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Adaptation of the Next Generation Science Classroom Questionnaire for Middle School Students to Turkish: A Validity and Reliability Study

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Abstract: *In this study, it was aimed to adapt the "Next Generation Science Classroom Questionnaire" into Turkish. The original scale form consists of four main factors and 35 items. Original scale factors: Understanding scientific explanations, generating scientific evidence, reflecting on scientific knowledge, participating productively in science. The Exploratory Factor Analysis (EFA) study group of the research consists of 408 middle school 7th and 8th grade students, and the Confirmatory Factor Analysis (CFA) study group consists of 799 middle school 7th and 8th grade students. EFA was used to examine the construct validity of the scale, and translation studies were conducted to examine the language validity. As a result of the EFA, a structure consisting of 30 items and 4 factors was obtained. As a result of the confirmatory factor analysis, it was observed that the values of the fit indices were within the acceptable value limits. Finally, Cronbach's Alpha values for the reliability of the scale tool in terms of internal consistency were calculated and it was seen that the Turkish version of the "Next Generation Science Classroom Questionnaire" was a valid and reliable measurement tool with adequate psychometric properties.*

Keywords: Science Education, Next Generation Science Standards, Scale Adaptation, Middle Students.

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INTRODUCTION

The importance of inquiry skills in students' learning processes is widely discussed in science education (Barrow, 2006; Dagher & Erduran, 2016; Rönnebeck et al., 2016; Sedano & Carvalho, 2017). Adapting scientific process skills and scientific research approach are among the main objectives of the science curriculum, which aims to raise individuals who are scientifically literate. In this context, it is important to provide solutions to the problems encountered, to use knowledge of science, scientific process skills and other life skills in solving problems, to help scientists understand how scientific knowledge is formed, the processes through which the knowledge is generated and how this knowledge is used in new research (MEB, 2018). In science education, it is important to include ideas and practices for arranging the courses in the curriculum in a way that resembles the work of professional scientists (Forman, 2018).

Individuals are expected to develop comprehensive and well-equipped skills in order to be successful in their careers. In this context, educational institutions aim to increase the quality of human resources with competencies that help individuals compete globally in parallel with scientific and technological developments (Rina, Murtini, & Indriayu, 2019). Next Generation Science Standards in science teaching in order to gain skills that will enable individuals to compete in a global context. Next Generation Science Standards (NGSS) is one of the most important

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reforms made in recent years. Argumentation and engineering practices are at the center of science and engineering practices (Achieve, 2013; Demirel & Özcan, 2021). NGSS, enable students to realize how knowledge emerges through active participation in science and engineering practices (NRC, 2012). As students identify problems and needs, they create explanations and design solutions, and sometimes discover ways they can test their new ideas. Students who have mastered the operation of the scientific process stages demonstrate their understanding and reasoning in four learning stages: Understanding scientific explanations, generating scientific evidence, reflecting on scientific knowledge, participating productively in science. The four pillars of science in learning science are: understanding scientific explanations, generating scientific evidence, reflecting on scientific knowledge, participating productively in science (NRC, 2008).

Understanding Scientific Explanations: At this stage, which is conceptualized as the ease of understanding and using scientific explanations, teachers support students in coordinating their basic scientific ideas with practices to make logical connections about the natural world **(**Braaten & Windschitl, 2011; Osborne & Dillon, 2008). At this stage, which supports students' understanding of the interrelationships between science concepts and how they can connect to construct and criticize scientific arguments, priority is given to understanding scientific concepts and applying scientific explanations (NRC, 2008).

Generating Scientific Evidence: Evidence is of paramount importance in science learning, as evidence helps students construct and refine their models and explanations of the natural world. Here, producing evidence is linked to a wide variety of science practices, including designing and conducting research, making decisions about what to measure and how. It focuses on how the resulting data should be structured, evaluated, and interpreted, and how scientific evidence produced is useful in improving arguments, models, and explanations (NRC, 2008).

Reflecting on Scientific Knowledge: The epistemological aspects of scientific knowledge are reflected in this stage of science learning. Specifically, the focus is on how theory and evidence are used as justifications in scientific knowledge (NRC, 2007). Reflecting scientific knowledge also requires recognizing how science knowledge is constructed over time, in ways that include repetitive features of participation in scientific inquiry and reviewing scientific knowledge as new evidence emerges. It focuses on the extent to which students revise their own ideas in the classroom representation of scientific activity, which reflects the types of revisions made by scientists in the process of learning new facts or developing a new model (NRC, 2008).

Participating Productively in Science: The importance of productive participation as a central feature of scientific activity that students must experience as part of the practice sequence can be seen in how progress in science is achieved largely through interactions between research communities. The importance of science as a social enterprise or practice community that benefits from the collective construction and critique of scientific explanations comes to fore (NRC, 2008).

The next generation science standards that emerged in 2012 include engineering design from pre-school to the end of high school. In addition, engineering and technology, which are the elements of STEM education, are emphasized in the next generation science standards. STEM education has included the curriculum in the USA with the next generation science education standards. Argumentation and design-based engineering practices are the basis of next generation science standards. While the argumentation skill includes activities based on evidence creation and speaking by approaching the data with a critical perspective, the design process consists of a series of repeated creative problem-solving stages (Demirel & Özcan, 2021).

With the next generation science standards, in addition to critical thinking skills, students are encouraged to develop scientific and mathematical literacy. By adapting the next generation science standards scale, a framework is drawn for students to understand scientific explanations, generate scientific evidence, reflect scientific knowledge, and participate productively in science. In this respect, the current study will provide a framework for the next generation science standards in courses.

Purpose of the study

Students will be directly affected by the next generation science standards used in the application of the STEM approach, which is made an effort to be implemented in an integrated manner today. For this reason, it is important to determine the views, experiences and interests of middle school students towards next generation science standards. The aim of the current study is to adapt the "Next Generation Science Classroom Questionnaire" developed by Campbell et al. (2021) for middle school students into Turkish.

