Environment, Development and Sustainability (2023) 25:4525–4537
https://doi.org/10.1007/s10668-022-02213-w

Development and validation of climate change awareness scale for high school students

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Received: 15 September 2020 / Accepted: 11 February 2022 / Published online: 11 May 2022

Abstract
The topic of climate change has begun to be referred to as the global climate change crisis. Despite the precautions taken through international accords, the main solution to climate change will be an increase in individual knowledge and awareness, as well as change in their behavior as a result. A valid and reliable climate change awareness (CCA) scale for high school students was developed in this study. As a scale development strategy, an inductive scale development approach was used. The study enrolled a total of 454 high school students. In this study, both exploratory and confirmatory factor analyses were used to provide validity. In this way, the CCA scale was developed and validated using two different randomly separated samples. Sample 1 (274 high school students) was assigned to the exploratory factor analysis group, while sample 2 (180 high school students) was utilized to confirm the factor structures via confirmative factor analysis. Confirmatory factor analysis was used to check model-data coherence and test assumptions about variable relationships. As a result of the study, a valid and reliable Likert-type scale for assessing high school students' climate change awareness was developed. The scale consists of 17 items and a Cronbach alpha value of 0.88. CFI (0.93), NFI (0.82), RFI (0.88) and GFI (0.90) RMSEA (0.045) have proven to be acceptable fit indexes between the model and the data for the research model. Thus, the fit indexes produced as a result of the CFA indicated that the model had good fit.

Keywords Climate change mitigation · Awareness · Knowledge level · Individual behavior · Scale

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1 Introduction

1.1 Background

Due to the rapidly accelerating effects of climate change in recent years, the frequency and intensity of catastrophic natural phenomena as a result of climate change have increased significantly, causing physical damage (Leffers et al., 2017; Sezen-Barrie et al., 2020). Non-governmental organizations, the private sector and governments are all being forced to make serious efforts to adapt to this situation. According to experts, the last experienced climate change event is due to anthropological effect.

However, legal regulations and sanctions are influenced by the population's level of awareness and differences in climate literacy among countries. At this point, it is necessary to develop a systematic educational activity to achieve permanent behavioral change in nature-friendly and climate-friendly qualities all over the world. Education and awareness concerns to reduce climate change are recognized in the literature as being very limited (Hess & Maki, 2019; Molthan-Hill et al., 2019).

Due to Turkey's significant key-position and direct interactions with the EU and Asia, it has demonstrated its capabilities and efforts in climate change mitigation, precautions, awareness, and legal infrastructure preparation. Despite making great efforts to prevent climate change and global warming by creating efficient legal infrastructure and social activities, Turkey still has to unify the concept and reach the "Zero-carbon society" with all members of its society. It is apparent that formal education courses in Turkey do not create awareness towards sustainability, the environment, and global warming (Aziz et al., 2020; Li et al., 2020).

1.2 Literature review

In terms of raising public awareness, eliminating the lack of information about climate change and adaptation in education within the framework of mitigation and adaptation to climate change is very critical. According to Kollmuss and Agyeman (2002), there is still a significant gap and disparity between individuals who are aware of and knowledgeable about climate change and those who do not. It was emphasized that this disparity must be overcome (Kollmuss & Agyeman, 2002). According to a study, establishing an effective climate change mitigation strategy requires first understanding public perceptions and awareness of climate change. Findings showed that social variables clearly indicate climate change mitigation and vulnerability. Furthermore, educational initiatives should emphasize scientific results in order to improve public communication about climate change (Ruddell et al., 2012). In addition to public perception and public awareness, promoting public knowledge of climate mitigation and adaptation among high school students, who represent the future generations, ensures sustainability in climate adaptation. Oliver and Adkins (2020) reported that, according to the data obtained in their study, fifteen-year-old students' self-reported awareness of greenhouse gases provides a unique insight into how it differs according to the achievement and socioeconomic status of students. Campaigns and public service announcements used in schools are an effective method for this (Oliver & Adkins, 2020). According to Alvi et al. (2020), it has been strongly suggested that raising climate change awareness through campaigns or training produces better results in the long term to mitigate climate change (Alvi et al., 2020). Thaller et al (2020) claim that it is

