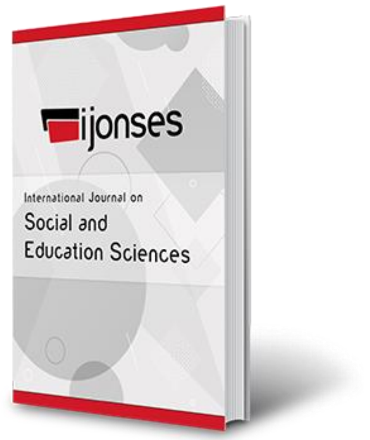

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Self-Regulation Scale for Science: A Validity and Reliability Study

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Abstract

Self-regulation is important at every stage of the education process and must be measured accurately in order to know at what students' levels are. The aim of this study is to develop a scale that is able to validly and reliably determine the self-regulation levels of secondary school students regarding science. The study uses the survey design, a quantitative research method. The sample of the research consists of 500 students enrolled in three secondary schools in Kayseri Province's Melikgazi district during 2018 spring semester. While preparing the scale, which was developed based on social cognitive theory, a literature review was conducted, expert opinions were sought, and a pilot study was conducted to test the suitability of the items. Exploratory and confirmatory factor analyses (EFA and CFA) were performed to ensure the construct validity. As a result of the EFA, a structure consisting of 26 questions was obtained whose three factors explain 48% of the variance. This structure was confirmed through CFA, which was conducted on the data obtained from a sample different than the one used in the EFA. Cronbach's alpha of reliability for the scale was calculated as .940. As a result, a valid and reliable scale for science education based on social cognitive theory and Zimmerman's self-regulation model was obtained that is simple enough that middle school student can understand it.

Introduction

The human capacity for self-regulation plays an important role in social cognitive theory. People do not act in accordance with the interests and wishes of others. Internal processes play an important role behind many organized behaviors. Social cognitive theory believes that people have the ability to control their own behavior. People decide for themselves what, when, where, with whom, and for how long to work; how long to rest; and how to behave before society. People's behaviors are usually based on their own internal standards and motivations (Bandura, 1986). According to social cognitive theory, self-regulation systems provide a basis for purposeful behavior by observing external factors and allowing people to gain control over their own thoughts, emotions, motivations, and actions. Recognition of individuals' potential for self-regulation is one of the basic principles of social cognitive theory. People are able to adjust their lives with respect to themselves, not others in all personal affairs such as nutrition, work conditions and styles, social lifestyles, and ways of rest and entertainment (Brown, 1999). Effective self-regulation is a cyclical process in which learners actively monitor the performance environment, develop functional task strategies, skillfully implement these plans, and monitor results (Locke & Latham, 2006).

According to Bandura (1986), students with good self-regulation skills have an active role in creating their own learning goals and regulating their metacognitive competencies and behaviors, and they control the whole process themselves. In parallel with this view, Zimmerman (2000) stated that an individual who can self-regulate has the potential to actively participate in their own learning processes in terms of metacognition, motivation, and behavior by taking into account the learning environment. Zimmerman (2002) explained the concept of self-regulation as providing learning autonomy and control in the individual through the acquisition of knowledge; the development of experience; and the monitoring, direction, and regulation of actions taken for self-improvement. In addition, self-regulation includes metacognitive processes, motivation, cognitive strategic behaviors, and knowing how to use the learning environment effectively with external resources (Zimmerman, 1990). In other words, self-regulation is not only a process in which personal characteristics are effective but also a cyclical process that includes environmental and behavioral components (Zimmerman, 1995). In this context, Zimmerman can be said to have centered on Bandura's social cognitive theory while explaining and defining the concept of self-regulation.

Considering its theoretical foundations, self-regulation is seen to be an umbrella concept for the field of education. In addition, self-regulation can be said to directly and indirectly affect the learning process and to be influenced by many variables and factors by raising learners' awareness during the lifelong learning adventure with its internal and external dimensions at every stage of education and training. The literature frequently mentions the characteristics of individuals who use self-regulation strategies effectively (Chung, 2006; Pintrich, 2000; Torrano Montalvo & González Torres, 2004; Wolters & Pintrich, 1998; Zimmerman, 1990, 1998; Zimmerman & Kitsantas, 1997; Zimmerman & Paulsen, 1995; Zimmerman & Schunk, 2008). Self-regulated learners are individuals who can choose goals that are suitable for them; determine the most likely strategies to achieve these goals; organize many factors such as effort, time, work environment, resource use, evaluate their behavior; and are aware of the need to actively participate in learning while doing all these (Torrano Montalvo & González Torres, 2004). In addition, individuals with advanced self-regulation skills are aware of their own abilities, know how to turn this into an opportunity to reach their goals regardless of the conditions in their social environment, and can improve themselves in many ways by performing effective learning.

Self-regulated learners are aware of their own abilities and what they can and cannot do; thus, they can create new ways to overcome the obstacles they encounter in the process of reaching the goals they set and try to avoid situations they think they cannot overcome. In addition, they prefer directed goals rather than performance goals and take care to use the most effective learning strategies to achieve those (Ambreen et al., 2016). Due to science, lifelong learning, which is also predicted by self-regulated learning, becomes a source for the individual to acquire the skills they need (Cokcaliskan, 2019).

