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

DEVELOPING AN ATTITUDE SCALE TOWARDS SCIENCE AND TECHNOLOGY COURSES: A STUDY OF VALIDITY AND RELIABILITY

Sinem Yalgin,
Kemal Akkan Batman,
Mert Bastas

Abstract: *Science education in primary school is critical for establishing a comprehensive understanding of the nature of science. Students with positive attitudes towards science courses are more likely to achieve academic success. Measuring and fostering positive attitudes is essential for effective instructional planning. This study aimed to develop a measurable scale to assess the attitudes of fourth-grade elementary school students in Northern Cyprus towards Science and Technology Courses (STC). While developing the Student Science and Technology Attitude Scale (SSTAS), the literature was reviewed, and 168 students were asked to write essays about STC. A pool of attitude items was created by analyzing the literature and essays, and expert opinions were sought. The preliminary scale was prepared based on expert consultation. The study group included 651 randomly selected fourth-grade students during the 2020-2021 academic year. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted to determine SSTAS's construct validity. The results indicated that the scale is valid and reliable, comprising three dimensions. The first dimension measures students' attitudes towards the teaching process, with 13 items. The second dimension assesses students' negative attitudes, including five items. The third dimension evaluates students' attitudes towards experiments, containing five items.*

Keywords: *science and technology lesson, attitude toward science and technology courses, attitude scale development*

Sinem Yalgin
Near East University, Cyprus
Kemal Akkan Batman
Atatürk Teacher Training Academy, Cyprus
Mert Bastas
Near East University, Cyprus

Introduction

The era marked by the development of worldwide trends is recognized as Society 5.0. Studies by Rodríguez-Abitia & Bribiesca-Correa (2021) and Suryantini et al. (2020) have established a connection and correlation between real and virtual space and Society 5.0. The cycle of data acquisition, evaluation, and translation into pertinent knowledge, subsequently applied in the real world, has been identified as a recurring feature of Society 5.0. This cycle has been proposed to operate on a societal level as well (Deguchi et al., 2020). The transformation of society will invariably lead to changes in the educational landscape. The primary concerns are the skills that students will gain and the courses that will be offered. Research has highlighted creativity (Carayannis & Morawska-Jancelewicz, 2022), soft skills (Sá & Serpa, 2022), higher-order thinking skills (Suryantini et al., 2020), communication (Joko et al., 2023), collaboration (Sá & Serpa, 2022), information and media literacy (Sá et al., 2021), computing and ICT literacy (Smuts & Van der Merwe, 2022), all of which mirror 21st-century skills, as leading elements to be imparted to students.

The acquisition of these skills has been the topic of educational study for decades (Chalkiadaki, 2018; Turiman et al., 2012; van Laar et al., 2017). According to several studies (Fakaruddin et al., 2023; Miwa, 2020; O'Neal et al., 2017), the learning of these abilities should begin in early grades and be integrated throughout numerous courses. The contribution of science education to the acquisition of these skills is undeniable. In the study conducted by Berg et al (2021), out-of-school science education suggestions have been developed to help students cultivate 21st-century skills. In order to develop 21st-century skills, many projects are carried out in the science courses (Chu et al., 2017).

One of the fundamental courses in elementary school that serves to build a strong foundation for essential skills is the Science and Technology course (STC). In elementary schools, the STC curriculum introduces students to a broad range of general science topics, carefully tailored to suit their cognitive development levels. This approach ensures that students are taught with appropriate content that enables them to understand

https://doi.org/10.33225/jbse/23.22.641

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

the world. Fitzgerald and Smith (2016) emphasize the critical importance of maintaining consistent teaching and learning standards throughout the science curriculum. This consistency is necessary for effective scientific knowledge in the broader context of student's intellectual development, enrichment of their reasoning abilities, comprehension skills, and overall cognitive talents. By doing so, educators can create a more holistic educational experience that fosters the development of well-rounded individuals. Science education plays a vital role in cultivating environmentally conscious, inventive, curious, and imaginative citizens within the society (Häyrynen et al., 2021; Schönfelder & Bogner, 2020). With the help of science and technology concepts, students acquire a deeper appreciation for the natural world, learn to think critically about complex issues and develop problem-solving skills that can be applied to various aspects of their lives. This education empowers students not only to understand scientific principles but also to engage actively with their environment and contribute positively to the world around them.

The most important aim of STC is to inform students about current scientific developments and to raise generations that can benefit from all fields and at all levels of science. Studies related to science education and teaching are of great importance for the future of humanity.

A lesson on contemporary science teaching should address the needs and interests of the student (Ornek & Saleh, 2012). It may be tailored in accordance with the child's stage of development and is taught using appropriate approaches that take environmental variables into account (Hansson et al., 2021). In contemporary pedagogical approaches within the sphere of scientific education, the emphasis has increasingly shifted towards the imperative of cultivating students' capacity for scientific reasoning and critical inquiry, rather than a sole focus on the comprehensive impartation of established scientific knowledge (Fakaruddin et al., 2023). The objective of this approach is to facilitate students' acquisition of skills vital to scientific inquiry, including research conduction, data analysis, and synthesis. The knowledge acquired through Science, Technology, and Society (STS) curriculum not only enhances these academic competencies but also equips students with practical skills applicable in their everyday lives. This multifaceted educational experience fosters an overall academic readiness, thereby simplifying the learning process for additional subjects. Therefore, science education serves a dual purpose: it not only imparts scientific knowledge but also cultivates an overarching learning skill set in students (Letina, 2020; Mateos-Núñez et al., 2020; Pöntinen & Räty-Záborszky, 2020).

