the total scores of a scale (Buyukozturk, 2018).

In the second stage, CFA was performed on independent sample by using AMOS 22.0 software to confirm the factor structure of the scale. Based on EFA results, CFA is mainly used to compare the models of the scale's factor structure, to test the scale's model-data fit, and to decide the model with the best fit (Kline, 2016; Tabachnick & Fidell, 2013). Accordingly, Tucker Lewis Index ($TLI \geq .90$), Comparative Fit Index ($CFI \geq .90$), Normed-Fit Index ($NFI \geq .90$), Goodness Fit Index ($GFI \geq .90$), ($IFI \geq .90$), Root Mean Square Error of Approximation ($RMSEA \leq .08$), and Standardized Root Mean Square Residual ($SRMR \leq .08$) values were assessed for data fit (Kline, 2016). Given the sensitivity to the larger sample size, the chi-square was not taken into consideration in interpreting the analysis findings (Satorra & Bentler, 2001). Instead of this value, chi-square/ degree of freedom (χ^2/df) ratio was given for information purposes.

In the third stage, the internal consistency of Cronbach's alpha coefficient (α) and Pearson correlation coefficient (r) for re-test reliability were calculated for determining the reliability of the scale by using SPSS 21.0 software. The respondents with higher scores have more belief of self-efficacy to perform the task in physics. After the analysis of the data, we prepared the final version of the scale. Figure 1 shows the stages of the scale development in this research.

Research Results

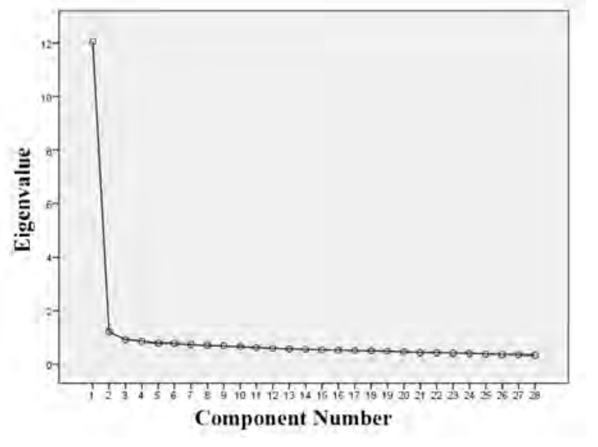
First Stage (Results of the Exploratory Factor Analysis)

Prior to performing the Exploratory Factor Analysis (EFA), Kaiser-Meyer-Olkin (KMO) was used to test the adequacy of sample and Bartlett's test of sphericity was applied to check the suitability of the data. According to the analysis results, KMO index was .95 ($KMO > .70$) and Bartlett's test of sphericity statistic for the correlation matrix was significant ($x^2 = 24471.75$; $SD = 378$; $p < .05$). These preliminary findings indicated that the data were suitable for EFA (Tabachnick & Fidell, 2013).

The data set for 1882 cases was analysed in EFA. The EFA was initially performed with 40 items in the scale. Based upon the principal component analysis method (Tabachnick & Fidell, 2013), the results showed that four factors had an eigenvalue greater than 1, explaining 58.93% of the total variance. A total of 12 items, which had factor loadings less than .40 and cut off points lower than .10 by overlapping in two factors, were excluded from the scale and then EFA was again performed in this research (Stevens, 2009). The repeated factor analysis indicated that 28 items with factor loadings ranging from .62 to .73 were distributed to a single factor, which accounted for 43.00% of the total variance in contrast to the first factor analysis. Cronbach's alpha reliability coefficient (α) was .93 with regard to the internal consistency of the scale.

In the factor analysis, the explained total variance values higher than 40% are acceptable for single-factor scales (Cokluk et al., 2014). Also, the observation of the scree plot graphic indicated the scale had single-factor structure as presented in Figure 2.

Figure 2
Scree-plot graphic of EFA



https://doi.org/10.33225/jbse/21.20.38

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Finally, it was seen that the scale consisted of 28 items with single factor. Based upon the total scores of the students, the independent t test was used to determine the significant differences between lower (n = 508) and upper (n = 508) groups (27% in each group). The t values for all items were significantly discriminative in the scale consisting of 29 items (t_{min} = 29.87; t_{max} = 36.62; p < .001). According to t test results, it was determined that each item had distinctiveness and these two groups were distinguished from each other.