self-evident that supporting climate-friendly behaviors through increased climate change awareness is more important than the policy measures (Thaller et al., 2020). There is only a limited number of research related to climate change awareness scale in the literature. A scale for awareness in developing cities was established by Iturriza et al. (2020). They claim that raising awareness among all stakeholders in a city is critical to develop cities that can withstand against the climate change effects (Iturriza et al., 2020). According to the Yale Project on Climate Change Communication, compared to 17% of adults, 34% of teens, are unable to say whether scientists think global warming is happening (Leiserowitz et al., 2011). After examining all these studies, the goal of this study is aimed at harmonizing the daily habits of the society with information about the environment and global warming in order to correct the weaknesses in the education system on climate change and promote sustainable behavior. Furthermore, early childhood education in order to develop environmental and climate awareness is one of the most effective approaches for climate mitigation and adaptation.

1.3 Objectives of the study

The general purpose of this study was to develop a validity and accuracy scale to test climate change awareness of high school students, which are the target audience.

The scale developed as part of the study can assist educators in determining the climate change awareness of high school students. The following are the sub-problems related to the general purpose of the scale: 1- How was the climate change awareness scale's factor structure verified using exploratory factor analysis? 2- Does the scale meet the reliability (Cronbach's alpha) value? and 3- How was the climate change awareness scale's factor structure verified using confirmatory factor analysis? Considering that the scale will provide hope for sub-problems, it is predicted that it will shed light on the development of climate change methods.

2 Material and methods

Jebb et al. (2015) recognized two distinct approaches to developing a scale: deductive and inductive approaches. Deductive approach is based on theory and already-formed conceptualizations of constructs to generate items. This approach is appropriate when the definition of the construct is known whereas inductive approach is used when the definition is uncertain. In this case, an inductive scale development approach is applied as a scale development approach (Jebb et al., 2015).

2.1 Participants and procedure

The climate change awareness (CCA) scale was developed and validated using two different randomly separated populations in this study. The original sample size was included in each sample. The pilot study contained Sample 1, and the data were assigned to the exploratory factor analysis group (EFA). Sample 2 was utilized to confirm the factor structures found in EFA using confirmative factor analysis (CFA). To complete the scale items, 299 high school students (male and female) in grades 11 and 12 were enrolled in the first sample. 25 of these students' questionnaires were not considered due to missing data. As a result, 274 questionnaires (147 male, 127 female) were used for the statistical analysis. The

second sample consisted of 180 (72 male and 108 female) high school students and all the participants were high school students in grades 11 and 12 from two public high schools located in Niğde, Turkey.

2.2 Theoretical framework and item development of the scale

The procedures outlined by Slavec and Drnovsek (2012) were used in developing the scale. According to Slavec and Drnovsek (2012), ten scale development steps are divided into three phases (Slavec, 2012). The first phase, which concerns the construct's theoretical importance and existence, consists of three steps: content domain specification (step 1), item pool generation (step 2) and content validity evaluation (step 3). The second phase, which is concerned with the representativeness and appropriateness of data collection, is divided into four steps: questionnaire development and evaluation (step 4), translation and back translation (step 5), pilot study (step 6) and sampling and data collection (step 7). The third phase, which regards the statistical analysis and statistical evidence of the construct, consists of three steps: dimensionality assessment (step 8) reliability assessment (step 9), construct validity assessment (step 10).

Before constructing the scale's components, a literature review was undertaken to determine the theoretical importance and presence of the construct phase, as well as what climate change awareness entails (Biasutti & Frate, 2017). Understanding climate change awareness, according to Dal et al. (2015), is a complex concept that includes biological, geological, ecological and geographical concepts as well as their inter-dimensional interactions (Dal et al., 2015). Climate change awareness, according to Oruonye (2011), is the result of a combination of individuals' predictions and interpretations that influence their habits, and reactions to climate change circumstances. Halady and Rao (2011) conducted a study to develop a scale to determine whether climate change awareness leads to behavioral change and they developed a four construct scale (Halady & Rao, 2010). These constructs were, energy conservation, emission free car users, active environmentalists and climate change friendly funds. A survey to assess households' knowledge and awareness of their environment and climate change is being developed in another study. As a result of that study, three constructs emerged. These constructs were as follows: the environmental and climate change knowledge, climate change, economy and environmental awareness and energy decisions awareness.