METHOD

The descriptive survey model was used in the study, which was designed with a quantitative research approach. The descriptive survey model includes researching previously applied and ongoing situations (Bilgin, Aykaç, & Kabaran 2014). The adaptation study of the scale was based on the "Guideline Checklist on Translation and Adaptation of Scales" of the International Test Commission (ITC) in order to demonstrate a standard approach. In the directive developed by the ITC, it is seen that there are issues such as ensuring cultural and linguistic equivalence, validity and reliability in the tests, and the meanings and norms of the scores obtained from the tests (Mor Dirlik, Altıntaş, Kartal, 2021). For this purpose, adaptation steps, which are frequently used in the literature, were used: (1) group translation consisting of at least two people, (2) back-translation consisting of at least two people, (3) expert opinion, and (4) pilot study (Beaton et al. 2000; International Testing Commission 2018; WHO 2018). In this context, it was aimed to determine the next generation science standards for middle school students by adapting the scale to Turkish.

Study group

Determining the sample size is important in ensuring the validity and reliability of the scale. While determining the study group, data were obtained from 7th and 8th grade students in 5 middle schools in Malatya by using simple random sampling method. It is a sampling method in which the principle of impartiality can be applied since each sample is given an equal probability of being selected with the simple random sampling method (Balcı, 2001). The scale was developed for 7th and 8th grade students as the next generation science standards clearly show the applications that should be included in middle school science lessons. In order to obtain more reliable and valid results it was stated that the sample size should be at least 200, the sample size should be at least 300 in order to reveal the factor structure, and ideally the sample size should be above 500 (ITC, 2018). In this context, data obtained from different study groups consisting of 408 students for Exploratory Factor Analysis (EFA) and 779 students for Confirmatory Factor Analysis (CFA) were used in the study. The study groups of the data used for EFA and CFA are given in Table1.

Table 1. *Demographic Variables of the Study Group*

	Variables		f	%
EFA	Gender	Female	210	51.5
		Male	198	48.5
	Grade	7th grade	212	52
		8th grade	196	48
		Total	408	100
CFA	Gender	Female	395	50.7
		Male	384	49.3
	Grade	7th grade	479	61.5
		8th grade	300	38.5
		Total	779	100

Data collection tool

In the study, the “Next Generation Science Classroom Questionnaire” developed by Campbell et. al (2021) for 7th and 8th grades was used as a data collection tool. The original scale form was created using the stages of Rea and Parker's (1997) scale study. The development process of the "Next Generation Science Classroom Questionnaire" was carried out in five different consecutive stages. These stages are literature review for the creation of the structure (a), creation of the item pool (b), seeking the opinions of content experts and science education researchers on the theoretical framework and next generation science standards to ensure content validity (c), piloting the 53-item next generation science classroom questionnaire (d) and the creation of a 35-item final next generation science classroom questionnaire as a result of the analyzes (e). Each item rated on a Likert type was created with a 5-point rating ranging from “Almost never” (0) to “Almost always (Almost always)” (4).

The original next generation science classroom questionnaire was applied to a total of 306 students studying in the 7th grade (n= 157) and 8th grade (n= 149) in the 2017-2018 academic year in New England. While applying the scale, students were given a 45-minute lesson time, but most students completed the questionnaire within 15-20 minutes. EFA was applied to all 53 items with 4 factors: understanding scientific explanations, generating scientific evidence, reflecting scientific knowledge and participating productively in science. As a result of the EFA, 18 items were removed from the scale, leaving 35 items in the scale. As a result of the EFA of the 53-item scale, it was seen that it had moderate goodness of fit indices (CFI = 0.85, NNFI = 0.85, RMSEA = 0.054). Then, as a result of EFA applied to the 35-item scale, it was found that there was sufficient model fit (CFI = 0.93, NNFI = 0.93, RMSEA = 0.04). Productive participation in science from the factors in the scale consists of four sub-dimensions (17 items). These sub-dimensions were named as: *Collaborative sense making (4 items)* , *Collaborative negotiation of ideas (3 items)* , *Pressing for elaboration (4 items)* , *Foregrounding ideas and connecting evidence (6 items)* . A more detailed CFA was performed for the four sub-dimensions of the factor of productive participation in science. Measures obtained for the four sub-dimensions (CFI = 0.95, NNFI = 0.94, RMSEA = 0.038, $R^2 <.40$ for one item only). Finally, a model consisting of 4 main factors and 35 items emerged. Since the goodness of fit indices of the final scale (CFI = 0.93, NNFI = 0.92, RMSEA = 0.047) were among acceptable values, its form consisting of four main factors and 35 items was decided for original questionnaire.

Making sure that all scales are highly correlated to validate the results of a scale is a fundamental assumption of many statistical analysis procedures. The most common statistical index of internal consistency reliability is the Cronbach alpha coefficient (Leong & Austin, 2006). Cronbach's alpha helps to measure the extent to which items aiming to measure the same construct result in similar scores. Cronbach's alpha was used to ensure internal consistency reliability of the original scale. The Cronbach alpha of the 35-item scale was found to be 0.957. Cronbach's alpha coefficients of the factors: Understanding scientific explanations dimension was 0.957, producing scientific evidence was 0.779, reflecting scientific knowledge was 0.808, productively participating in science dimension (with three sub-dimensions) ranged from 0.722 to 0.854. Ideally, Cronbach's alpha value should be above 0.7 (Nunnally & Bernstein, 1994). A total of 35 items and all dimensions were found to have acceptable internal consistency. With the “*Next Generation Science Classroom Questionnaire”* It has been stated that how students perceive and comprehend can be measured (Campbell & Fazio, 2020; Manz, 2020). With this scale development study, the researchers showed that a measurement tool can measure student experiences with emphasis on professional activities they undertake through the eyes of scientists (Forman, 2018).