The item-total correlations called discrimination index of the items were also calculated for item analysis (Buyukozturk, 2018). Item-total correlation coefficients were ranging from .65 to .59 values (p < .001). The factor loadings were ranging from .73 to .62 for these 28 items. These values are used to explain the relationship between the factor and its items. Factor loadings above or equal to .45 are, as a good criterion, acceptable for including the items in the scale (Buyukozturk, 2018). The items with a factor loading below this value were not considered within the scope of the scale. In this regard, these findings are summarized in Table 1.

Table 1
Factor Loadings and Item-Total Correlations of the Items

Items	Common Variance (h2)	Factor loadings	*r*	*t*
i32. I can explain the basic concepts related to the subject of sound.	.54	.73	.65*	35.26*
i31. I can offer solutions to reduce noise pollution.	.53	.73	.65*	36.62*
i26. I can solve problems related to the subject of light.	.53	.72	.64*	34.59*
i38. I can explain the differences between heat and temperature.	.52	.72	.64*	35.97*
i29. I can give examples from daily life for light sources.	.51	.72	.63*	35.25*
i28. I can do experiments about the propagation of light.	.50	.71	.63*	32.95*
i2. I can use problem solving stages in questions about the subject of force.	.49	.70	.63*	33.60*
i35. I can do experiments about the propagation of sound.	.48	.69	.63*	33.93*
i15. I can relate basic concepts of electricity to everyday life.	.47	.69	.63*	34.75*
i10. I can give examples from daily life with regard to energy types.	.47	.69	.63*	32.43*
i18. I can find solutions to problems related to electricity in everyday life by means of what I have learned about electricity.	.46	.68	.62*	35.81*
i24. I can do the assignments about the subject of electricity without difficulty.	.45	.68	.62*	32.69*
i23. I can develop new ideas to benefit from sunlight for a long time.	.45	.68	.62*	33.73*
i6. I can explain the relationship between force and movement with examples from daily life.	.44	.67	.62*	31.85*
i1. I can do experiments about the effect of force on objects.	.44	.66	.61*	35.09*
i25. I can explain the working principles of electrical appliances used in daily life.	.44	.66	.61*	32.68*
i39. I can do experiments about the effect of heat and temperature on substances.	.43	.64	.61*	33.27*
i34. I can tell about the development of audio technologies from past to present.	.43	.64	.61*	31.67*
i37. I can relate what I have learned about heat and temperature to everyday life.	.43	.64	.61*	32.64*
i19. I can solve problems related to electricity.	.42	.64	.61*	33.74*

https://doi.org/10.33225/jbse/21.20.38

Items	Common Variance (h2)	Factor loadings	*r*	*t*
i27. I can offer solutions to reduce light pollution.	.42	.63	.61*	35.16*
i30. I can prepare a project on lighting technologies.	.42	.63	.61*	32.07*
i13. I can give examples from daily life about solid, liquid or gas pressure.	.41	.63	.60*	31.68*
i4. I can explain the factors affecting the speed of moving vehicles.	.41	.63	.60*	29.94*
i7. I can explain the working principles of tools that facilitate daily errands.	.41	.63	.60*	30.39*
i5. I can solve problems related to speed.	.41	.62	.60*	29.87*
i22. I can apply what I have learned about electricity saving in everyday life.	.40	.62	.60*	32.31*
i11. I can do experiments about the interconversion of energies.	.40	.62	.59*	31.10*
Eigen value (Total)=12.04 Explained total variance (%) = 43.00 Cronbach alpha = .92				

*$p < .001$

With respect to the internal consistency coefficient, Cronbach's alpha value was .87 for the single factor of the scale. Based on this finding, it was seen that the results obtained from the data set ($\alpha > .80$) were quite reliable (Cohen et al., 2007).

Second Stage (Results of the Confirmatory Factor Analysis)

Following the EFA, the scale with single-factor model was tested by performing Confirmatory Factor Analysis (CFA) to confirm it on a different sample. Hence, the data set for 764 cases obtained from an independent sample was analysed in CFA.