In addition, importance is seen in individuals having the ability to fully adopt scientific knowledge and interpret it from different perspectives. In this case, individual differences and perspectives will need to be taken into account because an individual's current perspectives are a result of their previous learning and will also directly affect their later learning. In order to achieve the goals of science education, this criterion should be taken into account as well as the factors that are thought to form or affect their perspectives. Variables such as interest, motivation, self-confidence, self-efficacy, self-regulation, anxiety, and attitude are directly related to individuals' perspectives on learning (Tuan et al., 2005). Learners with self-regulation skills are individuals who actively participate using the necessary methods and techniques for the task assigned to them. In this respect, self-regulation is seen to overlap with science education (Ministry of National Education [MoNE], 2018).

In light of these studies showing learners' self-regulation levels to be important at every stage of the education process, accurately measuring students' self-regulation levels also comes to the fore. Undoubtedly, in order to make an accurate measurement and evaluation, a valid and reliable measurement tool specific to the determined area should be used. When examining the self-regulation scales in the literature, they are seen to be for different fields (Arslan & Gelisli, 2015; Arslantas & Kurnaz, 2017; Aydin, et al., 2014; Bayindir & Ural, 2016; Celikkaleli & Yildirim, 2015; Cho & Cho, 2017; Haslaman & Askar, 2015; Hwang & Lee, 2019; Okmen & Kilic, 2020; Oz & Sen, 2018; Senovska & Pryshliak, 2020; Tanribuyurdu & Yildiz, 2014) and to be suitable for high school age groups or above (Demiraslan Cevik et al., 2017; Darmawan et al., 2020; Ektirici et al., 2016; Kirbulut et al., 2016; Kocdar et al., 2018; Tee et al., 2019; Velayutham et al., 2011).

The scales suitable for science and secondary school level are seen to be limited in number and to have been adapted from the Motivation Belief Scale (Tosun & Sekerci 2014; Yetisir & Ceylan, 2015). This shows the self-regulation scales in the literature to not fully meet the criteria of being specific to a field or being suitable for the sample to whom it will be applied. Because the literature has no scale based on social cognitive theory or Zimmerman's self-regulation model exists for science education that is simple enough for secondary school students to understand, the current study aims to develop the Self-Regulation Scale for Science within its scope. Based on these reasons, the aim of the study is to develop a valid and reliable scale that can determine secondary school students' self-regulation levels in science. In line with this general purpose, answers were sought to the following sub-problems:

(1) Is the scale developed for determining secondary school students' self-regulation levels in science valid?

(2) Is the scale developed for determining secondary school students' self-regulation levels in science reliable?

Method

Research Design

The research uses the survey design, a quantitative research method. This design is based on larger samples compared with other designs and is used to reveal characteristics such as participants' interests, skills, opinions, and attitudes toward a concept (Fraenkel et al., 2012). The current study has preferred the survey design as the study aims to develop a scale by making use of secondary school students' self-regulation levels in science.

Population and Sample

The target population of this study is all secondary school students studying in Kayseri Province's Melikgazi district. The accessible population is the secondary school students in the Melikgazi district's 3rd, 5th, and 7th regions. The sample selected from the accessible population was determined using cluster sampling, a random sampling method. The sample size was determined by complying with the rule of 10% of the accessible universe and 10 times the number of items in the quantitative data collection tool being used (Kline, 2005). In this context, the sample of the research was determined as 500 students (125 5th graders, 132 6th graders, 127 7th graders, and 116 8th graders studying in three secondary schools in Kayseri Province's Melikgazi district in the 2018 spring semester for the item indices, independent samples t-test, and EFA. A different sample was used to obtain the CFA data who were comprised of a total of 308 students studying at the various grades of a 7th Region Melikgazi District secondary school during the 2018-2019 academic year different from the ones used in the sample for the EFA and in accordance with the rule of 10; the 26-item Self-regulation Scale for Science was applied to this sample. Within the scope of this scale development study, the data collection tool and data analysis and data collection processes are explained in detail in the findings section in order to avoid repetition as the intention is already to develop a data collection tool.

Findings

Validity Findings

Validity is defined as the degree to which the test questions actually target the features intending to be measured for a specific purpose or whether the questions actually measure the mental processes that are intended to be measured (Çepni, 2012). Examining the content validity, index analysis, criterion validity, and construct validity is recommended within the scope of internal validity studies, which are defined as the degree to which the observed and measured features among the variables are explained through the selected variables (Buyukozturk et al., 2008).

Content Validity Findings

Content validity can be defined as the degree to which the test represents the behavioral universe. Determining whether the questions in the test actually measure the intended behavior is also important (Cepni et al., 2009). In this context, how the items on the Self-Regulation Scale for Science were created is explained in detail. In other words, while the relevant scale was being prepared, a literature review was conducted, expert opinions were sought, and a pilot study was conducted to test the suitability of the items.