Data Collection Process

In order to adapt the “Next Generation Science Classroom Questionnaire” as the first step of the data collection process in the research, the researchers who developed the original scale form were contacted and the necessary permissions were obtained for the adaptation study. Afterwards, permission for the study was obtained from the Social and Human Sciences Scientific Research Ethics Committee of Inonu University on 24.03.2022 (No: 2022/6-22). After obtaining the necessary permissions, the original scale was translated into Turkish by three language experts who are fluent in Turkish and English. Turkish translations are written by linguists in the form of several alternatives that students can understand. Later, the translations were examined and the scale items were reviewed by the experts by looking at the differences and similarities between the translations. After the scale was translated into Turkish, the opinions of 2 experts in the fields of science education and assessment and evaluation, who had good command of the field and language, were asked to examine the original and translation forms and to make suggestions and corrections, if any. In this context, experts were expected to evaluate whether the expressions in the scale were used in the same meaning and context in both scale forms and whether the experiences required by the items were livable for students.

As a result of the evaluations made in this context, the concept of "phenomenon" was removed from the item "We apply scientific concepts and explanations we are learning to interpret many events or phenomena that happen in the world". Again, in the original scale, "We generate evidence as part of building and refining models and explanations of the natural world." A footnote has been added to the part where the word "model" is mentioned for the first time so that the concept of model in the article can be better understood by the students. The expression "model" refers to models such as the Sun-Earth-Moon model, DNA model, cell model, atomic model, simple machine model, human body model that you use in science lessons. The trial scale form, which was prepared as a result of the evaluation of the experts, was sent to a Turkish language expert to ensure that the items were analyzed conceptually, semantically and linguistically. At the end of the examinations and corrections, the final scale form was created and the original scale and translation form were applied to 42 students studying at the 3rd grade of English Language Teaching at the faculty of education at intervals of two weeks. For construct validity, the scale was applied to 1187 middle school students, 408 for EFA analysis and 779 for CFA, and analyzes of validity and reliability were made.

Analysis of Data

In the data analysis step, first of all, in order to determine the language validity of the scale, the original form of the scale and the Turkish form were applied to 42 students and the Pearson correlation coefficient between the obtained data was examined. Afterwards, the construct validity of the scale was determined by performing EFA. In order to verify the structure obtained from EFA, CFA was applied to the data obtained from 779 students. In the study, Cronbach's alpha reliability coefficients were calculated to ensure the reliability of the scale.

FINDINGS

1. Findings Regarding the Language Validity of the Scale

In order to determine the language validity of the scale translated into Turkish, the original scale form and the translation form were applied to 42 students and the correlation between the two data sets was examined. According to the Pearson correlation result, a high correlation of .916 was found between the two scale forms, and the language validity of the items in the translation form and the original scale form was ensured.

2. Findings Regarding the Construct Validity of the Scale

EFA was conducted in order to ensure construct validity by defining the feature that the test wanted to measure fully and clearly. In scale adaptation studies, it is recommended to perform an EFA first and then perform CFA in order to verify the validity of the revealed structure with a different data set. Starting the adaptation work with EFA or CFA will give the same result either way. However, in case of differences between the original and translated forms, it is more beneficial to start adaptation studies with EFA, since the structure cannot be determined only with CFA (Orçan, 2018). For this reason, in the study, CFA was performed starting with EFA and then to test the structure. Before EFA, normality criteria and KMO sampling adequacy criteria were examined in order to determine whether the data set was suitable for factor analysis (Cokluk, Şekercioğlu, & Büyüköztürk, 2012). In order to ensure normality in terms of univariability, values outside the ± 3 z score range were not taken and these values were accepted as extreme values (Field, 2009; Tabachnick & Fidell, 2013) and it was seen that there were no extreme values in the data set. By calculating Mahalanobis distance values ($p<.001$) and removing 39 extreme values from the data set, multiple normality was achieved (Pallant, 2011; Tabachnick & Fidell, 2013) and the analyzes were continued with 408 data sets. After examining the normality assumptions, the skewness (range -0.47 to -0.622) and kurtosis (range -0.687 to - 1.254) values were examined and it was seen that the data set showed a distribution close to the normal distribution. The relations between the items were examined with the correlation matrix and it was seen that the correlations between the variables were above .30 and these values showed that the data were suitable for factor analysis (Suhr, 2008; Tabachnick & Fidell, 2013). Since all of the correlation coefficients on the basis of the items are below .90, it can be said that there are no single or multiple correlation errors between the items. The result of the Bartlett sphericity test ($\chi 2$ = 6254.234; sd=435; p= .000<.05) used for multivariate normality assumptions shows that the data have sufficient sampling for factor analysis (Tavşancıl, 2006).

After testing the suitability for factor analysis, the factorization status of 35 items was examined by using Principal Components Analysis and Promax Rotation methods, which reveal the factor structure (Field, 2009). If the researcher wants to get the most appropriate results from the data he has obtained, oblique rotation; Orthogonal rotation is recommended if the researcher is more concerned with the generalizability of the results. In general, oblique and vertical rotation techniques give the same results (Rennie, 1997). In this respect, promax, one of the oblique rotation methods, was used in the study. The factor load for the analysis was determined as .32 as the lower cut-off point (Tabachnick & Fidell, 2013).

In determining the number of factors, the original structure criterion was that the eigenvalue should be at least 1 for each factor (Kaiser Criterion), line graph and parallel analysis indicators (Pallant, 2011; Suhr, 2008; Tabachnick & Fidell, 2013). The scree-plot chart is given in figure 2.