The modification was made by taking into account the relationship between the errors of some items in the suggested model (e.g., e1-e2). Based upon maximum likelihood method, CFA results indicated that the data fit statistics were at an acceptable level ($\chi^2/df = 3.52$, $p < .001$; $TLI = .91$; $CFI = .91$; $NFI = .89$; $GFI = .89$; $IFI = .90$; $RMSEA = .05$; $SRMR = .03$). In this context, these results related to the independent sample indicated that single-factor structure was suitable for the scale. Hence, none of the items was excluded from the scale.

With respect to the internal consistency coefficient, Cronbach's alpha value was .84 for the single factor of the scale. Based on this finding, it was seen that the results obtained from the data set ($\alpha > .80$) were quite reliable (Cohen et al., 2007).

Third Stage (The Results of Reliability Analysis)

In the final stage, both Cronbach's alpha (α) value for internal consistency and Pearson correlation coefficient (r) for re-test reliability were examined to determine the reliability of the scale. The data set for 91 cases obtained from an independent sample was analysed for reliability. With regard to the internal consistency of the scale, the results showed that Cronbach's alpha reliability coefficient (α) was found to be .84 for the internal consistency of the scale. In the related literature, if this coefficient is higher than .80, the scale is satisfactorily and highly reliable (Cohen et al., 2007). The students in the sample ($n = 91$) answered the items of the scale again three weeks after the previous application. The findings showed that there was a high level of relationship between the two applications ($r = .87$, $p < .001$). The high correlation coefficient showed that the scale was a stable measurement, and the findings were consistent when the scale was applied at different times.

Finally, the scale consisted of 28 items with single factor. While the lowest score can be 28, the highest score is 140. From this point of view, the upper scores from the scale mean that the student has higher self-efficacy belief

https://doi.org/10.33225/jbse/21.20.38

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

towards physics subjects in science education. On the contrary, lower scores mean that the student's self-efficacy belief is low.

Discussion

In this research, a valid and reliable scale was developed to measure the self-efficacy towards physics subjects in science education by using data obtained from 2737 students at 6th, 7th, and 8th grades in a province located in the north of Turkey. When the relevant literature was examined, it was observed that scale development studies were generally related to students' self-efficacy beliefs towards science education at lower-secondary school level (Aslam & Ali, 2017; Tatar et al., 2009). However, the number of the existing scales are insufficient to measure the self-efficacy belief regarding more specified domains such as specific subjects, tasks, units, themes or learning fields in science education. Moreover, the studies on these subjects were observed to have been conducted mainly at higher education level and no self-efficacy scale towards specific fields or areas was encountered in science education, particularly in physics at lower-secondary school level. Unlike the present research, it was seen that these scales had a multi-factor structure. For example, "Acid-Base Self-Efficacy Perception Scale", which included a specific subject in the field of chemistry, was developed for prospective teachers by Ilhan and Cicek (2017). The results showed that the explained total variance value of the two-factor scale consisting of 14 items (9 positive, 4 negative) was found to be 46.71% and the Cronbach's alpha (α) value for internal consistency was .86, like the findings of the reliability analysis in the research. Likewise, the scale entitled "Astronomy Subjects Teaching Self-Efficacy Beliefs" was developed by Demirci (2017) and its final version consisted of 14 items with 3-factor structure while the draft scale was composed of 41 items. With regard to biology, "Teaching Evolution Self-Efficacy Scale" was developed for undergraduate students by Inan et al. (2018). It was composed of 11 items with two factors (efficacy about evolution content knowledge, self-efficacy about teaching evolution).