Science education in elementary school serves as a crucial foundation for students, fostering a comprehensive and consistent understanding of the nature of science. This early exposure to scientific concepts and principles is crucial for preparing students to become scientifically literate, a key outcome of science education (Roberts, 2007). Scientific literacy equips students with the knowledge, skills, and mindset necessary to engage with and interpret scientific information in their everyday lives. In addition, elementary school science education is essential for igniting students' curiosity about the scientific world (Fitzgerald & Smith, 2016; Jufrida et al., 2019). By introducing engaging and age-appropriate content, educators can inspire students to ask questions, investigate concepts, and develop a genuine interest in scientific inquiry. This enthusiasm for learning can then be carried over into later years, encouraging students to pursue further education in science-related fields and contribute to the advancement of scientific knowledge. A comprehensive science education in elementary school helps students develop skills in critical thinking, problem-solving, and analysis. Students are equipped to navigate complex issues and make informed decisions in a technologically advanced and interconnected world by acquiring these competencies. According to Harlen and Qualter (2004), elementary school science teaching has a helpful role in the formation of attitudes along with the development of students' ideas and skills. In this respect, elementary school teachers need to create teaching processes in which students will participate at a high level. The capacity of elementary school instructors to design scientific courses that are engaging for children and that pique students' interest about the outside world has a significant effect in kids' improved involvement in science classes (Harrison, 2020). For this reason, it is essential for elementary school teachers to prepare fun teaching processes that will arouse students' interest in STC topics, attract their attention, and enable students to be active. With such environments, it will be easier for students to learn, and it will also serve to create positive attitudes towards science starting from an early age.

The achievement of goals and behaviors in the Science and Technology course (STC) is strongly linked to the course success and the students' attitudes towards it. Attitude has been defined by numerous scholars in various ways. Thurstone (1931) described the attitude as a state of readiness to exhibit a positive or negative response towards objects and symbols (Tavşancıl, 2010). In contrast, Katz (1967) characterized attitude as a preliminary

https://doi.org/10.33225/jbse/23.22.641

thought process wherein an individual perceives a symbol, object, person, or the world as either good or bad, beneficial or harmful, based on their personal value system.

Attitude can be characterized as an acquired phenomenon that significantly impacts an individual's behavioral patterns, potentially introducing a degree of subjectivity or bias into their decision-making processes (Eaton et al., 2008). Eagly and Chaiken (2007) defined attitude as a psychological tendency expressed through the evaluation of a specific entity in either a favorable or unfavorable manner. There is a broad agreement among researchers that attitude represents a summary assessment of a psychological object along dimensions such as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-unlikable (Ajzen, 2001).

When learning new information, an individual needs to possess some prior knowledge about the subject matter. However, the interest and curiosity that the individual displays toward learning the material are equally significant (Hidi & Renninger, 2020). Consequently, fostering positive attitudes towards subjects like the STC is essential to enhance students' engagement, curiosity, and overall success in the learning process.

Affective entry behaviors consist of dimensions related to feelings such as interest, motivation, anxiety, and academic self-design. Children attitudes begin to take shape at a young age (Halbeisen et al., 2017), making them a crucial factor in the development of good behavior toward STC at the elementary school level (Harlen & Qualter, 2004; Kerr & Murphy, 2012).

Recent research has demonstrated that students with good attitudes about science courses are more likely to achieve academic achievement than those with negative attitudes. For instance, Osborne et al. (2003) discovered that students with good attitudes toward science were more likely to get higher grades in scientific classes than those with negative views. There are several reasons why attitudes toward scientific courses may influence academic performance. Students with positive attitudes about scientific courses are more likely to participate in learning activities and be motivated to study, resulting in improved academic success (Linnenbrink-Garcia et al., 2016; Teppo et al., 2021). Good attitudes toward science may enhance self-efficacy, or the idea that one can succeed in science courses, which can result in improved effort and perseverance (González-Gómez et al., 2022; Mao et al., 2021; Retni S et al., 2021; Ültay et al., 2020). Positive attitudes about scientific courses may result in a stronger interest in science-related occupations, which can drive students to do better in their classes (Mao et al., 2021). As conclusion, there is a considerable correlation between attitudes toward scientific courses and academic performance. The use of engaging and dynamic teaching techniques, the provision of chances for hands-on learning, and the promotion of science's relevance to students' everyday lives may all contribute to the development of favorable attitudes toward scientific courses.

Due to societal prejudices, many students perceive STC to be confusing and difficult to comprehend. This misconception impacts students' perceptions of science and technology and, consequently, their academic performance (Ogunkola & Samuel, 2011; Patall et al., 2018). Consequently, scholarly recommendations advocate for the early exposure of children to scientific principles and suggest fostering an enjoyment for the subject. This approach is proposed as an effective strategy for the development of positive and constructive attitudes towards science (Stagg & Verde, 2019; Teppo et al., 2021). By developing a positive attitude towards science, it is possible to increase students' interest in this field and to direct them to professions related to science in the future (George, 2006). In this respect, attitudes are one of the most effective elements in learning.

According to Bentley et al. (2007), the attitude dimension of science is the dimension of feeling and value, and it is the driving force of learning. In addition, the interest and curiosity of the student generate research and then provide the construction of new knowledge (Bentley et al., 2007).

In the Northern Cyprus elementary school program, STC subjects are included within the Life Sciences courses in the 1st, 2nd, and 3rd grades, while they are included as Science and Technology Courses in the 4th and 5th grades. In the 2003-2004 academic year, within the scope of the Basic Education Support project, a decision was made to change the name of the Primary Education Science course to STC, and it was put into practice in the 2004-2005 academic year (MEB, 2004). The Northern Cyprus Education System was revised in 2005 under the name of the New Education System on the basis of constructivism (KKTC MEB, 2005). Elementary education curricula were reconsidered in 2016 and rewritten based on the constructivist approach (http://tepgp.emu.edu.tr/).

In this context, the objective is to create a valid and reliable measurement instrument specifically designed to assess the attitudes of elementary school students toward the Science and Technology course. Developing such a tool would provide valuable insights into students' perceptions, feelings, and preferences regarding the course, enabling educators and researchers to better understand and address factors that may influence their engagement, motivation, and overall academic performance.

https://doi.org/10.33225/jbse/23.22.641

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

Research Methodology

Research Design

In this study, the scale development process was carried out and this process involved a quantitative research approach to construct a comprehensive and robust instrument. The primary aim was to create a scale that effectively captures various aspects of students' attitudes toward Science and Technology Courses (STC), allowing a deeper understanding of their perceptions and feelings. In addition to scale development, the study also aimed to assess and establish the psychometric properties of the instrument, ensuring validity and reliability. By concentrating on both the scale generation process and the examination of its psychometric features, the study aimed to give educators, academics, and policymakers a helpful and trustworthy instrument for measuring students' views regarding STC. In return, this would guide instructional planning, curriculum development, and interventions to encourage positive attitudes and improve students' academic performance in scientific education.