According to the literature, the theoretical framework of the climate change awareness scale took the following content domain specifications into account: Climate change awareness and climate change recklessness are two related to each other. The researchers then examined the objectives of the Turkish Ministry of National Education's high school curriculum related to climate change in order to develop scale items.

Following the content domain specification of the climate change awareness concept, several scientific articles were examined for best practice of data collection tools connected to climate change awareness in order to compose an item pool for the scale. On the topic of climate change awareness, 14 high school students were engaged in discussions. Finally, 40 items were produced, including 33 positive and 7 negative elements defining high school students' understanding of climate change. Then, for content validity, a specification table was developed to describe the dimensions to be covered by the climate change awareness and the number of items which was associated with each. A sample of the specification table can be found in "Appendix."

The Lawshe technique, which is a widely used method for expert judgments, was used to ensure the content validity of the scale (Ermis-Demirtas, 2018). Two experts from the education faculty, an expert from the science faculty and two experts from engineering faculty were measured for what was necessary, useful but should be corrected and what was not necessary for the 40 items. Each expert had a PhD degree, was an academician in a university and had conducted scientific research on the climate change and global warming. For 40 items, the experts were asked to control and comment. Each expert negotiated, and their comments were discussed while reviewing the scale, and additional suggestions were applied to the items. Each items' Lawshe points were calculated and determined to be higher than 0.51. Later, 40 items were developed and grouped into five categories: "strongly disagree" (1), "Disagree" (2), "Neutral" (3), "Agree" (4) and "totally agree" (5), comparable to the Likert scale. The scale was applied to 30 high school students with these five categories. During this application, researchers were also asked if any of the items were difficult to understand. In case any of the items were found to be difficult, those items were considered for correction. The content validity of all items was tested using a sample of the specification table. Later, these 40 items were then applied to 10th grade high school during the 2017–2018 educational years. The original scale was written in Turkish language. It also included demographic questions at the beginning, including gender, general academic average.

3 Results and data analysis

The acquired data were statistically tested by IBM SPSS Statistics version 20 and LISREL version 8.80 to determine the scale's validity and reliability. Both exploratory and confirmatory factor analysis were integrated for providing validity in this study. Factor analysis is a statistical terminology that refers to determining and correlating factors which have similar quality, pattern and construct (Büyüköztürk, 2002). So that, affective behavioristic sciences can be studied with similar construct outputs utilizing factor analysis (Büyüköztürk, 2002). Exploratory factor analysis was used to demonstrate the scale's factor construct. Explanatory factor analysis is a technique used for identifying variables' relationships. Confirmatory factor analysis was used in order to verify the model-data cohesion and to test the hypotheses of variables' relationships. Additionally, Cronbach's Alpha was calculated (ERCAN & KAN, 2004; Fletcher et al., 2000). For confirmatory factor analysis, comparative fit (CFI), goodness of fit (GFI), the chi-squared statistics ($\times 2$) and root-mean-square error (RMSEA) fit indexes were studied. Composite reliability (CR) and average variance extracted (AVE) values were studied to confirm concurrent validity.

3.1 Results related the research question one

The first research question focused on the climate change awareness scale's factor structure. To begin, data from 274 10th grade high school students were entered into the SPSS (Statistical Package for the Social Sciences) software package. The data were excluded prior to EFA based on the analysis of normality of each variable (skewness and kurtosis); outliers; and missing cases. The normality of each variable (item) was collected using the skewness and kurtosis values' accepted level (± 3.29) (Hair et al., 2006). In the study, Mardia's Multivariate Normality Test was examined as well and it was found to be 0.000. Multiple normality was accepted for the presented data since the Mardia kurtosis test value of

0.05 was less than the critical value for the significance test. In line with the result obtained (p.05), it was determined that the data exhibited normal distribution. Exploratory factor analysis and an un-rotated principle component analysis were used, as previously indicated. The Kaiser–Meyer–Olkin (KMO) and Barlett's (BTS) tests were used to assess the sampling adequacy. The main component analysis produced factor analysis results; with the KMO value of the scale being 0.92 and the BTS test result being $\chi^2 = 160.71$, $df = 118$; $p = p < 0.01$. Because the acquired KMO and BTS values were higher than 0.50 and highly significant in the BTS test (99% confidence interval), they were approved to be used in this study for applying factor analysis (Büyüköztürk, 2002). Un-rotated principle component analysis revealed nine factors with eigenvalues greater than 1.0 (Hair et al., 2006). The scree plot, on the other hand, experienced four sharp falls before leveling off. Explanatory factor analysis was done again for the rotation using principle component analysis, as shown below. Explanatory factor analysis was refreshed by excluding items with factor load points lower than 0.45 and a difference between item load points of the two factored scale under 0.10 (Büyüköztürk et al., 2010). According to the analysis results, the eigenvalue line chart could only be drawn by one factor (Fig. 1).