Before preparing the Self-Regulation Scale for Science, the first author conducted a literature review and created a pool of questions covering self-regulation scales. As a result of this scan, the decision was made to prepare the Self-Regulation Scale for Science as using a specific scale for science learning that is clear and simple, especially for secondary school students is what is desired. While preparing this scale, the scales used in the literature to determine self-regulated learning strategies in particular were used (Dadli, 2015; Eker, 2012; Gok, 2014; Ilgaz, 2011; Israel, 2007; Karabacak, 2014; Kayan Fadlelmula, 2011; Suer, 2014).

In addition, a conceptual framework was created based on Zimmerman's (1998) self-regulation model to meet the questions of why, what, how, when, where, and with whom should I learn and how much I've learned. In addition, attention was given to making sure the scale questions included the stages of self-regulation, setting goals, controlling the process, and evaluating and were blended with Zimmerman's self-regulated learning strategies. What is meant by evaluation here involves the pre-thinking phase with the set goals, the process control and performance/volitional control phase, and the self-reflection stage. In addition, some of the strategies students with high self-regulation use to control their learning and their definitions were also taken into account (Zimmerman, 1989). As a result of this preliminary preparation, a draft version of the Self-Regulation Scale for Science consisting of 51 items with a 5-point Likert-type response system was prepared.

Based on the above-mentioned criteria, the draft scale was seen to consist of nine factors and 51 items, the factors being: repetition (Items 1, 9, 17, 25, 32, 39, 44), elaboration (Items 2, 10, 18, 26, 33, 40, 51, 47), organization (Items 3, 11, 19, 27, 34, 41, 49), critical thinking (Items 4, 12, 20, 28, 35), seeking social assistance (Items 5, 13, 21, 29, 36, 42, 46), regulation of time and study environment (Items 6, 14, 22, 30, 37, 43, 50, 48, 45), effort organization (Items 7, 15, 23, 31, 38), and goal setting and theoretical planning (Items 8, 16, 24). These factors and items were attempted to be created in a way that supports the literature and with special emphasis on Zimmerman's self-regulation strategies. For example, the first item under the repetition factor of the draft scale (I always repeat the subject I am trying to learn while studying for the science course) expresses Dadli's (2015) relationship between middle school students' self-regulation skills and self-efficacy for science and technology course with their academic achievement; it was created by using the Motivating Strategies in Learning Scale (Pintrich et al., 1991).

Item 47 in the factor of elaboration (I go to the library to have more knowledge on science) was created by quoting Nota et al. (2004) who described learning strategies based on self-regulation to exemplify students' thoughts when using the strategy. Item 49 is found in the factor of organizing factor (I prepare a draft before I do my science course homework) and is from Suer's (2014) master's thesis investigating the effects of self-regulation skills on the TEOG exam (Pintrich & DeGroot, 1990). Item 49 is also supported by the scale Dadli (2015) used as well as Zimmerman's (1986) and Suer's (2014) definitions. As can be understood from the examples, the aim of the literature, the research, and the theoretical foundations on which it is based were taken into consideration with great precision while creating the draft version of the self-regulation scale's items.

The prepared draft version of the Self-Regulation Scale for Science was applied to 500 students following the 10-fold rule (Secer, 2017, p. 155). As a result of the application, the completeness and objectivity of the data were checked and entered into the package program SPSS Statistics 20 in order to conduct the validity and reliability studies. After entering all the data, the decision was made to assign an average value to items that were left blank, as less than 5% of the data were missing; the scale's reverse-coded items (Items 7, 22, 23, 48, and 50) were recoded. The scores obtained from the items prepared for analysis were determined to be normally distributed. Cronbach's alpha of reliability for the draft scale was calculated as .950. When examining the reliability analysis results for each item, the reliability of Item 50 was determined to be less than .30 and low at .085. While developing the measurement tool, removing items from the scale was decided to be a last resort, so despite Item 50's low reliability, it remained on the scale until the evaluation of the other analysis results.

Table 1. Item Difficulty and Discrimination Indexes for the Self-Regulation Scale for Science

Item Number	Item Difficulty Index	Item Discrimination Index
Item 1	0.57	0.55
Item 2	0.64	0.62
Item 3	0.54	0.56
Item 4	0.54	0.50
Item 5	0.60	0.38
Item 6	0.68	0.38
Item 7	0.61	0.51
Item 8	0.67	0.62
Item 9	0.65	0.69
Item 10	0.49	0.59
Item 11	0.56	0.67
Item 12	0.49	0.50
Item 13	0.70	0.46
Item 14	0.63	0.61
Item 15	0.68	0.53
Item 16	0.46	0.56
Item 17	0.67	0.56
Item 18	0.61	0.53
Item 19	0.64	0.56
Item 20	0.62	0.57
Item 21	0.56	0.48
Item 22	0.44	0.29
Item 23	0.63	0.56
Item 24	0.58	0.60
Item 25	0.59	0.68
Item 26	0.60	0.61
Item 27	0.43	0.63
Item 28	0.70	0.58
Item 29	0.59	0.61
Item 30	0.45	0.50
Item 31	0.64	0.64
Item 32	0.69	0.59
Item 33	0.64	0.58
Item 34	0.65	0.67
Item 35	0.51	0.69
Item 36	0.52	0.56
Item 37	0.59	0.66
Item 38	0.57	0.56