Study Group

The research study's participant group comprised 651 fourth-grade students attending private elementary schools under the North Cyprus Ministry of National Education and Culture during the 2020-2021 academic year. Information was not collected solely on the sociodemographic description of the participants. While opinions may vary regarding the ideal sample size for scale development studies, it is generally recommended that the sample size be five to ten times larger than the number of items in the scale (Child, 2006; Çokluk et al., 2014; Williams et al., 2010). Since there are 35 questions in the first form of the scale, the sample size must be at least 350. In this case, it can be said that the sample size is sufficient since 651 people participated in the scale development process.

Scale Development Process and Data Collection

During the development of the scale, the literature (Dijkstra & Goedhart, 2012; Summers & Abd-El-Khalick, 2018; Yurdakal & Kırmızı, 2019) was scanned to create an item pool and examined. At the same time, the answers of 168 students to open-ended questions via Google forms were analyzed. By analyzing the answers of each student, the researchers determined the frequencies of expressions that could be potential attitude expressions. Based on the literature review and analyses, an item pool consisting of 40 items was created. Every effort has been made to ensure that the items are clear and comprehensible, and that each item conveys a unique opinion.

The item pool was examined by a Curriculum and Instruction, linguist, psychological counseling, and guidance specialist, as well as elementary school teachers. An overview was taken in terms of suitability for the levels of student development, language, curriculum development, and assessment and evaluation. Two of the draft items were found to be problematic in terms of language, and three of them were removed from the scale as they were found to be problematic in terms of suitability for the student's level, and an initial form consisting of 35 items was prepared.

To assess the level of agreement among respondents for the items in the scale, a 5-point Likert-type scale was utilized, with response options ranging from "Strongly agree" to "Strongly disagree," with "Agree," "Undecided," and "Disagree" in between. The scale comprises 35 items, of which 19 are positive and 16 are negative. Students responded to the items using a 5-category rating scale. For positive attitude items, scoring was assigned as follows: "Strongly agree" = 5, "Agree" = 4, "Undecided" = 3, "Disagree" = 2, and "Strongly disagree" = 1. For negative items, the scoring was reversed: "Strongly agree" = 1, "Agree" = 2, "Undecided" = 3, "Disagree" = 4, and "Strongly disagree" = 5. The attitude scale was converted into a Google Form and distributed to fourth-grade students. A total of 697 students participated in the study by responding to the survey. This method allowed for the efficient collection and analysis of data, helping to understand better the students' attitudes toward the subject matter in question.

Data Analysis

Analysis of the data was carried out to provide evidence for the construct validity of SSTAS, "Exploratory Factor Analysis (EFA)" and "Confirmatory Factor Analysis (CFA)". SPSS 21.0 package program was used for EFA. "Kaiser Meyer Olkin Test (KMO)" and "Barlett Sphericity" test methods were used to determine whether the data were suitable for

https://doi.org/10.33225/jbse/23.22.641

principal component analysis. Varimax transformation was used to determine the factors so that the factors to be obtained are not correlated with each other. The factors that emerged as a result of the analysis were named. For CFA, the Lisrel 8.8 package program was used, and the suitability of the model revealed in EFA was checked. For the content validity of the scale, the opinions of academicians who are experts in their fields were consulted. To determine the reliability of SSTAS, the Cronbach-Alpha test and composite reliability are calculated.

Research Results

Exploratory factor analysis and confirmatory factor analysis were applied to examine the construct validity of the SSTAS, and the findings of the applied factor analyses are as shown below;

Exploratory Factor Analysis

Before initiating the Exploratory Factor Analysis (EFA) procedures, the dataset was thoroughly examined to ensure that it met the necessary assumptions for conducting factor analysis. In this regard, the researchers first assessed the draft form of the Student Science and Technology Attitude Scale (SSTAS) for its compatibility with the multivariate normal distribution. Upon examination, it was confirmed that the draft form conformed to the multivariate normal distribution requirements. Next, the Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett's sphericity tests were employed to ascertain the dataset's suitability for performing EFA. The SSTAS yielded a KMO coefficient of .934, which provides valuable insights into the data matrix's appropriateness for factor analysis and the data structure's suitability for factor extraction. For a dataset to be considered factorable, the KMO coefficient should be higher than .60. According to Çokluk et al. (2014), KMO values of .90 or greater are deemed 'perfect.' Additionally, the Bartlett test was used to examine the presence of relationships between variables based on partial correlations (Çokluk et al., 2014; Williams et al., 2010). Upon analyzing the results of Bartlett's Test of Sphericity, the researchers found that the test's calculated chi-square value was 5333.200, which was statistically significant ($p < .05$). Based on these findings, it was concluded that the SSTAS was appropriate for EFA, allowing the researchers to proceed with confidence in their analysis.

Figure 1
Scree plot of SSTAS

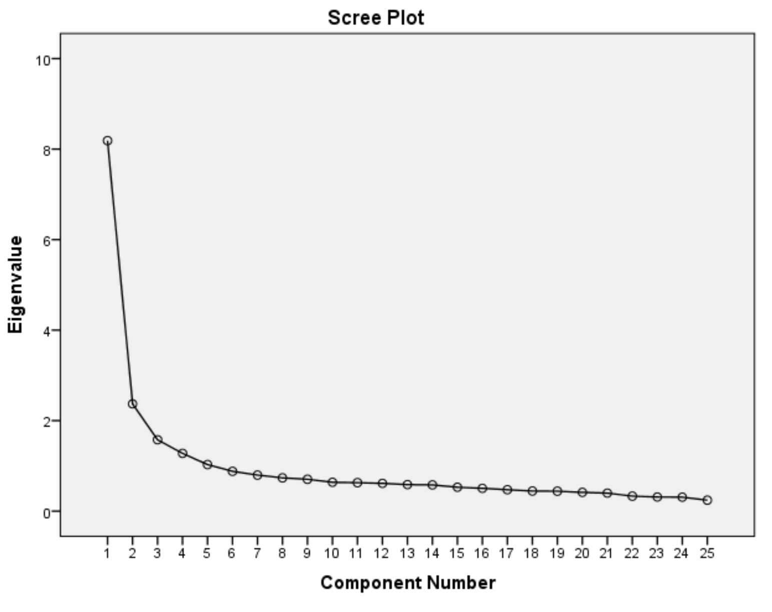


Figure 1 shows the scree plot used to have an idea about the factor structure of SSTAS, and it was concluded that the scale has a 3-factor structure.