The initial change in eigenvalue-component numbers came at the first factor. The full items of the CCA scale are provided both in Turkish and in English, in Table 1.

The scale is made up of 17 items and two factors according to the analysis results. Since there is at least one item for each explanation given in the table of specification ("Appendix") after comparing the remainder of the items to the table of specification, the scale was

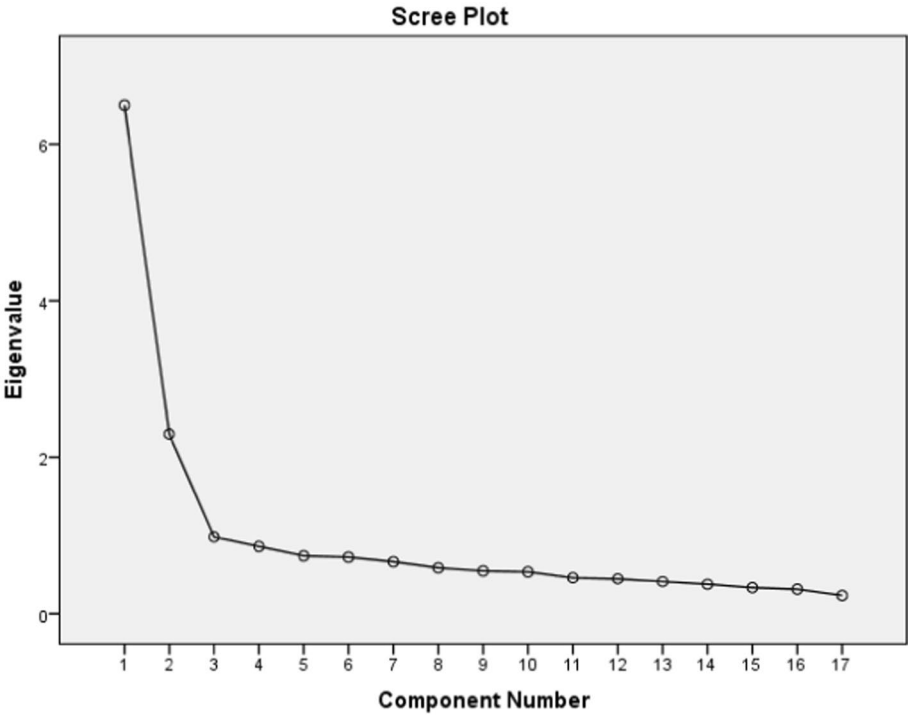

Fig. 1 The first change in eigenvalue-component numbers

Table 1 Explanatory factor analysis results of climate change awareness scale

		Reason (factor1)	Recklessness act (factor 2)	$\bar{x}$	*df*	Sig. (1 tailed)	Item-total correlation
RE1	Hayvan topluluklarının habitatlarının kalıcı olarak değişmesi küresel ısınmanın sonuçlarından biridir *Permanent changes in the habitats of animal communities is one of the consequences of global warming*	**0.802**	0.083	20.28	10.54	0.00	0.742
RE2	Günümüzde yaşanan iklim değişikliğinin doğal süreçteki iklim değişikliğinden farkı insan etkisiyle gerçekleşmesi olduğunun farkındayım *I am aware of that the difference between climate change in nowadays and climate change in the natural process is realized by human impact*	**0.799**	− 0.029	20.4	10.56	0.00	0.697
RE3	Her geçen yıl sonbahar aylarında yaşanan sıcak havaların daha uzun sürdüğünün farkındayım *I am aware that the warm weather in autumn months lasts longer each year*	**0.766**	0.048	20.51	10.64	0.00	0.693
RE4	İklim değişikliğinin ne kadar tehlikeli olduğundan habersiz kişilere çok şaşırıyorum *I'm amazed by people who are unaware of how dangerous climate change is*	**0.701**	0.026	20.64	10.48	0.00	0.616
RE5	Dünyanın sıcaklığının artması durumunda sel felaketlerinin yaşanacağının farkındayım *I am aware that floods will occur if the temperature of the world increases*	**0.797**	0.064	20.71	10.52	0.00	0.691
RE6	İnsan kaynaklı CO_2 salınımlarının büyük kısmı fosil türevli yakıtların kullanılması ile gerçekleştiğinin farkındayım *I am aware that most of the human-induced CO2 emissions are caused by the use of fossil derived fuels*	**0.713**	0.098	20.66	10.55	0.00	0.593
RE7	Araçlarda kullanılan benzin veya motorinden gelen N_2O küresel ısınmayı artırdığının farkındayım I am aware that N_2O from gasoline or engine used in vehicles increases global warming	**0.729**	0.028	20.49	10.56	0.00	0.633
RE8	İklim değişikliği nedeniyle enerji üretimi konusunda yeni iş alanları ortaya çıkması beni mutlu eder *It will make me happy that due to climate change, new business areas will be created in energy production*	**0.729**	0.03	20.77	10.41	0.00	0.635
RE9	CO_2 ve CH_4 gazlarının doğal sera gazları olduğunun farkındayım I am aware thar CO_2 and CH_4 gases are natural greenhouse gases	**0.731**	0.004	20.56	10.53	0.00	0.646
RE10	Enerji israfı yapan kişiler beni endişelendirir I'm worried about energy waste	**0.654**	0.194	20.68	10.58	0.00	0.622