Item Number	Item Difficulty Index	Item Discrimination Index
Item 39	0.66	0.56
Item 40	0.63	0.53
Item 41	0.60	0.66
Item 42	0.53	0.62
Item 43	0.64	0.54
Item 44	0.65	0.55
Item 45	0.64	0.50
Item 46	0.43	0.56
Item 47	0.37	0.45
Item 48	0.50	0.37
Item 49	0.46	0.61
Item 50	0.31	0.13
Item 51	0.63	0.61

After examining the content validity of the Self-Regulation Scale for Science, the difficulty and discrimination index analyses were performed for the scale items, particularly for Item 50. While calculating the item difficulty indexes (p), the groups were determined using the upper and lower 27th percentiles. According to the total scores for the answers given to the scale items, the students were ranked from those with high scores to those with low scores. As a result of this calculation, the number of students in the upper and lower groups was determined as 135. The number of students who answered the relevant item correctly in the upper and lower groups (those who marked 4 or 5) was divided by the total number of students in the upper and lower groups (n = 270), and the difficulty index for each item was calculated by entering the specified formula into the program Microsoft Excel (Cepni et al., 2009). When examining the item difficulty indexes (see Table 1), items below .30 can be said to be difficult, and items above .70 can be said to be easy. All the items on the self-regulation scale were observed to be within the mentioned range, and whether items should remain on or be removed from the scale should be decided by looking at the distinctiveness of these items.

When calculating the distinctiveness (r) of the self-regulation scale items for science, the upper and lower groups used in calculating the item difficulty index were taken into account. The number of students in the lower group was subtracted from the number of students in the upper group (n = 4 or n = 5) who correctly answered the relevant item. This difference is divided by the number of students in the upper or lower group (n = 135; Cepni, 2012). Similar to the item difficulty index calculation, the item discrimination index was calculated by entering the specified formula into Microsoft Excel. The discrimination for Item 50 from the self-regulation scale was found to be .13, which is quite low (see Table 1); this item was thus removed from the scale due to these statistical results.

Criterion Validity Findings

Criterion validity can be defined as the degree of correlation between the scores individuals obtain from one scale and the score obtained from another scale prepared for the same purposes and outcome for which validity and reliability studies have already been conducted (Cepni, 2012). In the current study, a criterion validity study could not be conducted because no scale exists whose validity and reliability studies had been conducted on examining the variables determining self-regulation and role modeling perceptions toward science. This can be considered one of the study's limitations.

Construct Validity Findings

Construct validity can be defined as the degree to which the measurement tool or test can reveal the theoretical structure desired to be measured with that instrument (Cepni, 2012). Many methods can be used to determine construct validity. One of these is to perform factor analysis. In this context, after performing the exploratory factor analysis for the Self-Regulation Scale for Science using the SPSS program, confirmatory factor analysis was carried out using the program LISREL with the data obtained by applying the relevant scale to a different sample than the one on which the pilot study had been conducted. Within the scope of the construct validity analysis, the KMO value for the Self-Regulation Scale for Science was found to be .952. This value informs that the factor analysis can be conducted as the data are normally distributed and the sample is sufficient; thus, EFA was started (Pallant, 2020; p. 200).

As a result of the first factor analysis performed without any factor limitation, Items 30, 46, 48, 4, 5, and 22 were determined to overlap, and nine significant factors were obtained. As a result of the second factor analysis, Items 21, 13, 49, 29, and 42 were determined to overlap; Item 43 was seen to not fall under any factor, and this time seven significant factors were obtained. In the third analysis, Item 7 was determined to overlap and Item 37 to not fall under any factor; this analysis found six significant factors. The fourth analysis found Item 36 to not be included in any factor and found six significant factors. The analysis results obtained in the fifth EFA were also evaluated, and the decision was made to limit the number of factors to three.

As a result of repeated factor analyzes with limitations, the extraction values for Items 1, 3, 4, 5, 6, 7, 12, 10, 13, 23, 24, 27, 38, and 45 were less than .30, and Items 22, 30, 46, 48, and 49 overlapped; Items 22, 47, and 16 were also excluded from the scale as they were not gathered under any factor in the repeated factor analyses. What is meant here by saying the items overlap is that an item has sufficient factor loading values under more than one factor. Another important situation here is that a minimum difference of .10 points was found between the factor loading values for the items that overlapped under different factors (Secer, 2017).

Table 2. Total variance explained in Self-Regulation Scale for Science

Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadingsa
Total	% of Variance	Cumulative %	Total	% Variance	Cumulative %	Total
10.369	39.882	39.882	10.369	39.882	39.882	8.747
1.128	4.338	44.219	1.128	4.338	44.219	6.872

Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadingsa
Total	% of Variance	Cumulative %	Total	% Variance	Cumulative %	Total
1.050	4.040	48.260	1.050	4.040	48.260	5.975
.997	3.833	52.092				
.922	3.548	55.640				
.866	3.332	58.972				
.827	3.181	62.153				
.791	3.042	65.195				
.714	2.748	67.943				
.686	2.638	70.581				
.684	2.630	73.211				
.614	2.360	75.571				
.593	2.279	77.850				
.588	2.260	80.110				
.552	2.121	82.232				
.531	2.042	84.273				
.516	1.984	86.257				
.480	1.848	88.105				
.457	1.756	89.861				
.423	1.626	91.487				
.416	1.601	93.088				
.404	1.553	94.641				
.387	1.487	96.128				
.382	1.470	97.598				
.321	1.233	98.831				
.304	1.169	100.000				

Hutcheson and Sofroniou (1999) stated the sample size is good when the KMO value is in the 0.7-0.8 range, very good in the 0.8-0.9 range, and excellent in the above 0.9 range (as cited in Secer, 2017, p. 155). After removing the items, the study obtained a KMO value of .958; thus, the sample size can be said to be perfectly adequate and the collected data to be sufficient and appropriate for carrying out the factor analysis. Statistically significant Bartlett values also support the assumption that the data provide a multivariate normal distribution.