On the other hand, there are few scales on self-efficacy belief toward physics. Most of them were concentrated on upper-secondary school and higher education students, not lower-secondary or middle school students. In addition, some researchers (see Alpaslan & Isik, 2016; Lin et al., 2015) adapted the self-efficacy scale which was developed by Lin and Tsai (2013) for science learning to physics learning. Selcuk et al. (2018) investigated the self-efficacy belief toward physics according to the factors of physics achievement and skills of using physics knowledge in the upper-secondary school. However, while being centred upon the general structure of physics, these scales neither focused on a task- or a subject-based construct nor were they at lower-secondary school level. In Turkey, the physics subjects are covered by science course curricula at these grades. From a multidimensional perspective, the previous scale development studies have offered a general or comprehensive framework in science education. Likewise, there are also some studies exploring science self-efficacy with one-factor structure as a component of motivation through a course- oriented approach (Glynn et al., 2009; Tuan et al., 2005; Pintrich et al., 1991). To illustrate, Motivated Strategies for Learning Questionnaire (MSLQ) was developed by Pintrich et al. (1991) has been frequently used to measure the self-efficacy -as a predictor of motivation- for science or other disciplines in the literature. However, the single-factor structure in the current research is substantial; at least for the following reasons, it differentiates from other studies. First, it may profoundly provide to subject-based evidence in examining the cognitive or affective features of science. Second, it can transform into a multi-dimensional structure together with variables regarding other sub-disciplines (the subjects of biology, chemistry etc.) of science. Finally, it may specifically reveal the latent variables of science learning in terms of physics subjects rather than a general perspective.

The final version of the scale consists of 28 items with single factor. Based on the findings of this research, the several implications may be emphasized for science education. The scale can be used as a valid and reliable instrument by educators or researchers to understand students' self-efficacy towards physics subjects. Using these findings, teachers may design learning environments by identifying the students with poor self-efficacy. For instance, they can initially give students easier tasks for learning activities rather than difficult in physics education. Another way to develop students' self-efficacy belief is usage of instructional technologies or combination of these technologies and several learning methods in physics teaching process (Fidan, 2018; Seifert & Tshuva-Albo, 2014). Moreover, the scale can be utilized as a mediator variable in determining the effects of other latent factors in science learning.

https://doi.org/10.33225/jbse/21.20.38

Conclusions and Implications

In conclusion, the current research showed that the scale had good performance to measure self-efficacy belief towards physics subjects for lower-secondary school in science education. Based on the relevant literature reviews, 52 items were identified for a draft scale form by taking the experts' views to ensure face and content validity. After that, a pilot application of the scale was performed on the participants from the lower-secondary schools. Firstly, EFA ($n = 1918$) was conducted for determining the factor structure of the self-efficacy scale. 12 items were excluded from the scale owing to their poor factor loadings. The EFA findings demonstrated that the scale consisted of 28 items with single factor. To determine the discrimination of the item, both item-total correlations and the comparison between the scores of lower and upper groups (27% in each group) were examined.

In the second stage, the scale with single-factor model was tested to confirm it on a different sample by conducting CFA ($n = 785$). CFA results showed that these fit indexes were acceptable and suitable for construct validity. After all, both Cronbach's alpha (α) value for internal consistency and Pearson correlation coefficient (r) for re-test reliability ($n = 91$) were examined to determine the reliability of the scale. The Cronbach's alpha reliability coefficient (α) was .84 for the internal consistency of the scale and re-test reliability coefficient (r) was found as .87 for a three-week interval. The high reliability coefficients indicated that the reliability of the scale was at a satisfactory level and it measured accurately.

The current research had some limitations. The first of these limitations was that the data were collected from a province located in the north of Turkey. It is recommended for future studies that the scale can be applied to a larger sample or different cultures including the students studying at different regions in Turkey. As another limitation, the interrelationships among variables of science (attitude, motivation etc.) were not examined in this study. As a matter of fact, physics is related to mathematics, natural science laws or rules, and the behaviours of the universe. Hence, further correlational, predictive, or modelling studies should provide solid evidence about the cause-effect relationship of variables and offer a general picture of science learning. It would be worth to explore the relationships between physics self-efficacy belief and the sources of self-efficacy. Because the scale includes topics and concepts of physics in detail, it can be used at higher grade levels aside from lower-secondary level. In future studies, it can be examined whether self-efficacy differentiates in terms of demographic variables such as student's gender and class or not. Similar to the findings of this research, self-efficacy scales on specific-domain subjects or tasks (biology subjects or themes, chemistry experiments etc.) can be developed in science education. Moreover, the subject-based self-efficacy scales (force and movement, pressure, electricity etc.) may be created separately in terms of physics subjects.

Acknowledgements

The research which supported by funding from the Bolu Abant Izzet Baysal University Scientific Research Projects Committee in Turkey (Project Number: 2016.02.02.1101) was derived from first author's PhD dissertation conducted under the supervision of the second author.