Table 1 (continued)

		Reason (factor1)	Recklessness act (factor 2)	$\bar{x}$	*df*	Sig. (1 tailed)	Item-total correlation
RE11	İklim değişikliği ile mücadele konusundaki bilgilerimi geliştirmek isterim *I would like to improve my knowledge on combating climate change*	**0.683**	0.051	20.74	10.41	0.00	0.605
RE12	Fosil yakıtlardan elde edildiği sürece daha az enerji tüketiminin küresel ısınmayı yavaşlattığının farkındayım *As long as it is derived from fossil fuels, I am aware of that less energy consumption slows down global warming*	**0.685**	− 0.101	20.77	10.56	0.00	0.561
RA13	İklim değişikliği nedeniyle dünyanın çeşitli ülkelerinde artan aç insan sayısı beni endişelendirmez* I am not worried about the number of hungry people in various countries of the world due to climate change*	0.024	**0.745**	10.41	0.86	0.00	0.53
RA14	İklim değişikliği nedeniyle su altında kalacak ada ülkeleri halkının yaşayacağı çaresizliği önemli bulmuyorum* I do not find the helplessness of the people of the island countries to be inundated by climate change*	0.20	**0.695**	10.82	10.29	0.00	0.46
RA15	İkim değişikliği nedeni ile yok olan buzulların üzerinde yaşayan beyaz kutup ayılarının yaşam alanlarının yok olması ile ilgilenmiyorum* I'm not interested in the disappearance of the white polar bears living on the glaciers that disappear due to climate change*	0.065	**0.688**	10.75	10.19	0.00	0.44
RA16	Küresel iklim değişikliğinin bemim ülkemde kuraklığa neden olmayacağını düşünüyorum I think that global climate change will not cause drought in my country	00.23	**0.652**	10.74	10.27	0.00	0.43
RA17	Deniz seviyesinin kalıcı olarak yükselmesi öngörüsü küresel ısınmaya bağlı değildir* The forecast of sea level to rise permanently is not due to global warming*	00.34	**0.557**	10.98	10.27	0.00	0.36

The numbers written in bold letters indicate the degree of meaningful results

both effective in terms of content and construct. The scale loads, which consisted of 17 items with two factors, were varied between 0.557 and 0.802.

The second question of the research asked about the factor structure reliability (Cronbach's alpha) value and the stability of the scale. The reliability of the scale refers to the internal consistency among responses to items. Cronbach's alpha reliability coefficient was used to determine the CCA scale reliability and was measured as 0.88 based on item analysis for two factors, 17 items and 51.75% total variance(Büyüköztürk, 2002). It is widely assumed that alpha values of greater than 0.70 are required for acceptable reliability. The results indicated that the Cronbach's alpha of value for the CCA scale was considered acceptable for this research and the scale possesses favorable internal consistency. Table 2 shows arithmetic average, standard deviation, total variance and Eugen value.