After checking the KMO value, the factor analysis was continued with the remaining items. The remaining 26 items were determined to be grouped under three significant factors in the scale. When examining the distribution of the items in the factors using the direct Oblimin vertical rotation technique, all the items are seen to have an acceptable load value in the factor in which they'd been entered (the lowest item load value was .339, and the highest item load value was .820; see Table 3). The scree plot graph of these factors is given in Figure 1.

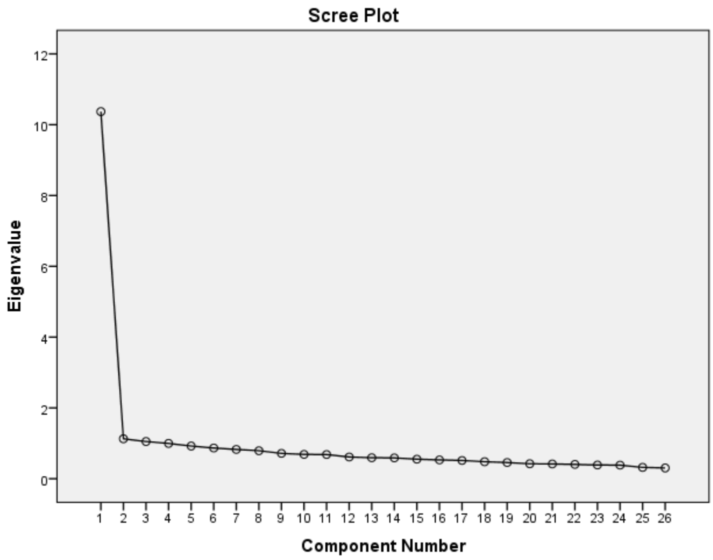

Figure 1. Scree plot for the Self-Regulation Scale for Science

Table 3. Pattern Matrix Values for the Self-Regulation Scale for Science

Item Number	Pattern Matrix Values		
	1	2	3
Item 11	.820		
Item 32	.683		
Item 34	.631		
Item 9	.600		
Item 26	.586		
Item 25	.585		
Item 39	.542		.301
Item 40	.506		
Item 41	.506		
Item 19	.491		
Item 33	.478		
Item 44	.433		.302
Item 2	.417		
Item 51	.339		
Item 20		.716	
Item 35		.653	
Item 28		.647	
Item 36		.540	
Item 18		.525	
Item 17		.439	
Item 8	.304	.378	
Item 15			.725

Item Number	Pattern Matrix Values		
	1	2	3
Item 31			.703
Item 14			.595
Item 37			.449
Item 43			.416