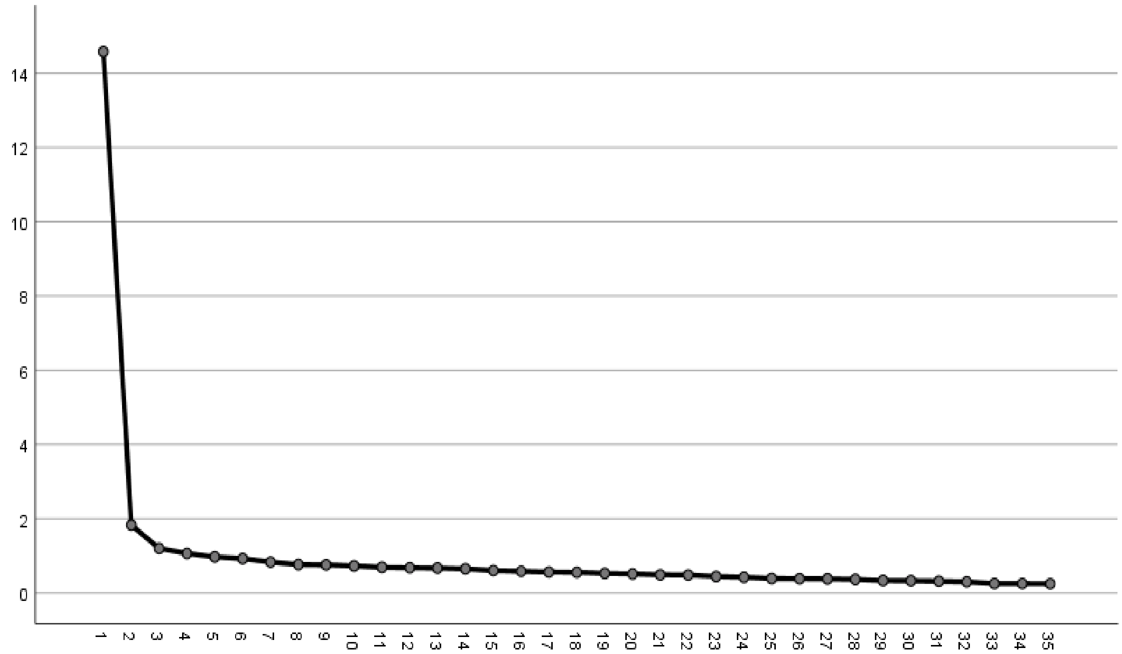

Figure 2. *Scree plot for factor solution of scale items*

“Next Generation Science Classroom Questionnaire” consists of 4 main factors. As a result of the principal components analysis, it was seen that there was a total of 4 factors with an eigenvalue bigger than 1. The Kaiser criterion indicates a 4-factor structure as a result of EFA, and the eigenvalues of these factors are respectively 1. Factor: 14.583, 2. Factor: 1.827, 3. Factor: 1.197 and 4. Factor: 1.062. Then, it was seen that the slope made a plateau after the fourth point in the scree plot and the contribution of the components to the variance after the fourth point was small (Pallant, 2011) and approximately the same (Figure 2). As a result of the EFA, a four-factor scale structure was decided. The original scale consists of 4 main factors, and the items of the Turkish version of the scale were also placed on four factors and were found to be compatible with the original scale form (Campbell et al., 2021). It was concluded that the confirmed four-factor structure explained approximately 56% of the total variation in variance. Variance explanation rates between 40 % and 60% are seen as sufficient in social sciences (Tavşancıl, 2006).

As a result of the EFA, the final scale consisting of 30 items was obtained by removing the overlapping items (Items 10, Items 18 and 19) and overlapping items from the scale (Items 20, Item 23). Items removed as a result of EFA; "We use the results from our investigation to develop and refine arguments and models we are working to develop" (Item 10), "Explanations that explain evidence more completely are valued most" (Item 18), "We create representations to explain and argue for our ideas with peers" (Item 19). "We engage in whole class discussions where we publicly share our thinking and coordinate claims and evidence" (Item 20), "Our teacher guides us to share, expand, and clarify our ideas" (Item 23). The extracted items generally contain statements that students create models in which they actively make claims, participate in class discussions, and make presentations in science lessons. In this context, the extracted items also give information about the methods and techniques used in the classrooms in general terms. The four-factor structure and the factor loads of the items revealed as a result of EFA are given in Table 2.

Table 2. *Results of the Exploratory Factor Analysis (items are specified according to the original scale form given in appendix 1.)*

Items	Participating productively in science	Reflecting on scientific knowledge	Generating scientific evidence	Understanding scientific explanations
Item 32	.823			
Item 26	.803			
Item 27	.705			
Item 25	.704			
Item 31	.702			
Item 22	.652			
Item 24	.647			
Item 34	.640			
Item 28	.630			
Item 29	.612			
Item 33	.605			
Item 21	.586			
Item 23	.544			
Item 30	.463			
Item 35	.418			
Item 13		.813		
Item 12		.660		
Item 14		.545		
Item 9		.533		
Item 8		.486		
Item 17		.459		
Item 16		.459		
Item 15		.457		
Item 11		.434		

Items	Participating productively in science	Reflecting on scientific knowledge	Generating scientific evidence	Understanding scientific explanations
Item 6			.681	
Item 5			.564	
Item 7			.387	
Item 1				.739
Item 2				.643
Item 3				.484

It was seen that the 4 main factors and the items belonging to these factors in the original structure and the factors revealed as a result of the adaptation and the items belonging to these factors were compatible. Factors and variance explanation rates are given in Table 3.