The average mean of the scale (consisting of 17 items) was 40.0 and the standard deviation of the scale was 14.33, as shown in Table 2. The three elements resulted in minimum and the maximum scores of 17 and 85, respectively. Because of the responses of the 10th grade pupils, the total variance increased to 51.75% due to the 10th grade students' responses. The eigenvalue of the factor was 8.79 (accounted for 51.75%).

The third question of the research was about the factor structure of the CCA scale, which was supported using confirmatory factor analysis. Confirmatory factor analyses were used to see if the scale could accurately assess a theoretical structure that was unknown (Erkuş, 2003). Confirmatory factor analyses using a structural equation model (SEM) were used to assess the relevance of a one-dimensional structure. A CFA was done using data from Sample 2 to approve the factor structure that was derived from the EFA using data from Sample 1. the values of the various fit indexes were assessed for the adequacy of CFA models initially using the LISREL software to evaluate the adequate fit of the model to the data.

The goodness of fit index (GFI), the adjusted goodness of fit index (AGFI), the normalized fit index (NFI), the relative fit index (RFI), the incremental index (IFI) and the comparative fit index (CFI) are the most commonly used fit indexes in SEM evaluation (Adelodun et al., 2013). As a result, the chi-square, normed fit index (NFI); comparative fit index (CFI); and root-mean-square error approximation (RMSEA) were all used to confirm the factor structure of the CCA scale in CFA. When the fit indices of the drawn model as a result of confirmatory factor analysis for the total samples are examined after the modifications, $\chi^2 = 160.75$ ($df = 118$; $p < 0.00$) is found. If the value for the chi-square to degrees of freedom ratio is < 2, this indicates an excellent fit. Since the χ^2/df value was below two, the CCA scale had an excellent fit (BÜYÜKÖZTÜRK et al., 2010; Jöreskog & Sörbom, 1989).

Table 2 Descriptive values of the 'Awareness towards the Climate Change Scale'

Factor	Items	*N*	$\bar{x}$	Total variance %	Eugen value	sd	Cronbach's alpha
Reasons of climate change	12	274	31.27	38.24	6.50	13.48	0.92
Recklessness act to climate change	5		8.27	13.51	2.29	3.96	0.70
Total	17		40	51.75	8.79	14.33	0.88

If the fit indices for the GFI (0.90), CFI (0.96), IFI (0.96) and are > 0.90, it is deemed a satisfactory model fit (Jöreskog & Sörbom, 1989). In all these indexes, the value obtained for the model is closer to 1, indicating a very high degree of harmony between the data (Jöreskog & Sörbom, 1989; Kelloway, 1998). CFI (0.93), NFI (0.82), RFI (0.88) and GFI (0.90) have proved to be acceptable fit indexes between the model and the data for the research model. An RMSEA value of < 0.06 indicates a good fit and 0.06–0.08 indicates a reasonable fit. For the research model, RMSEA value is 0.045. Thus, those results indicated that the fit indexes obtained as a result of the CFA showed that the model had a good fit. The standardized coefficients between the latent variables and observed variables are shown below. The average variance AVE (Average Variance Extracted) value explained was investigated in addition to the item factor loads established in the factor analysis to indicate the convergent validity. Within the purview of scale reliability analysis, Cronbach alpha coefficients for internal consistency reliability and CR (Composite Reliability) coefficients for composite reliability were evaluated. Because the CR value (for reason sub facto is 0.92, for recklessness is 0.83) is greater than 0.70 and the AVE value (for reason sub facto is 0.56, for recklessness is 0.53) is greater than 0.50 in each sub-factor of the awareness scale for climate change, internal consistency reliability and convergent validity are provided (Claes Fornell & Larcker, 1981).