https://doi.org/10.33225/jbse/23.22.641

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

Table 1
SSTAS Exploratory Factor Analysis Results

	F1	F2	F3
Eigenvalues	7.571	2.566	1.418
Explained variance (%)	32.918	11.157	6.164
Cumulative explained variance (%)	32.918	44.075	50.239
20. Science class is good.	.817		
15. I enjoy doing science homework.	.804		
35. I would like to take a science class.	.737		
31. I would be happy to increase the course hours of the Science course.	.711		
3. Science class is fun.	.690		
1. I love science class.	.676		
24. Science lesson is easy.	.671		
33. I think everyone should like Science class.	.665		
17. Science class is boring.	.664		
21. I find science class boring.	.648		
29. Science lesson is practical.	.623		
32. Studying for science class makes me uncomfortable.	.614		
18. Science lesson teaches us the information we want to learn.	.514		
6. The knowledge we learn comes in handy in everyday life.	.500		
5. The subjects of the science lesson are difficult.	.497		
10. I don't like studying science.		.757	
14. I do not like learning by doing science lessons.		.726	
19. I don't like science and technology in science class.		.710	
28. I don't like reading books about science class		.669	
16. We do not learn different information in science class		.551	
25. Experiments are interesting.			.725
4. Experiments do not make science class fun.			.634
12. I will not be happy if the experiments multiply.			.606
27. It makes the laboratory science lesson more beautiful.			.606
13. Experiments ensure the permanence of knowledge. 0.516			.516

Table 1 presents the eigenvalues obtained from the Exploratory Factor Analysis (EFA) applied to the Student Science and Technology Attitude Scale (SSTAS), along with the variances explained by these eigenvalues both individually and cumulatively. In the EFA, the Principal Components Analysis method was employed to identify the factor structure of SSTAS, and a varimax transformation was conducted on the dataset to enhance the interpretability of the results. A close examination of the factor loadings of the items in STAS revealed that they ranged from .31 to .81. As per Tabachnick and Fidell (2007), a minimum factor loading of .30 is expected for an item on a factor. As a result, 10 out of the 35 items in the SSTAS were eliminated from the scale due to factor loadings below the acceptable threshold.

For the 25-item version of STAS, the factor loadings of the items varied from .497 to .817. Based on these findings, it was determined that the SSTAS consisted of a 3-factor structure, which provided a comprehensive and coherent framework for assessing elementary school students' attitudes toward the Science and Technology Course. The factor names were as follows:

https://doi.org/10.33225/jbse/23.22.641

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

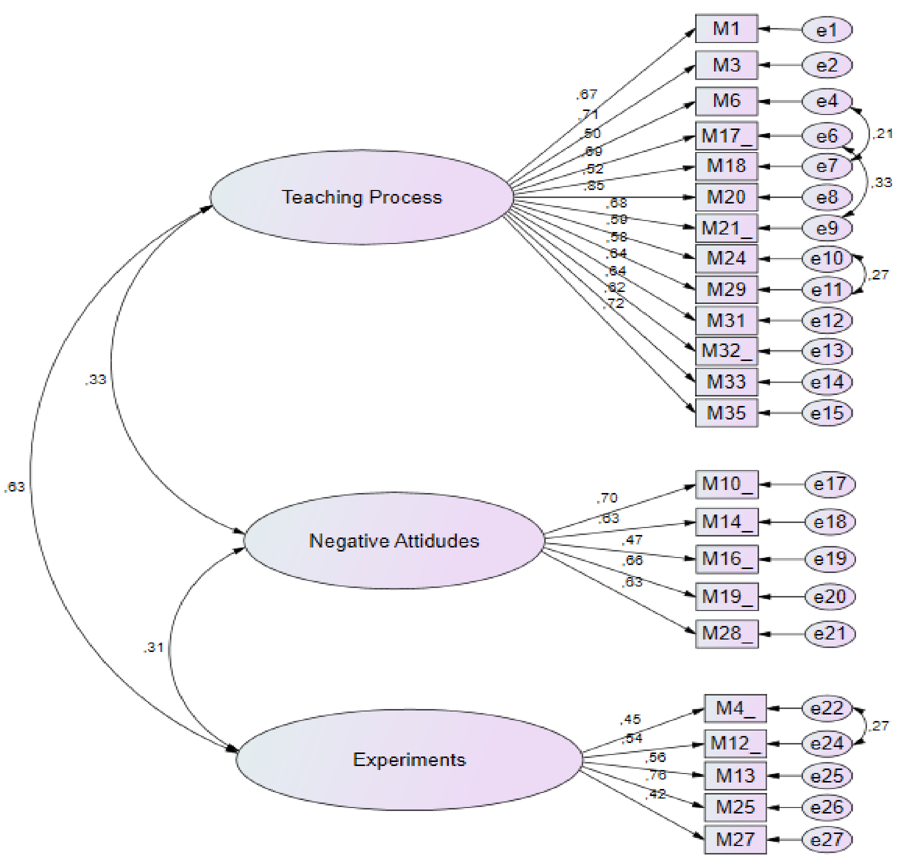
Factor 1: Teaching Process (Items: 1, 3, 5, 6, 15, 17, 18, 20, 21, 24, 29, 31, 32, 33, 35)
Factor 2: Negative Attitudes (Items: 10, 14, 16, 19, 28)
Factor 3: Experiments (Items: 4, 12, 13, 25, 27)

This 3-factor structure provided a clear and organized framework for understanding and interpreting the elementary school students' attitudes toward the Science and Technology Course.

Confirmatory Factor Analysis

Upon identifying the factor structure of the Student Science and Technology Attitude Scale (SSTAS), Confirmatory Factor Analysis (CFA) was implemented to validate the appropriateness of the factor structure and to scrutinize the relationships between the factors. CFA is considered an extension of EFA, as it serves to verify the factor structure established during the exploratory stage. CFA is a valuable tool in the scale development process, as it allows researchers to test the hypothesized factor structure based on the results of the EFA against the actual data. By doing so, it provides empirical evidence for the construct validity of the scale and ensures that the factor structure is robust and generalizable to the target population. Furthermore, CFA helps in determining the extent to which the factors are correlated, enabling researchers to gain a better understanding of the relationships between the factors and their underlying constructs. In the context of the SSTAS, applying CFA was essential to confirm that the three-factor structure, which included the Teaching Process, Negative Attitudes, and Experiments factors, accurately represented the attitudes of elementary school students towards the Science and Technology Course. By confirming the suitability of the factor structure, researchers could ensure that the SSTAS was a valid and reliable tool for measuring students' attitudes, allowing for more effective assessment, intervention, and improvement of their learning experiences in the Science and Technology Course.