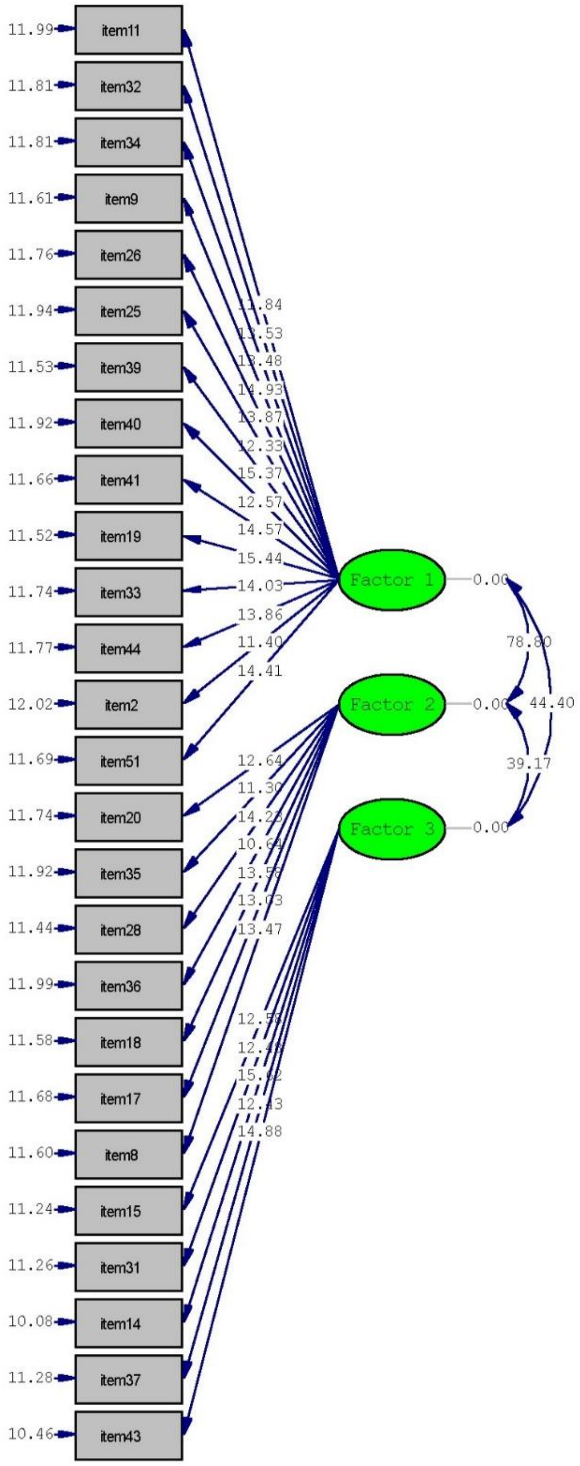

Figure 2. Path Diagram Showing the CFA t Values of the Self-Regulation Scale for Science

The items representing the initial factors were observed to come together upon examining the items belonging to the factors in detail. In other words, the dimensions of elaboration, organization, repetition, goal setting, and planning as initially envisaged fall under the factor of learning strategies; the dimensions of asking for social assistance, arranging time and working environment, and arranging effort fall under the factor of time and effort management; and the dimension of critical thinking is again gathered under the factor of critical thinking. As such, the prepared scale still has a solid theoretical foundation that continues to support the self-regulation model found in the literature, especially as per Zimmerman (1986).

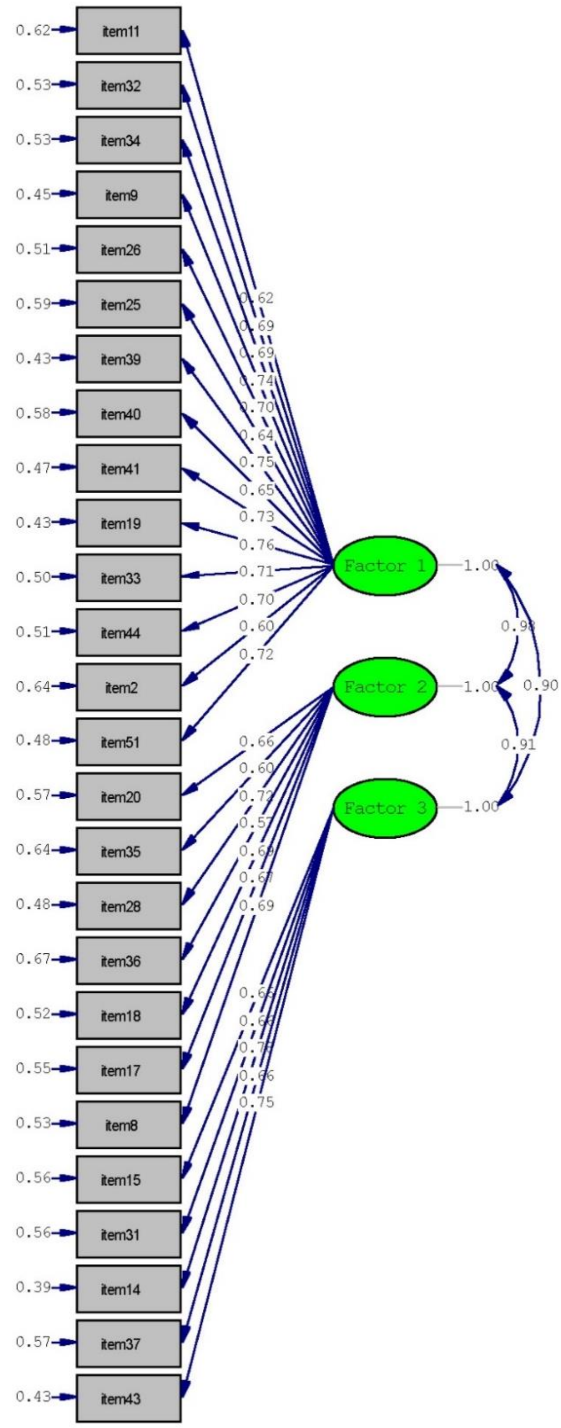

Figure 3. Path Diagram Showing the Standardized Factor Loadings in the CFA for the Self-Regulation Scale for Science

Confirmatory factor analysis (CFA) is one of the most valid factor analysis techniques today (Secer, 2017, p. 172) and was performed using LISREL 8.80 in order to statistically verify the exploratory factor analysis results. Before applying the scale, the remaining 26 items from the EFA were renumbered; however, they've been reported here using the initial item numbering in order to increase comprehensibility. The obtained data were completely and objectively transferred to the computer environment after being checked by the first author. Raw data and the items in the scale were grouped according to the factors that had been determined as a result of EFA, and syntax commands were written and made suitable for CFA.

The t values obtained as a result of the CFA are given in Figure 2. While examining these t values, Jörskog and Sörbom (1993) draw attention to the presence of a red arrow. At this stage, whether a color change has occurred in the arrows between each item should be checked with the relevant factor. If no red arrow has occurred, the analysis and interpretation of the model can continue, assuming no other problems exist in terms of t values and no items have been removed (Secer, 2017, p. 186). As can be seen in Figure 2, the analysis was continued with the same items as no issues were observed with the t values.