Standardized values belonging for the CCA scale are shown in Fig. 2. Standardized analysis values provide feedback on how well each item's own hidden variable was represented. The final model indicated that the CCA of the 10th grade high school students

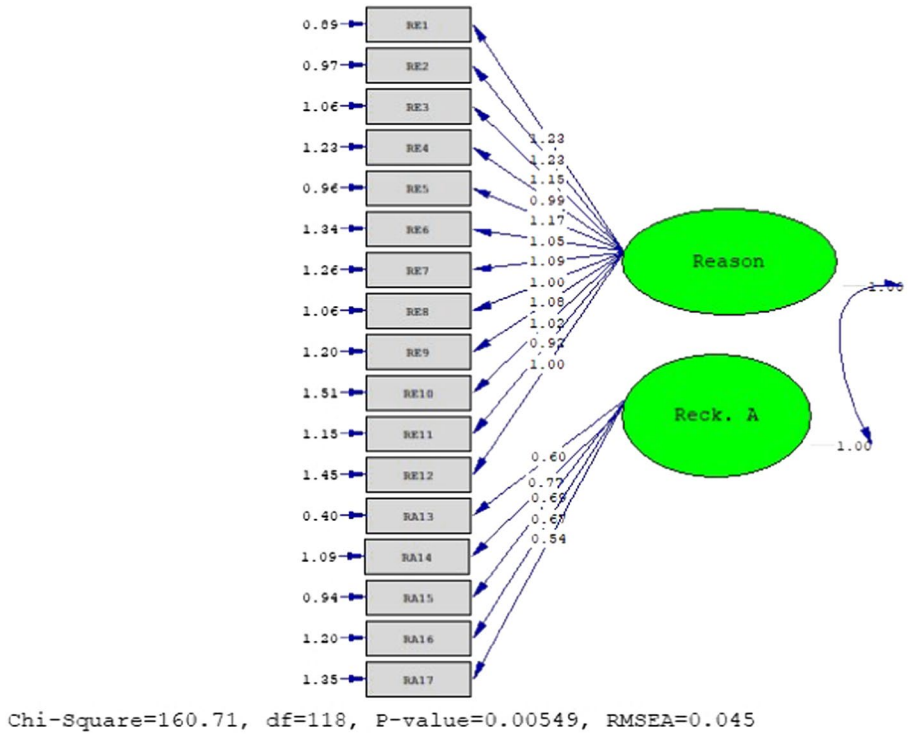

Fig. 2 Path diagram regarding confirmatory factor analysis

can be explained in 17 different reliable ways. The correlation coefficient between the factors was found to be 0.075. Also, standardized load values, *t* values, correlation between each observed variable and the set of variables are presented in Table 3.

The correlation between each "observed variable" and "the group of variables" to which it relates to is shown by standardized loads. In Table 3, it was determined that the standardized factor loads of the model were sufficient and the t values were significant.

4 Discussion

Starting with second-grade high school pupils in Nigde's city center, the sustainable training model is highly promising for increasing the low-awareness and low-knowledge capacity. This scale can be used to compare students' level of awareness level before and after the application of the sustainable training model for climate change and mitigation activities, in order for the scale to be helpful to educators.

To assess the validity and reliability of the scale, all collected data from 454 students from 10th grade of high schools were processed t. All 17 scale items were investigated and it was determined that there are statistically significant items for the scale development, with scores ranging from 0.557 to 0.802.

Table 3 Correlation analysis results between factors

Factor/Item	Standardized load values	*t*	R^2
Reasons of climate change			
RE1	0.79	12.50	0.62
RE 2	0.78	12.20	0.60
RE3	0.74	11.39	0.54
RE4	0.67	9.80	0.45
RE5	0.77	11.85	0.59
RE6	0.67	9.9	0.44
RE7	0.70	10.42	0.49
RE8	0.70	10.36	0.49
RE9	0.70	10.50	0.49
RE10	0.64	9.27	0.41
RE11	0.65	9.52	0.42
RE12	0.64	9.28	0.41
Recklessness act to climate change			
RA13	0.69	8.44	0.47
RA14	0.59	7.19	0.35
RA15	0.58	7.05	0.34
RA16	0.52	6.26	0.27
RA17	0.42	4.94	0.18

Appendix: specification table

Scale structures	Items
Awareness towards the reasons of climate change	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Recklessness Act to climate change	14, 15, 16, 17

Acknowledgements This study has been conducted and supported by European Union and Turkish Republic co-funded project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme (CCGS), Reference: CFCU/TR2013/0327.05.01-02, EuropeAid/138406/ID/ACT/TR. The data presented in this article were produced under the project number of TR2013/0327.05.01-02/006, name of Enhancement of High School Students' Knowledge Capacity and Awareness for Climate Change Mitigation by Sustainable Training in Niğde.

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