Figure 2
Confirmatory Factor Analysis Path Diagram of SSTAS



https://doi.org/10.33225/jbse/23.22.641

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

The CFA path diagram of the SSTAS shown in Figure 2 is given, and it was discarded from the 3-factor and 25-item scale determined by EFA because the 2-item factor loads were not appropriate and disrupted the model fit. Accordingly, in the final form of the scale, a total of 23 items were included in the Science and Technology Lesson Teaching Process sub-dimension 13 items, Negative Attitudes Science and Technology Lesson sub-dimension 5 items, and Experiments in the Science and Technology Lesson sub-dimension 5 items.

Table 2

SSTAS Goodness-of-Fit Indices for SSTAS

Factor/Dimension	χ^2/SD	GFI	NFI	CFI	RMSEA
Criteria	< 3 (perfect fit)	> .90	> .90	> .90	.05 and .08 (acceptable fit)
Model	2.693	.916	.904	.923	.53

When the SSTAS, CFA goodness-of-fit index values (as shown in Table 2) were examined, it was determined that $\chi^2/^{SD}$ was 2.693, which indicates that SSTAS has a perfect fit in terms of $\chi^2/^{SD}$. According to Kline (2005), a value of χ^2/sd below 3 indicates a perfect fit, and a value between 3 and 5 indicates an acceptable fit.

According to SSTAS and DFA results, the Goodness of Fit Index (GFI) value of the scale was .916, the Normalized Fit Index (NFI) value was .904 and the Comparative Fit Index (CFI) value was .923. According to Tabachnick and Fidell (2007), the limit value determined for GFI, NFI and CFI is between .90 and 1.00. GFI, NFI and CFI values are expected to be between the specified limit values, and this indicates an acceptable fit. Root Mean Square Error (RMSEA) value of the scale was found to be 0.053. According to Brown (Brown, 2015), a RMSEA value between .00-.05 indicates perfect fit, and a value between .05-.08 indicates acceptable fit. Accordingly, it has been determined that SSTAS has an acceptable fit in terms of RMSEA.

As a result of the CFA, it was determined that all goodness-of-fit indices of SSTAS except GFI were appropriate and the construct validity of the scale was ensured.

SSTAS Reliability Analysis

In order to examine the reliability of the SSTAS, the Cronbach's alpha test and the split-half test were performed, respectively, and the item-total correlations of the scale were examined.

Table 3

Reliability Results for Sub-dimension and Total Scale

	Cronbach's α	McDonald's ω
Teaching Process	.900	.904
Negative Attitudes	.754	.757
Experiments	.693	.697
Total	.877	.898

Upon examining Table 3, it was determined that the Cronbach's alpha coefficient for the overall Student Science and Technology Attitude Scale (SSTAS) was .877. Additionally, composite reliability (McDonald's ω) was calculated for each dimension and the total scale to further assess the internal consistency of the scale. According to Büyüköztürk (2015), a Cronbach's alpha reliability coefficient above .70 is considered an acceptable level, while Taber (Taber, 2018) suggests that a coefficient above .60 is adequate for scale reliability.

Considering these criteria, the reliability coefficients of the SSTAS's sub-dimensions and the total scale are within acceptable levels, indicating that the scale exhibits satisfactory internal consistency. This internal consistency is crucial in the context of academic research, as it provides evidence that the items within each dimension of the SSTAS are measuring the same underlying construct, leading to more accurate and reliable results.

https://doi.org/10.33225/jbse/23.22.641

Journal of Baltic Science Education, Vol. 22, No. 4, 2023
ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Having a reliable scale is vital for assessing students' attitudes toward the Science and Technology Course, as it ensures that the scale can consistently and accurately capture the attitudes of the target population. Consequently, the SSTAS can be considered a valuable tool for educators, researchers, and policymakers in evaluating the effectiveness of instructional practices and in informing potential improvements in science education for elementary school students.

Discussion

This research was conducted to develop a valid and reliable attitude scale to determine the positive and negative attitudes of elementary school students toward STC. Attitude scales are measurement tools used to determine students' attitudes toward the courses. An attitude scale has been reached to determine the attitudes of secondary school students towards STC in the TRNC. However, a scale aiming to measure elementary school students' attitudes toward STC could not be found in the North Cyprus. In the literature, there exists a scale for School Improvement to Transform Education into being sustainable environments but not about STC in North Cyprus (Mafratoglu et.al, 2023). Therefore, this study can be accepted as a contribution to the literature in determining the positive and negative attitudes of elementary school students toward STC. The validity of each item was verified by the fact that a broad variety of publications were researched in the process of generating the item pool, and that the items themselves were evaluated by specialists in the relevant fields. Expert evaluation is one of the first steps to be implemented in scale development (Koc & Budak, 2021; Zapata-Ospina & García-Valencia, 2022). The scale was prepared in a 5-point Likert type. During the scoring of the items in the scale, negative items should be scored in reverse.

Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to determine the construct validity of the developed scale. It has been observed that the findings obtained serve to measure the feature which the scale aims to measure and can distinguish individuals who have the desired feature to be measured and those who do not. EFA is among the multivariate statistical techniques used to determine the latent sub-dimensions of the scale (Watkins, 2018). The scale consists of 23 items and three factors. Three factors explain 52.23% of the total variance of the attitude variable. The first factor constitutes 32.9% of the scale, the second factor 11.16% and the third factor 6.16%. The total explained variance is over 50%.