Table 3. *Factors and Variance Explanation Percentages*

Factor	Total	Percentage of variance	Cumulative percentage
1	12,812	42,707	42,707
2	1,735	5,784	48,492
3	1,095	3,649	52,141
4	1,040	3,467	55,608
5	,886	2,953	58,560
6	,830	2,766	61,327
7	,753	2,510	63,836
8	,696	2,321	66,158
9	,692	2,305	68,463
10	,670	2,234	70,697
11	,655	2,183	72,880
12	,629	2,096	74,976
13	,598	1,993	76,969
14	,574	1,915	78,883
15	,562	1,873	80,756
16	,536	1,788	82,544
17	,525	1,751	84,296
18	,492	1,641	85,937
19	,462	1,541	87,478
20	,439	1,465	88,943
21	,425	1,417	90,360
22	,397	1,324	91,684
23	,383	1,277	92,961
24	,365	1,215	94,177
25	,343	1,144	95,321
26	,325	1,082	96,403
27	,306	1,021	97,424
28	,268	,895	98,319
29	,255	,851	99,170

Factor	Total	Percentage of variance	Cumulative percentage
30	,249	,830	100,000

When we look at the variance explanation rates of the final scale consisting of 30 items given in Table 3, it is seen that the rate of explaining the change in variance of the 4-factor structure revealed is approximately 56%.

3. Findings Regarding the Confirmatory Factor Analysis

CFA was performed to test the construct validity by confirming the structure of the scale, whose four-factor structure was revealed by EFA (Kline, 2011). While performing CFA, data obtained from a different study group than the data used in EFA were used. In order to test the suitability of the data set for CFA, it was examined whether there were values outside the ±3value range in the data set, which was converted into z scores as criteria for univariate normality, and it was seen that there were no extreme values in the data. By calculating Mahalanobis distance values ($p<.001$) and removing 29 extreme values from the dataset, multiple normality was achieved (Pallant, 2011; Tabachnick & Fidell, 2013) and the analyzes were continued with 779 data sets. After examining the normality assumptions, skewness (-0.02-0.691) and kurtosis (-0.287-0.984) values were examined and it was seen that the data set showed a distribution close to the normal distribution. The data set of 779 people was transferred to the AMOS program and it was determined that the scale had a four-factor structure. The DFA results of the four-factor model are presented in Table 4.

Table 4. *Results of the Confirmatory Factor Analysis*

Goodness of Fit Values	Perfect	Acceptable	Four-Factor Model
P	> .01 or .05	≤ .01 or .05	.000 (Acceptable)
X2 / Df	≤ 2	2-5	2.103 (Acceptable)
RMESA	≤.05	≤ .08	.038 (Excellent)
RMR	≤.05	≤ .08	.051 (Acceptable)
GFI	≥ .95	≤ .90	.933 (Acceptable)
AGFI	≥ .95	≤ .90	.922 (Acceptable)
CFI	≥ .95	≤ .90	.952 (Excellent)
NFI	≥ .95	≤ .90	.913 (Acceptable)
IFI	≥ .95	≤ .90	.953 (Excellent)

It is desirable that the p-value, which indicates the significance of the difference between the expected and observed covariance matrices, is not significant. The significance of this value in CFA can be neglected in many studies due to the sample size (Cokluk et al., 2012).

χ^2 / sd less than [5] indicates that the model is compatible with the dataset in general terms (Tabachnick & Fidell, 2013). RMSEA (Root Mean Square Error of Approximation) value is known as the root mean square of approximate errors, and a RMSEA of 0 indicates perfect fit (Brown, 2006). Now the square root of the mean RMR (Root Mean Square Residuals) are the mean of residual covariance between the predictive covariance matrices of the universe and the covariance matrices of the sample, and a value close to 0 indicates a perfect fit. GFI (Goodness of Fit Index) is a goodness fit index developed in the evaluation of model fit independent of sample size, and it shows how much the model measures the covariance matrix in the sample. AGFI (Adjusted Goodness Fit Index) Goodness of Fit Index) is a modified type of GFI and it is sensitive to sample size, giving more appropriate values in large samples (Kline, 2011; Tabachnick & Fidell, 2013). The CFI (Comparative Fit Index) value, which is the comparative fit index, is close to 1, indicating perfect fit.

NFI (Normed Fit Index), which is the value of the Normed Fit Index, has the same understanding as the incremental fit indices and is similar to the CFI, and when this value is close to 1, it indicates perfect fit. The fact that the increasing fit index, which is IFI (Incremental Fit Index), approaches 1, shows that the fit of the model is high

(Sümer, 2000; Tabachnick & Fidell, 2013). According to the CFA results, the four-factor structure of the measurement tool was confirmed (Table 3). The parameters of the model are given in figure 3.