Factor 1 is learning strategies, Factor 2 represents critical thinking, and Factor 3 represents time and effort management. In the next step, attention was paid to ensure that each item had a factor loading value of at least .30 (Secer, 2017, p.188). When examining Figure 3, the factor loading values for all items are understood to be .30 or higher. Because no problem was found in the factor loading and t values, the model fit indices were examined. At this stage, the compatibility index that should be examined first is the Chi-square ($\chi 2$) value and the ratio of this value to the degrees of freedom (df). When examining the path diagram, the $\chi 2$ value is seen to be 408.78, df = 296, p = 0.00, $\chi 2$ / df = 1.38. The Chi-square value is understood to be low but significant in terms of the model fit indices, and the $\chi 2$ / df value is less than 3. According to Kline (2011), a $\chi 2$ / df < 5 is good, with $\chi 2$ / df < 3 showing perfect harmony. In this case, the current scale can be said to have perfect fit.

Although the initial data on model fit appears positive, examining the other fit indices would be useful as the $\chi 2$ value is significant. Considering the possible limitations of the Chi-square test and the biases related to model fit, a large number of fit and significance tests (i.e., second group tests) have been developed. These tests are especially recommended when using large samples (Hu & Bentler, 1995). These values, generally known as goodness-of-fit indices (GFI), are gathered in two general categories: absolute and incremental fit indices. The leading absolute fit indices are GFI and AGFI, developed by Jörskog and Sörbom (1993). The GFI, developed for the purpose of evaluating the model fit independently from the sample is the sample variance representing the ratio of the model and measures the variance-covariance matrix in the sample. Meanwhile, AGFI is the GFI value that takes sample size into consideration, with values of .95 or greater for both indexes being considered perfect. Values greater than .90 are considered to have a satisfactory level of fit.

The absolute fit indices developed based on the degree of error are the root mean square (RMS) and root mean square error of approximation (RMSEA). According to Steiger (1990), an RMSEA value (being the square root of the mean squared error) of less than 0.05 indicates perfect fit, with less than 0.10 indicating good fit. CFI (comparative fit index) comes first among the incremental fit indices based on the assumption that no relationship exists among the variables; it indicates a model to have better fit the closer it gets to 1. NFI (normed fit index) and NNFI (non-normed fit index) were developed by Bentler with similar logic. The plus NFI has over CFI is that it analyzes without having to comply with the assumptions brought by the Chi-square distribution.

On the other hand, NNFI analyzes by taking into account the degrees of freedom of the models being compared. Again, these indexes are considered perfect for values of .95 or higher and acceptable when greater than .90 (Sumer, 2000). In addition to these, IFI represents the increasing fit index, and RFI represents the relative fit index; the closer they get to 1, the better the fit (Ilhan & Cetin, 2014). The breakpoints of the CFA fit indices and the CFA analysis results of the current study's Self-Regulation Scale for Science are given in Table 4.

Table 4. Results of CFA Fit Indices and Self-Regulation Scale

Fit Indexes	Acceptable limit	Perfect fit limit	Value of scale	The scale's fit decision
NFI	.90 and above	.95 and above	.98	Excellent
NNFI	.90 and above	.95 and above	.99	Excellent
IFI	.90 and above	.95 and above	.99	Excellent
RFI	.90 and above	.95 and above	.98	Excellent
CFI	.95 and above	.97 and above	.99	Excellent
GFI	.85 and above	.90 and above	.91	Excellent
AGFI	.85 and above	.90 and above	.89	Acceptable
SRMR	Between =.050 and =.080	Between = .000 and <.050	.034	Excellent
RMSEA	Between =.050 and =.080	Between = .000 and <.050	.035	Excellent

During the development phase of the Self-Regulation Scale for Science, the scale was determined to consist of 26 questions and three factors as a result of the EFA. This result was confirmed in the CFA. After completing the validity and reliability studies, the visual aspects of the form were designed by the first author using Sekonic Program to facilitate applicability. Another reason for recommending the collection of data in a visual form was to minimize the error rate in the process of transferring the raw data of the research to the computer.

Reliability Findings

Reliability is the first condition to meet in scientific studies, it is used to express the repeatability and consistency of the scores obtained from the scale (Cepni et al., 2009). In this context, the reliability coefficient of the scale and each item were first examined for the 51-item draft scale, then the validity studies were begun. This reliability analysis has been explained in detail in the content validity section. In addition, as a result of the reliability analysis performed after completing the validity studies, the Self-Regulation Scale for Science was obtained.

The scale has a reliability coefficient of .940 and consists of 26 questions and three factors that explain 48% of the variance. The factors were renamed upon considering the item contents collected under the factors. The results of the reliability analysis for these renamed factors and sample items from each factor are given in Table 5.