The results of exploratory factor analysis (EFA) indicated reasonable (.50 to.90) and significant ($p < .001$) coefficients, thus a confirmatory factor analysis was carried out in order to validate the three-component structure that EFA had discovered. This indicates that each item makes a substantial contribution to the subscale that is being considered. The number that was derived from the ratio of proposed chi-square to degree of freedom was employed in order to establish whether or not the model was a good fit. The results of this investigation are presented in Table 2, where it can be seen that the ratio of chi-square to degrees of freedom is 2.693. According to Kline (2005), a perfect match is indicated by a value of χ^2/sd that is less than 3, whereas an adequate fit is indicated by a value that falls between 3 and 5. In light of these standards, it is possible to assert that the model provides a satisfactory fit for the data. It was discovered that the NFI for the model was equal to .91, and the CFI was equal to .93. According to Brown (Brown, 2015), a perfect match is indicated by an RMSEA value of between .00 and.05, while a good fit is indicated by a value between .05 and .08. As a result, we may deduce that the value of the RMSEA for the Science and Technology Lesson Attitude Scale is .053, indicating that it has an adequate fit.

When the results of the reliability analysis are examined, it is concluded that it is reliable at an acceptable level in terms of both general and sub-factors. The Cronbach Alpha internal consistency coefficient of the whole scale was found to be .87. In structural equation modeling (SEM), the concept of composite reliability refers to a statistic that evaluates the internal consistency of a latent variable or construct (Brunner & Süß, 2005). McDonald's ω is calculated for composite reliability and coefficient (.898) is at acceptable level.

It is highlighted that there are various structures for assessing the attitude toward the science course, as opposed to a single structure (George, 2006; Kerr & Murphy, 2012; Osborne et al., 2003). Hence, scales may contain several factors. This concept is supported by the emergence of a triple-factor structure in this investigation. According to Williams et al. (2010), the process of labeling factors is a complex and nuanced task that requires researchers to balance their subjective interpretations, theoretical knowledge, and inductive reasoning to assign meaningful and coherent labels to the factors identified in their analysis. This process is crucial for ensuring that the results of factor analysis are both meaningful and relevant to the broader context of the research question being investigated.

Although other names are feasible for the elements in factor 1, it is believed that "teaching process" is more inclusive because it symbolizes the teaching process. In a research study involving the development of an attitude scale toward science, attitude-related questions were frequently titled "Attitude toward science" (Summers & Abd-El-Khalick, 2018). In as much as the research in question contains elements connected to belief, naming demonstrates differ-

https://doi.org/10.33225/jbse/23.22.641

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

ence along other dimensions. When the elements of Factor 2 were analyzed, they were termed "Negative Attitudes" since they were entirely negative. In a different research study (Liaghatdar et al., 2011), negative items were labeled "Science Anxiety." The third aspect in our analysis was titled "Experiments." In another research (Nuhoğlu, 2008), it was referred to as "class activities." In essence, although the naming of the scale items is considered subjective, there are similar namings in the literature, and the fact that they were called to correspond with the items gave the meaning of the scale's components.

Conclusions and Implications

This scale was designed to assess the attitudes of elementary school students about the science and technology curriculum. Based on the outcomes of the EFA, CFA, and reliability analyses, the scale can be argued as valid and reliable. In its final form, the scale has three dimensions. The first dimension evaluates the attitudes of students toward the teaching process. This dimension has 13 components, of which 3 are negative and 9 are positive. The second dimension evaluates the negative views of the students. This dimension has a total of five negative items. The third dimension evaluates the students' perspectives on the experiments. There are a total of five items in this dimension, one of which is negative.

Attention should be paid to the fact that all items were marked by the students and that the negative items were coded in reverse during the assessment stage when using the scale. Using different populations, future researchers can evaluate the validity and reliability of the scale. It is also adaptable to other cultures and languages. The main limitation of the study is that EFA and CFA were performed on the same data set. Due to the use of the same dataset as researchers, each step was checked for overfitting, capitalization on chance and inflated fit indices. In particular, it was checked whether there were idiosyncrasies in the data. The reliability of the scale can be more clearly demonstrated by future researchers' studies on different data sets.

Declaration of Interest

The authors declare no competing interest.

References

Ajzen, I. (2001). Nature and operation of attitudes. *Annual Review of Psychology*, *52*(1), 27–58. https://doi.org/10.1146/annurev.psych.52.1.27

Bentley, M. L., Ebert II, E. S., & Ebert, C. (2007). *Teaching constructivist science, K-8: Nurturing natural investigators in the standards-based classroom*. Corwin Press.

Berg, T. B., Achiam, M., Poulsen, K. M., Sanderhoff, L. B., & Tøttrup, A. P. (2021). The Role and Value of Out-of-School Environments in Science Education for 21st Century Skills. *Frontiers in Education*, *6*(May), 1–8. https://doi.org/10.3389/feduc.2021.674541

Brown, T. A. (2015). *Confirmatory Factor Analysis for Applied Research*. The Guilford Press.

Brunner, M., & Süß, H.-M. (2005). Analyzing the Reliability of Multidimensional Measures: An Example from Intelligence Research. *Educational and Psychological Measurement*, *65*(2), 227–240. https://doi.org/10.1177/0013164404268669

Büyüköztürk, Ş. (2015). Sosyal bilimler için veri analizi el kitabı. *Pegem Atıf İndeksi*, 1–213.

Carayannis, E. G., & Morawska-Jancelewicz, J. (2022). The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities. *Journal of the Knowledge Economy*, *13*(4), 3445–3471. https://doi.org/10.1007/s13132-021-00854-2

Chalkiadaki, A. (2018). A Systematic Literature Review of 21st Century Skills and Competencies in Primary Education. *International Journal of Instruction*, *11*(3), 1–16. https://doi.org/10.12973/iji.2018.1131a

Child, D. (2006). *The essentials of factor analysis*. A&C Black.

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2017). Twenty-First Century Skills Education in Switzerland: An Example of Project-Based Learning Using Wiki in Science Education. In *21st Century Skills Development Through Inquiry-Based Learning* (pp. 61–78). Springer Singapore. https://doi.org/10.1007/978-981-10-2481-8_4

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2014). *Sosyal Bilimler İçin Çok Değişkenli İstatistik SPSS ve LİSREL Uygulamaları*. Pegem Akademi.

Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T., Oshima, K., Tai, M., & Tani, S. (2020). *Society 5.0: A People-centric Super-smart Society*. Springer Singapore. https://doi.org/10.1007/978-981-15-2989-4

Dijkstra, E. M., & Goedhart, M. J. (2012). Development and validation of the ACSI: Measuring students' science attitudes, pro-environmental behaviour, climate change attitudes and knowledge. *Environmental Education Research*, *18*(6), 733–749. https://doi.org/10.1080/13504622.2012.662213

Eagly, A. H., & Chaiken, S. (2007). The advantages of an inclusive definition of attitude. *Social Cognition*, *25*(5), 582–602. https://doi.org/10.1521/soco.2007.25.5.582

Eaton, A. A., Majka, E. A., & Visser, P. S. (2008). Emerging perspectives on the structure and function of attitude strength. *European Review of Social Psychology*, *19*(1), 165–201. https://doi.org/10.1080/10463280802383791

https://doi.org/10.33225/jbse/23.22.641

Fakaruddin, F. J., Shahali, E. H. M., & Saat, R. M. (2023). Creative thinking patterns in primary school students' hands-on science activities involving robotic as learning tools. *Asia Pacific Education Review*, *0123456789*. https://doi.org/10.1007/s12564-023-09825-5

Fitzgerald, A., & Smith, K. (2016). Science that matters: Exploring science learning and teaching in primary schools. *Australian Journal of Teacher Education*, *41*(4), 64–78. https://doi.org/10.14221/ajte.2016v41n4.4

George, R. (2006). A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education*, *28*(6), 571–589. https://doi.org/10.1080/09500690500338755

González-Gómez, D., Jeong, J. S., & Cañada-Cañada, F. (2022). Enhancing science self-efficacy and attitudes of Pre-Service Teachers (PST) through a flipped classroom learning environment. *Interactive Learning Environments*, *30*(5), 896–907. https://doi.org/10.1080/10494820.2019.1696843

Halbeisen, G., Walther, E., & Schneider, M. (2017). Evaluative Conditioning and the Development of Attitudes in Early Childhood. *Child Development*, *88*(5), 1536–1543. https://doi.org/10.1111/cdev.12657

Hansson, L., Leden, L., & Thulin, S. (2021). Nature of science in early years science teaching. *European Early Childhood Education Research Journal*, *29*(5), 795–807. https://doi.org/10.1080/1350293X.2021.1968463

Harlen, W., & Qualter, A. (2004). The Teaching of Science in Primary Schools. In *British Journal of Educational Studies* (Fourth Edi, Vol. 8, Issue 1). David Fulton Publishers.

Harrison, A. (2020). The wonder of science. In V. Dawson & G. Venville (Eds.), *The Art of Teaching Primary School Science* (second edi). Routledge.

Häyrynen, S., Keinonen, T., & Kärkkäinen, S. (2021). Promoting Environmental Citizenship Through Local Socio-Cultural Traditions in Science Education. *Discourse and Communication for Sustainable Education*, *12*(2), 5–30. https://doi.org/10.2478/dcse-2021-0013

Hidi, S. E., & Renninger, K. A. (2020). On educating, curiosity, and interest development. *Current Opinion in Behavioral Sciences*, *35*, 99–103. https://doi.org/10.1016/j.cobeha.2020.08.002

Joko, J., Putra, A. A. P., & Isnawan, B. H. (2023). Implementation of IoT-Based Human Machine Interface-Learning Media and Problem-Based Learning to Increase Students' Abilities, Skills, and Innovative Behaviors of Industry 4.0 and Society 5.0. *TEM Journal*, *12*(1), 200–207. https://doi.org/10.18421/TEM121-26

Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education*, *8*(4), 630–636. https://doi.org/10.11591/ijere.v8i4.20312

Katz, D. (1967). The functional approach to the study of attitude readings in attitude theory and measurement. In M. Fishbein (Ed.), *Readings in attitude theory measurement* (pp. 457–460). John Wiley and Sons.

Kerr, K., & Murphy, C. (2012). Children's Attitudes to Primary Science. In *Second International Handbook of Science Education* (pp. 627–649). Springer Netherlands. https://doi.org/10.1007/978-1-4020-9041-7_42

KKTC MEB. (2005). *Kıbrıs türk eğitim sistemi* [Turkish Cypriot education system]. Talim ve Terbiye Dairesi.

Kline, T. J. B. (2005). *Psychological testing a practical approach to design and evaluation*. Sage publications.

Letina, A. (2020). Development of students' learning to learn competence in primary science. *Education Sciences*, *10*(11), 1–14. https://doi.org/10.3390/educsci10110325

Liaghatdar, M. J., Soltani, A., & Abedi, A. (2011). A Validity Study of Attitudes toward Science Scale among Iranian Secondary School Students. *International Education Studies*, *4*(4), 36–46. https://doi.org/10.5539/ies.v4n4p36

Linnenbrink-Garcia, L., Patall, E. A., & Pekrun, R. (2016). Adaptive Motivation and Emotion in Education: Research and Principles for Instructional Design. *Policy Insights from the Behavioral and Brain Sciences*, *3*(2), 228–236. https://doi.org/10.1177/2372732216644450

Mao, P., Cai, Z., He, J., Chen, X., & Fan, X. (2021). The Relationship Between Attitude Toward Science and Academic Achievement in Science: A Three-Level Meta-Analysis. *Frontiers in Psychology*, *12*(December), 1–12. https://doi.org/10.3389/fpsyg.2021.784068

Mateos-Núñez, M., Martínez-Borreguero, G., & Naranjo-Correa, F. L. (2020). Learning science in primary education with STEM workshops: Analysis of teaching effectiveness from a cognitive and emotional perspective. *Sustainability (Switzerland)*, *12*(8). https://doi.org/10.3390/SU12083095

Miwa, C. (2020). *Early Childhood Care and Education Practices in Japan for the Era of Society 5.0*. *503*(Iceccep 2019), 27–32. https://doi.org/10.2991/assehr.k.201205.080

Nuhoğlu, H. (2008). İlköğretim Fen ve Teknoloji Dersine Yönelik Bir Tutum Ölçeğinin Geliştirilmesi [The Development of an Attitude Scale for Science and Technology Course]. *Elementary Education Online*, *7*(3), 627–639.