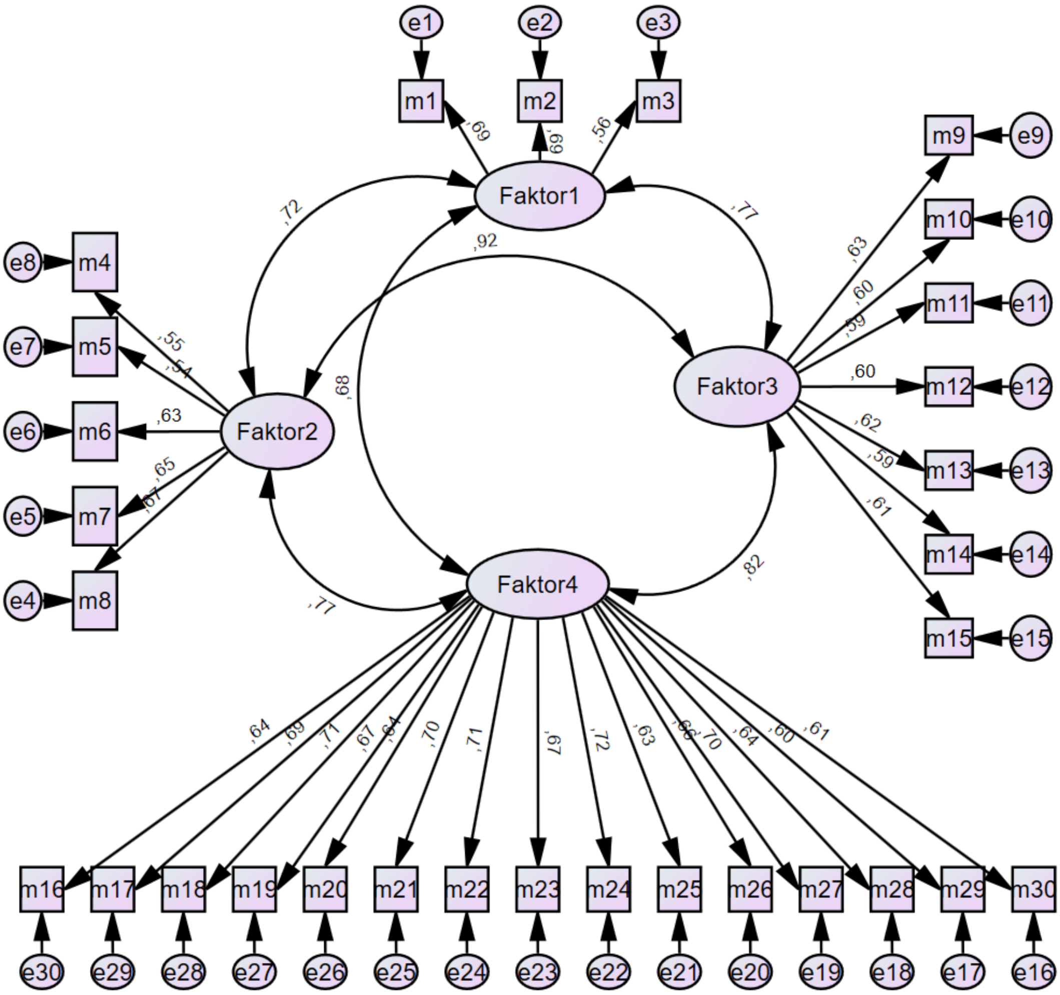

Figure 3. Model for DFA

4. Findings Regarding the Reliability of the Scale

In order to determine the reliability of the measurement tool, the Cronbach's alpha coefficient values of the original scale, EFA and CFA samples are given in Table 5.

Table 5. *Reliability Analysis Results*

Factors	Original Scale Cronbach Alpha Coefficient	EFA Sample Cronbach Alpha Coefficient	CFA Sample Cronbach Alpha Coefficient
Understanding scientific explanations	.957	.734	.816
Generating scientific evidence	.779	.779	.780
Deepening scientific knowledge	.808	.854	.803
Engaging in science productively	[.722-.854]	.942	.923
Total	.957	.958	.943

The most common statistical index of internal consistency reliability is the Cronbach alpha coefficient (Leong & Austin, 2006) and ideally, this value should be above .70 (Nunnally & Bernstein, 1994). In the study, Cronbach's Alpha values were examined in order to determine the internal consistency reliability of the scale. Reliability coefficients were found to be above .70 for EFA and CFA samples.

DISCUSSION & CONCLUSION

The next generation science standards clearly show the practices that should take place in middle school science lessons. An exemplary science teaching responds to students' interests, strengths, experiences, and needs; focuses on the student's understanding and use of knowledge, ideas and inquiry processes; directs students to active and comprehensive research; provides opportunities for discussion and debate among students; shares responsibility for learning with students and supports a classroom community where collaboration, shared responsibilities and respect are important. By including these actions and developing thinking, reasoning and problem-solving skills, students will learn what it really means to be proficient in science. Focusing on students' learning experiences in science lessons is important for reviewing and improving learning opportunities (Campbell et al., 2021). In this context, the aim of examining the next generation science classroom questionnaire by adapting it to Turkish is to bring a measurement tool to the literature on how middle school students perceive science lessons and science. In this context, it can be said that the next generation science classroom questionnaire will be useful for examining students' science-focused efforts and interaction ways in science education and teaching. Argumentation and engineering practices are at the center of next generation science standards (Achieve, 2013). Applications for next generation science standards, which are based on the integration of science lessons with engineering applications, are among the strategies adopted in the science curriculum (MEB, 2018).

Campbell et al. (2021), it is aimed to adapt the "*Next Generation Science Classroom Questionnaire"* to Turkish and Turkish culture and to bring it into the literature. For this purpose, permission to adapt the scale and necessary ethical permissions were obtained by interviewing Todd Campbell, one of the authors who developed the scale. After the necessary permissions were obtained, the scale was translated into Turkish by three linguists. Then, the language validity and conformity of the scale to Turkish culture were ensured by taking the opinions of the experts in the field of science education and measurement and evaluation. As a result of the EFA analysis performed to ensure construct validity, a structure consisting of 4 factors and 30 items was obtained. The scale form adapted to Turkish was rated as Almost never (0), Rarely (1), Occasionally (2), Often (3) and Almost always (4) on a 5- point Likert scale as in the original scale. In the study, it was seen that the four-factor structure explained approximately 56% of the variation in the total variance. The factors obtained are respectively; *Factor 1: Understanding scientific explanations, Factor 2: Generating scientific evidence, Factor 3: Reflecting scientific knowledge, Factor 4: Participating in science productively. The original scale consists of 4 main factors, and the items of the Turkish version of the scale were also placed on four factors and were* found to be compatible with the original scale form (Campbell et al., 2021). According to the CFA result, the factor loads standardized on the basis of the items were between .54 and .72 and the CFA goodness of fit values; $\chi 2$/ sd =2.103, RMSEA=.038, RMR=0.58, SRMR=.051 GFI=.93, AGFI=.90, CFI=.92, NFI=.91, IFI=.95. Among these values, X^2 / sd , RMR, GFI, AGFI and NFI values showed that the goodness of fit values were within acceptable limits, while RMSEA, CFI and IFI values showed that the model had excellent fit values (Cokluk et al., 2012; Tabachnick & Fidell , 2013) .