Table 5. Reliability of the Self-Regulation Scale for Science's Factors and Sample Items

Factors	Items	Reliability Coefficient	Sample Item
Learning Strategies	2, 9, 11, 19, 25, 26, 32, 33, 34, 39, 40, 41, 44, 51	.905	I try to combine the information we learned in the lesson with the information in the book, while studying for the science exams,
Critical Thinking	8, 17, 18, 20, 28, 35, 36	.808	I try to develop my thoughts on the subjects in the science course.
Regulation time-effort	14, 15, 31, 37, 43	.780	I work hard to be successful, even if I don't like what we do in science class,

Discussion and Conclusion

Social cognitive theory and Zimmerman's self-regulation model have been used as the basis in this study, which was conducted to develop a valid and reliable scale to determine the self-regulation levels of secondary school students in science. The literature has studies that do not specify which theory and model their scales were based on for their self-regulation scale development studies (Bayindir & Ural, 2016; Celikkaleli & Yildirim, 2015; Demiraslan Cevik et al., 2015; Haslaman & Askar, 2015; Keskin & Atmaca, 2014; Kirbulut et al., 2016; Oz & Sen, 2018; Reyna et al., 2019; Velayutham et al., 2011; Yetisir & Ceylan, 2015) as well as those that do (Aslan & Gelisli, 2015; Aydin et al., 2014; Kocdar et al., 2018; Tanribuyurdu & Yildiz, 2014; Tosun & Sekerci, 2014). The current study has explained the theoretical basis and the model in detail in order to clarify in which field the developing scale is used, to obtain more effective and efficient results, and to contribute to the content validity.

This aspect of the study has been implemented with the hope that it will guide future scale development studies. Similar to scale development studies in the literature (Altun Yalcin et al., 2020; Benek & Akcay, 2019; Gunes & Bati, 2018), a literature review was conducted to ensure content validity, expert opinions were sought, and a pilot study was conducted to test the suitability of the items and calculate item difficulty and distinctiveness indices. The reliability coefficient of the scale and each of the items were first examined for the 51-item draft scale, and then the validity studies were begun.

EFA and CFA were performed to ensure construct validity. As a result of EFA, a structure consisting of 26 questions and three factors explaining 48% of the variance was obtained. In a good factorial analysis, the least number of factors are expected to explain the highest amount of variance. An analysis that explains 50-75% of the total variance is considered a valid analysis (Beavers et al., 2013). In this respect, the developed scale can be said to be valid at an acceptable level. When examining the factors of learning strategies, critical thinking, and regulation of time and effort obtained as a result of the EFA, the items were concluded to have a solid theoretical foundation that continues to support Zimmerman's (1986) self-regulation model as based on social cognitive theory.

The structure consisting of 26 items and three factors was confirmed as a result of the CFA made with the data obtained by applying the scale to a sample different from the one in the EFA. When examining the self-regulation scales in the literature, either no CFA had been applied (Aydin et al., 2013; Bayindir & Ural, 2016; Tosun & Sekerci, 2014; Velayutham et al., 2011) or a CFA had been done with the data obtained by applying the scale to the same sample as in the EFA (Aslan & Gelisli, 2015; Celikkaleli & Yildirim, 2015; Demiraslan Cevik et al., 2015; Haslaman & Askar, 2015; Keskin & Atmaca, 2014; Kocdar et al., 2018; Reyna et al., 2019; Tanribuyurdu & Yildiz, 2014; Yetisir & Ceylan, 2015). Meanwhile, studies where EFA and CFA had been applied to the same sample reported the factor structure to have been confirmed by the data obtained from the same students answering the same questions. However, studies are also found that used different samples for their EFA and CFAs (Kirbulut et al., 2016; Oz & Sen, 2018). The current study verified the factor structure using a sample for the CFA who had never encountered the questions in the scale. The construct validity of the developed scale can be said to be robust in this respect.

This study calculated Cronbach’s alpha of reliability, which is frequently preferred in scale development studies in the literature (Akca & Kavak, 2021; Burak & Gultekin, 2021; Ertas Capan & Uzuncarsili, 2022). The reliability coefficient for the overall scale was calculated as .940, as .905 for the factor of learning strategies, .808 for the factor of critical thinking, and as .780 for the factor of regulation of time and effort. The developed scale and each of its factors has been concluded to have high reliability (Fraenkel & Wallen, 1996). The present study also reports the reliability coefficient for each factor. Thus, the aim was to know if the obtained results are reliable when evaluating just one factor rather than the entire scale. The visual aspect of the form was designed in accordance with the scale and developed differently from the literature. Thus, the aim is so that researchers can both transfer the data to the computer without error and use their valuable energy and time to do more valuable research. As a result, a valid and reliable scale for science education has been obtained based on social cognitive theory and Zimmerman’s self-regulation model that is simple enough to be able to be understood by middle school students.

Recommendations

- This developed scale can be used by science teachers at the beginning of the year or the semester to determine their students’ self-regulation levels. Teachers can also determine their students’ development levels in terms of self-regulation by applying them at the end of the semester/year.
- The scale can be used at the beginning and end of an application to determine whether any strategy or method used in science education has affected students’ self-regulation.
- These scale items have been prepared for children at the secondary school level and may also be developed and made suitable for high school and university levels.
- Criterion validity can be checked by determining a criterion test with a similar structure.
- The developed scale can be used as a data collection tool in quantitative research in science education.

Note

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