O'Neal, L. T. J., Gibson, P., & Cotten, S. R. (2017). Elementary School Teachers' Beliefs about the Role of Technology in 21st-Century Teaching and Learning. *Computers in the Schools*, *34*(3), 192–206. https://doi.org/10.1080/07380569.2017.1347443

Ogunkola, B., & Samuel, D. (2011). Science Teachers' and Students' Perceived Difficult Topics in the Integrated Science Curriculum of Lower Secondary Schools in Barbados. *World Journal of Education*, *1*(2), 17–29. https://doi.org/10.5430/wje.v1n2p17

Ornek, F., & Saleh, I. M. (2012). *Contemporary science teaching approaches: Promoting conceptual understanding in science*. IAP.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Patall, E. A., Hooper, S., Vasquez, A. C., Pituch, K. A., & Steingut, R. R. (2018). Science class is too hard: Perceived difficulty, disengagement, and the role of teacher autonomy support from a daily diary perspective. *Learning and Instruction*, *58*(July), 220–231. https://doi.org/10.1016/j.learninstruc.2018.07.004

Pöntinen, S., & Räty-Záborszky, S. (2020). Pedagogical aspects to support students' evolving digital competence at school. *European Early Childhood Education Research Journal*, *28*(2), 182–196. https://doi.org/10.1080/1350293X.2020.1735736

Retni S, B., Dwi Agus, K., Elza, T., & Rahmat, P. (2021). Evaluation of the Results of Attitudes and Self-Efficacy of Middle School Students in Science Subjects. *Journal of Education Research and Evaluation*, *5*(4), 525. https://doi.org/10.23887/jere.v5i4.36409

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

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Lawrence Erlbaum Associates.

Rodríguez-Abitia, G., & Bribiesca-Correa, G. (2021). Assessing digital transformation in universities. *Future Internet*, *13*(2), 1–17. https://doi.org/10.3390/fi13020052

Sá, M. J., Santos, A. I., Serpa, S., & Ferreira, C. M. (2021). Digital Literacy in Digital Society 5.0: Some Challenges. *Academic Journal of Interdisciplinary Studies*, *10*(2), 1–9. https://doi.org/10.36941/ajis-2021-0033

Sá, M. J., & Serpa, S. (2022). Higher Education as a Promoter of Soft Skills in a Sustainable Society 5.0. *Journal of Curriculum and Teaching*, *11*(4), 1–12. https://doi.org/10.5430/JCT.V11N4P1

Schönfelder, M. L., & Bogner, F. X. (2020). Between Science Education and Environmental Education: How Science Motivation Relates to Environmental Values. *Sustainability*, *12*(5), 1968. https://doi.org/10.3390/su12051968

Smuts, H., & Van der Merwe, A. (2022). Knowledge Management in Society 5.0: A Sustainability Perspective. *Sustainability (Switzerland)*, *14*(11). https://doi.org/10.3390/su14116878

Stagg, B. C., & Verde, M. F. (2019). Story of a Seed: educational theatre improves students' comprehension of plant reproduction and attitudes to plants in primary science education. *Research in Science and Technological Education*, *37*(1), 15–35. https://doi.org/10.1080/02635143.2018.1455655

Summers, R., & Abd-El-Khalick, F. (2018). Development and validation of an instrument to assess student attitudes toward science across grades 5 through 10. *Journal of Research in Science Teaching*, *55*(2), 172–205. https://doi.org/10.1002/tea.21416

Suryantini, N. P. S., Darmayanti, N. P. A., & Arsawan, I. W. E. (2020). Knowledge sharing behavior: critical thinking, implications, and future agenda. *Economics. Ecology. Socium*, *4*(1), 15–23. https://doi.org/10.31520/2616-7107/2020.4.1-2

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. Allyn & Bacon/Pearson Education.

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tavşancıl, E. (2010). *Tutumların ölçülmesi ve SPSS ile veri analizi* [Measurement of attitudes and data analysis with SPSS]. Nobel.

Teppo, M., Soobard, R., & Rannikmäe, M. (2021). Grade 6 & 9 student and teacher perceptions of teaching and learning approaches in relation to student perceived interest/enjoyment towards science learning. *Journal of Baltic Science Education*, *20*(1), 119–133. https://doi.org/10.33225/jbse/21.20.119

Thurstone, L. L. (1931). The measurement of social attitudes. *The Journal of Abnormal and Social Psychology*, *26*(3), 249.

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. https://doi.org/10.1016/j.sbspro.2012.09.253

Ültay, N., Ültay, E., & Yılmazer, H. (2020). Determining the Relationship between Preschool Teachers' Attitudes towards Science Teaching and Self-efficacy Beliefs in Terms of Various Variables. *Science Education International*, *31*(4), 391–399. https://doi.org/10.33828/sei.v31.i4.8

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, *72*, 577–588. https://doi.org/10.1016/j.chb.2017.03.010

Watkins, M. W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology*, *44*(3), 219–246. https://doi.org/10.1177/0095798418771807

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Journal of Emergency Primary Health Care*, *8*(3), 1–13. https://doi.org/10.33151/ajp.8.3.93

Yurdakal, İ. H., & Kırmızı, F. S. (2019). Reading attitude scale: Validity and reliability study. *Elementary Education Online*, *18*(2), 714–733. https://doi.org/10.17051/ilkonline.2019.562036

Zapata-Ospina, J. P., & García-Valencia, J. (2022). Validity based on content: A challenge in health measurement scales. *Journal of Health Psychology*, *27*(2), 481–493. https://doi.org/10.1177/1359105320953477

Received: *March 22, 2023* Revised: *May 23, 2023* Accepted: *June 08, 2023*

Cite as: Yalgin, S., Batman, K. A., & Bastas, M. (2023). Developing an attitude scale towards science and technology courses: A study of validity and reliability. *Journal of Baltic Science Education*, *22*(4), 641-652. https://doi.org/10.33225/jbse/23.22.641

Sinem Yalgin	PhD, Near East University, Cyprus. E-mail: sinemsilaydin@gmail.com ORCID: https://orcid.org/0000-0002-3729-5450
Kemal Akkan Batman	PhD, Assistant Professor, Atatürk Teacher Training Academy, Cyprus. E-mail: kemal.batman@aoa.edu.tr ORCID: https://orcid.org/0000-0001-8972-2226
Mert Bastas *(Corresponding author)*	PhD, Associate Professor, Near East University,, Cyprus. E-mail: mert.bastas@neu.edu.tr ORCID: https://orcid.org/0000-0001-5149-5451

https://doi.org/10.33225/jbse/23.22.641