References

Alpaslan, M., & Isik, H. (2016). Examination of the validity and the reliability of physics self-efficacy scale. *Mustafa Kemal University Journal of Social Sciences Institute, 13*(33), 111-122.

Anderson, L. W. (1988). Attitudes and their measurement. In Keeves, J. P. (Ed.), *Educational research, methodology and measurement. An international handbook* (pp. 421-426). Elsevier Science & Technology.

Aslam, S., & Ali, M. S. (2017). Effect of self-efficacy on students' achievement in science: A case of secondary school students in Pakistan. *European Journal of Education Studies, 3*(11), 219-234. https://doi.org/10.5281/zenodo.105029

Aypay, A. (2010). The adaptation study of general self-efficacy (GSE) scale to Turkish. *Inonu University Journal of the Faculty of Education, 11*(2), 113-132.

Ayre, C., & Scally, A. J. (2014). Critical values for Lawshe's content validity ratio: Revisiting the original methods of calculation. *Measurement and Evaluation in Counseling and Development, 47*(1), 79-86. https://www.tandfonline.com/doi/full/10.1177/0748175613513808

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* Freeman.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares, & T. Urdan (Eds.), *Adolescence and education, Vol. 5: Self-efficacy beliefs of adolescents* (pp. 307-337). Information Age.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

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

Buyukozturk, S. (2018). *Manual of data analysis for social sciences: Statistics, research pattern SPSS applications and interpretation* (24. ed.). Pegem Akademi.

Cohen, L. M., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). Routledge.

Comrey, A., & Lee, H. (1992). *A first course in factor analysis.* Erlbaum.

Cokluk, O., Sekercioglu, G., & Buyukozturk, S. (2014). *Multivariate statistic for social sciences: SPSS and LISREL applications* (3rd ed.). Pegem Akademi.

Demirci, F. (2017). *Science teachers' self-efficacy beliefs about astronomy subjects teaching: A mixed method research* (Unpublished master's thesis). Ordu University, Ordu.

Fidan, M. (2018). *The impact of problem-based science teaching assisted with augmented reality applications on academic achievement, retention, attitude, and belief of self-efficacy* (Unpublished PhD thesis). Bolu Abant Izzet Baysal University. https://tez.yok.gov.tr/UlusalTezMerkezi

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

Ilhan, N., & Cicek, Ö. (2017). The development of acid-base self-efficacy perception scale and the investigation of pre-service science teachers' self-efficacy perceptions on acid-base. *Sakarya University Journal of Education, 7*(1), 123-141.

Inan, S., Irez, S. Han-Tosunoglu, C., & Cakır, M. (2018). Teaching evolution self-efficacy scale: The development, validation, and reliability study. *Trakya University Journal of Education Faculty, 8*(2), 241-260.

Kapucu, S. (2017). Predicting physics achievement: attitude towards physics, self-efficacy of learning physics, and mathematics achievement. *Asia-Pacific Forum on Science Learning and Teaching, 18*(1), 1-22. https://www.eduhk.hk/apfslt/v18_issue1/kapucu/page4.htm

Karasar, N. (2012). *Bilimsel araştırma yöntemi* [Scientific research methods]. Nobel.

Klassen, R. M., & Usher, E. L. (2010). Self-efficacy in educational settings: Recent research and emerging directions. In T. C. Urdan, & S. A. Karabenick (Eds.), *Advances in motivation and achievement: Vol. 16A. The decade ahead: Theoretical perspectives on motivation and achievement* (pp. 1-33). Emerald.

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). The Guilford.

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology, 28*(4), 563-575.

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

Lin, T. C., Liang, J. C., & Tsai, C. C. (2015). Conceptions of memorizing and understanding in learning, and self-efficacy held by university biology majors. *International Journal of Science Education, 37*(3), 446-468. https://www.tandfonline.com/doi/abs/10.1080/09500693.2014.992057

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure models. *Psychological Methods, 1,* 130-149.