The Cronbach Alpha reliability coefficients for the internal consistency reliability of the next generation science classroom questionnaire were .816 for the dimension of understanding scientific explanations; .780 for the dimension of producing scientific evidence; It was calculated as .803 for the dimension of deepening scientific knowledge and .923 for the dimension of productive participation in science. The Cronbach Alpha reliability coefficient for the overall scale was calculated as .943. Ideally, the reliability coefficient should be above 0.70 (Nunnally & Bernstein, 1994). It can be stated that the results of the reliability analysis of the scores obtained from the Turkish form of the scale are at the desired level and the measurement tool is reliable. It can be said that the next generation science classroom questionnaire, which was adapted into Turkish as a result of the structural and language validity and reliability analyzes of the scale form adapted in the study, is a valid and reliable measurement tool for middle school students. It can be said that the adapted measurement tool will help science educators work towards developing more original scientific activity and activity plans to determine student learning experiences in science lessons.

The Turkish version of the scale was collected in four factors as in the original scale, and the current study will allow students to evaluate themselves according to the four pillar of science learning in science classroom. The application of the four strands of science learning (*Understanding scientific explanations, Generating scientific evidence, Reflecting scientific knowledge, Participating in science productively)* in a classroom is the basis for student development (NRC, 2012). In this context, the inclusion of these four dimensions, which have an important place in science learning, in the adapted scale will contribute to the literature, and it will be useful for teachers and students to apply the processes followed by scientists more effectively in science lessons (Huff & Yager, 2016). In this context, it is thought that the scale developed for middle school students and adapted to Turkish according to next generation science standards will guide educators by presenting data and evidence for more effective teaching of science lessons.

The scale can be examined by applying it to larger study groups by conducting validity and reliability studies with students at different grade levels studying in regions with different socioeconomic and demographic structures by future researchers. In this way, differences can be determined by determining the learning opportunities that students have in the region and socioeconomic context, and in-depth research can be carried out in parallel with these results.

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Appendix 1. Nex Generation Science Standarts Questionnaire Original Form

Nex Generation Science Standarts Questionnaire Original Form		Almost never				Almost always
Understanding Scientific Explanations						
1.	We focus on knowing, using, and interpreting explanations about things that happen in the world.	0	1	2	3	4
2.	We apply scientific concepts and explanations we are learning to interpret many events or phenomena that happen in the world.	0	1	2	3	4
3.	We use scientific concepts we learn in one context to explain something that is happening in different contexts.	0	1	2	3	4
Generating Scientific Evidence						
4.	We learn the relationships between science concepts as we use many ideas of science together to explain or predict naturally occurring phenomena.	0	1	2	3	4
5.	We generate evidence as part of building and refining models and explanations of the natural world.	0	1	2	3	4
6.	We evaluate whether the evidence we have generated is sufficient for drawing conclusion.	0	1	2	3	4
Reflecting on Scientific Knowledge						
7.	We determine what kind of additional data are needed when the generated evidence is insufficient to draw a conclusion.	0	1	2	3	4
8.	We design and carry out investigations to refine models and explanations we are developing.	0	1	2	3	4
9.	We analyze investigations by organizing, interpreting and evaluating data.	0	1	2	3	4
10.	We use the results from our investigation to develop and refine arguments and models we are working to develop.	0	1	2	3	4
11.	We continually reflect on and refine our scientific ideas.	0	1	2	3	4
12.	We revise our ideas as needed on the basis of seeing new evidence, learning new facts, or developing a new model.	0	1	2	3	4
13.	We test our own ideas and sometimes change these ideas.	0	1	2	3	4
14.	We consider multiple explanations of the same phenomenon.	0	1	2	3	4

	Nex Generation Science Standarts Questionnaire Original Form	Almost never				Almost always
15.	We refine our explanations of a phenomenon by conducting many different investigations.	0	1	2	3	4
Participating Productively in Science						
16.	We use science ideas we've learned about previously and build on them to understand more complex ideas.	0	1	2	3	4
17.	We use scientific explanations to generate new and productive questions to investigate.	0	1	2	3	4
18.	Explanations that explain evidence more completely are valued most.	0	1	2	3	4
19.	We create representations to explain and argue for our ideas with peers.	0	1	2	3	4
20.	We engage in whole class discussions where we publicly share our thinking and coordinate claims and evidence.	0	1	2	3	4
21.	The teacher guides us to reason our way to deep understanding of explanations, data or natural phenomena.	0	1	2	3	4
22.	The teacher encourages us to build on and critique one another's ideas.	0	1	2	3	4
23.	Our teacher guides us to share, expand, and clarify our ideas.	0	1	2	3	4
24.	Everyone's ideas are heard.	0	1	2	3	4
25.	The teacher is patient and gives us time to come up with our own ideas.	0	1	2	3	4
26.	The teacher encourages us to say more, rephrase, or to clarify our thoughts.	0	1	2	3	4
27.	The teacher helps us develop our reasoning by asking for evidence of our thoughts.	0	1	2	3	4
28.	We share, expand, and clarify our own thinking and ideas.	0	1	2	3	4
29.	The teacher asks us challenging questions that make us think deeply about our ideas and how they might be applied to different situations.	0	1	2	3	4
30.	We work together to determine what ideas are most persuasive.	0	1	2	3	4
31.	The teacher guides us to share our prior experiences or ideas about a phenomenon or topic to inform future experiences.	0	1	2	3	4
32.	The teacher helps us solidify our understanding of how we are planning to carry out an investigation.	0	1	2	3	4

Nex Generation Science Standarts Questionnaire Original Form		Almost never				Almost always
33.	The teacher helps us recognize patterns in data to propose reasons for why these patterns exist.	0	1	2	3	4
34.	The teacher helps us to gather and use multiple forms of evidence to construct evidence-based explanations for a phenomenon at the end of units.	0	1	2	3	4
35.	The teacher asks us to make claims based on evidence and share why we think the evidence supports our claims.	0	1	2	3	4

Appendix 2. Turkish Form of Next Generation Science Classroom Questionnaire

Yeni Nesil Fen Standartları Ölçeği Türkçe Uyarlama Formu		Neredeyse hiç	Nadiren	Ara sıra	Sıklıkla	Neredeyse her zaman
Bilimsel Açıklamaları Anlama						
1.	Fen bilimleri dersinde dünyada olup bitenleri anlamaya ve yorumlamaya odaklanırız.	0	1	2	3	4
2.	Fen bilimleri dersinde dünyada meydana olayları yorumlamak için bilimsel kavramları ve açıklamaları kullanırız.	0	1	2	3	4
3.	Fen bilimleri dersinde bir konuda öğrendiğimiz bilimsel kavramları farklı konularda gerçekleşen bir şeyi açıklamak için kullanırız.	0	1	2	3	4
Bilimsel Kanıt Üretme						
4.	Fen bilimleri dersinde ürettiğimiz kanıtların yeterli olup olmadığını değerlendiririz.	0	1	2	3	4
5.	Fen bilimleri dersinde doğal yaşam ile ilgili açıklamalar ve modeller* oluşturmak amacıyla kanıtlar üretiriz.	0	1	2	3	4
6.	Fen bilimleri dersinde ürettiğimiz kanıtın yetersiz olduğu durumda ne tür ek bilgilere ihtiyaç duyduğumuzu belirleriz.	0	1	2	3	4
Bilimsel Bilgiyi Derinleştirme						
7.	Fen bilimleri dersinde bazen fikirlerimizi test ederek değiştiririz.	0	1	2	3	4
8.	Fen bilimleri dersinde yeni kanıtlar gördükçe, yeni gerçekler öğrendikçe veya yeni bir model geliştirince gerekirse fikirlerimizi gözden geçiririz.	0	1	2	3	4
9.	Fen bilimleri dersinde aynı olayın birden fazla açıklamasını ele alırız.	0	1	2	3	4
10.	Fen bilimleri dersinde araştırmalarımızı, bilgileri düzenleyerek, yorumlayarak ve değerlendirerek analiz ederiz.	0	1	2	3	4
11.	Fen bilimleri dersinde oluşturduğumuz modelleri ve açıklamaları geliştirmek için araştırmalar planlarız ve yürütürüz.	0	1	2	3	4
12.	Fen bilimleri dersinde yeni ve yaratıcı sorular üretmek için bilimsel açıklamaları kullanırız.	0	1	2	3	4
13.	Fen bilimleri dersinde karmaşık fikirleri anlamak için daha önce öğrendiğimiz fen fikirlerini kullanırız.	0	1	2	3	4
14.	Fen bilimleri dersinde farklı araştırmalar yürüterek bir olaya ilişkin açıklamalarımızı geliştiririz.	0	1	2	3	4
15.	Fen bilimleri dersinde bilimsel fikirlerimizi sürekli olarak derinlemesine düşünür ve geliştiririz.	0	1	2	3	4
Bilime Üretken Bir Şekilde Katılma						

Yeni Nesil Fen Standartları Ölçeği Türkçe Uyarlama Formu		Neredeyse hiç	Nadiren	Ara sıra	Sıklıkla	Neredeyse her zaman
16.	Fen bilimleri dersinde öğretmenimiz bir araştırmayı nasıl planladığımıza dair fikirlerimizi geliştirmemize yardımcı olur.	0	1	2	3	4
17.	Fen bilimleri dersinde öğretmenimiz bizi daha fazla konuşmaya, kendimizi farklı şekillerde ifade etmeye veya düşüncelerimizi netleştirmeye teşvik eder.	0	1	2	3	4
18.	Fen bilimleri dersinde öğretmenimiz düşüncelerimize kanıt sunmamızı isteyerek akıl yürütme yeteneğimizi geliştirmemize yardımcı olur.	0	1	2	3	4
19.	Fen bilimleri dersinde öğretmenimiz sabırlıdır ve bize kendi fikirlerimizi bulmamız için zaman verir.	0	1	2	3	4
20.	Fen bilimleri dersinde öğretmenimiz bir konu hakkında gelecekteki deneyimlerimizi desteklemek için geçmiş deneyim ya da fikirlerimizi paylaşmamızda bize rehberlik eder.	0	1	2	3	4
21.	Fen bilimleri dersinde öğretmenimiz birbirimizin fikirlerini geliştirmeye ve eleştirmeye teşvik eder.	0	1	2	3	4
22.	Fen bilimleri dersinde herkesin fikirlerine değer verilir.	0	1	2	3	4
23.	Fen bilimleri dersinde öğretmenimiz ünite sonundaki bir olaya ilişkin çok sayıda kanıt toplamamız ve kullanmamıza yardım eder.	0	1	2	3	4
24.	Fen bilimleri dersinde kendi fikirlerimizi paylaşır, geliştirir ve netleştiririz.	0	1	2	3	4
25.	Fen bilimleri dersinde öğretmenimiz bize fikirlerimiz hakkında derinlemesine düşünmemizi sağlayan ve bu fikirlerin farklı durumlara nasıl uygulanabileceği ile ilgili merak uyandıran sorular sorar.	0	1	2	3	4
26.	Fen bilimleri dersinde öğretmenimiz olaylardaki bağlantıların neden var olduğuna yönelik sebepler sunmamız için bize yardımcı olur.	0	1	2	3	4
27.	Fen bilimleri dersinde öğretmenimiz doğal olayları derinlemesine anlamada bize rehberlik eder.	0	1	2	3	4
28.	Fen bilimleri dersinde öğretmenimiz fikirlerimizi paylaşmamız, geliştirmemiz ve netleştirmemiz için bize rehberlik eder.	0	1	2	3	4
29.	Fen bilimleri dersinde hangi fikirlerin daha ikna edici olduğunu belirlemek için birlikte çalışırız.	0	1	2	3	4
30.	Fen bilimleri dersinde öğretmenimiz kanıta dayalı iddialarda bulunmamızı ve iddialarımızı neden bu kanıtların desteklediğini paylaşmamızı ister.	0	1	2	3	4