MoNE (2013). *Physics curriculum for secondary education.* http://mufredat.meb.gov.tr

MoNE (2018). *Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar)* [Science curriculum (elementary and lower-secondary 3, 4, 5, 6, 7 and 8. grades)]. http://mufredat.meb.gov.tr

OECD (2017). *PISA 2015 assessment and analytical framework: Science, reading, mathematic financial literacy and collaborative problem solving (revised edition).* PISA. http://dx.doi.org/10.1787/9789264281820-en

Oluwatayo, J. (2012). Validity and reliability issues in educational research. *Journal of Educational and Social Research, 2,* 391-400.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the motivated strategies for learning questionnaire (MSLQ)*. The University of Michigan, Ann Arbor, MI. https://files.eric.ed.gov/fulltext/ED338122.pdf

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin, 138*(2), 353-387. https://doi.org/10.1037/a0026838

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square statistic for moment structure analysis. *Psychometrika, 66,* 507-514. https://link.springer.com/article/10.1007/BF02296192

Selcuk, G. S., Caliskan, S., & Demircioglu, S. (2018). Determining the applicability of the physics self-efficacy scale for high school students. *Turkish Studies, 13*(4), 225-244.

Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational Psychologist, 25,* 71-86.

Schunk, D. H., & Pajares, F. (2009). Self-efficacy theory. In K. R. Wentzel, & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 35-53). Routledge.

Schunk, D. H., & Usher, E. L. (2011). Assessing self-efficacy for self-regulated learning. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 282-297). Routledge.

Seifert, T., & Tshuva-Albo, V. (2014, April). Teaching based augmented reality and smartphones to promote learning motivation among middle school students. *Proceedings of the 19th Annual TCC Worldwide Online Conference* (pp. 111-121). The University of Hawai'i Kapi'olani Community College & The University of Hawai'i at Manoa.

Stevens, J. (2009). *Applied multivariate statistics for the social sciences.* Routledge.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Allyn and Bacon.

Tatar, E., Yildiz, N., Akpinar, E., & Ergin, Ö. (2009). Exploratory and confirmatory factor analysis of the metacognition scale for primary school students. *Educational Sciences: Theory & Practice, 9*(3), 1591-1604.

https://doi.org/10.33225/jbse/21.20.38

Tezer M., & Asiksoy, G. (2015). Engineering students' self-efficacy related to physics learning. *Journal of Baltic Science Education, 14*(3) 311-326. http://www.scientiasocialis.lt/jbse/files/pdf/vol14/311-326.Tezer_JBSE_Vol.14_No.3.pdf

Tuan, H., Chin, C., & Shieh, S. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education, 27,* 639-654. https://www.tandfonline.com/doi/abs/10.1080/0950069042000323737

Tuncel, M., & Fidan, M. (2018). Subjects perceived as difficult in secondary science course and recommendations. *Proceedings of the 6th International Congress on Curriculum and Instruction*. Kafkas University, Kars.

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology, 34,* 89-101.

Yelgun, A. (2009). *Misconceptions and their forming reasons of 8th class students' in primary schools about buoyant force.* (Unpublished master's thesis). Ataturk University, Erzurum. https://tez.yok.gov.tr/UlusalTezMerkezi

Zimmerman, B. J. (1995). Self-efficacy and educational development. In A. Bandura (Ed.), *Self-efficacy in changing societies* (pp. 202-231). Cambridge. https://doi.org/10.1017/CBO9780511527692.009

Received: *July 20, 2020* Accepted: *January 06, 2021*

Cite as: Fidan, M., & Tuncel, M. (2021). Developing a self-efficacy scale toward physics subjects for lower-secondary school students. *Journal of Baltic Science Education*, *20*(1), 38-49. https://doi.org/10.33225/jbse/21.20.38

Mustafa Fidan
(Corresponding author)
PhD, Assistant Professor, Department of Educational Sciences, Faculty of Education, Bartin University, Bartin, 74100, Turkey.
E-mail: mfidan19@gmail.com
ORCID: https://orcid.org/0000-0001-7461-4994

Meric Tuncel
PhD, Assistant Professor, Department of Educational Sciences, Faculty of Education, Bolu Abant Izzet Baysal University, Bolu, 14280, Turkey.
E-mail: merictuncel@gmail.com
ORCID: https://orcid.org/0000-0002-4816-9521