Educational Policy Analysis and Strategic Research, V20, N1, 2025

Astronomy Attitude Scale Development for Secondary School Students[1]

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Abstract

The aim of this study is to develop a valid and reliable astronomy attitude scale for secondary school students. The method of this research is a scale development study. The study group of the research consists of 300 students studying in 3 different secondary schools in Turkey in the first semester of the 2022-2023 academic year. A 32-item 5-point Likert-type scale was prepared with the data collected from the experts. In the first stage, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted within the scope of validity analysis for the scale whose reliability value was calculated at a "very good" level. In the EFA stage, a total of 12 items with high loading values in more than one factor were removed from the scale due to overlapping, and the explained variance of the 3-factor 20-item scale was found to be 53.704%. In the confirmatory factor analysis stage, the model fit of the 20 items with three factors determined in the EFA stage was tested with the SPSS AMOS programme. At this stage, one more item with low standardized loadings was removed from the scale and model fit values were calculated as $\chi 2$ /sd=1,907; GFI=,913; CFI=,941; NFI=,885; RMSEA=,055 and it was determined that the model showed "acceptable" and "excellent" fit. Cronbach's Alpha values were calculated as 0.914 for the whole scale. As a result of the construct validity and reliability analyses of the scale, the values found in the analyses showed that the astronomy attitude scale is a valid and reliable scale for secondary school students.

Keywords: Science Education, Astronomy Education, Attitude Towards Astronomy, Attitude Scale Development

DOI: 10.29329/epasr.2025.1297.2

Submitted: 21 May 2024 **Accepted:** 09 November 2024 **Published:** 31 March 2025

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Introduction

In the modern education era, there are continuous developments in education, and these developments cover a wide area in the literature. These developments are tried to be implemented by all countries as they help to innovate in education and eliminate deficiencies (Biesta, 2015). It is seen that astronomy education, which is one of the subjects that have been developed in education, has increased interest in astronomy activities and studies related to these activities, especially after 2009 was the World Astronomy Year. (Taner et al., 2017) In an interest, many arrangements are made in education programmes and the teaching of the subject is tried to be brought to the forefront as a result of the interest. However, when the studies conducted are examined, it is seen that the most preferred data collection tool among the data collection tools used in astronomy education research is open-ended questionnaire questions, and since there is a limited number of studies on scale development in the field of astronomy, researchers are recommended to conduct research on this subject (Oğuzman et al., 2021). Kurnaz et al. (2016), in their literature review study, stated that there are very few reliable and valid measurement tools for astronomy and achievement tests are frequently used as measurement tools. In recent periods, when it is recommended to carry out affective field goals together with cognitive field goals, there is a need to develop scales other than achievement tests for astronomy in astronomy education.

It is stated that valid and reliable measurement tools are needed to determine the level of learning and to evaluate the programmes. Since attitude is one of the affective characteristics effective in learning, activities that enable students to develop positive attitudes should be included in their education (Fidan & Baykul, 1994). Before developing a behavior, it is necessary to look at the input characteristics of the behavior, and this can be possible with alternative measurement tools such as attitude scales to determine the individual's attitude towards an educational subject, which is called affective behavior (Kar, 2022). In the measurement and evaluation process in education, instead of using achievement tests that only provide information about the development of the cognitive field as valid and reliable measurement tools, attitude scales towards students' learning subject area can also be used. In this way, it can be ensured that individual differences are fully included in education and training.

As the mentioned situations are valid for every course and subject, they are also valid for astronomy education, which is the content of the research. Colantonio et al. (2021), in their study examining young students' astronomy identities in 4 dimensions: interest, utility value, confidence and conceptual knowledge, concluded that interest has both a direct and indirect effect on astronomy identity. Stating that the indirect effect of interest is mediated by utility value, they suggest the development of the design of learning-teaching techniques that can encourage interest in performance and retention within the framework of astronomy identity.

It is seen that attitude scales, which are tools that can be used to measure and evaluate attitude, are needed during education and training. In the literature review, the fact that there are studies on astronomy subjects generally at the level of concept and understanding, there are few studies on the themes of attitude, motivation and curiosity, and when it is desired to reach the tools measuring attitudes towards astronomy, there are generally adaptation scales, and there is no astronomy attitude scale developed for secondary school students has added importance to the research by creating a road map for this research.

Uçar & Aktamış (2019) stated that there is no valid and reliable scale measuring students' attitudes towards astronomy in the literature and that they developed an "astronomy attitude scale" consisting of 3 factors and 14 items for secondary school students. They also stated that the items of the scale they developed differ from the attitude scales developed for astronomy and that the scale can be used to determine the attitudes of secondary school students towards astronomy.

Türk & Kalkan (2016), in their study titled "Astronomy Attitude Scale Adaptation Study for Higher Education Students", suggested that studies revealing the attitudes of individuals for the field of astronomy should be carried out based on the results.

Demir & Öner Armağan (2019) developed a 3-dimensional 23-item attitude scale towards astronomy in their scale development study with 215 8th-grade students studying in Kayseri province. They stated that the scale was valid and reliable based on the results of the study. They also suggested that studies that reveal the attitudes of individuals in the field of astronomy education and the reasons for the changes in attitudes should be carried out.

In this study, it was aimed to develop an astronomy attitude scale for secondary school students with detailed validity and reliability analyses for secondary school students due to the fact that there is not enough astronomy attitude scale in the literature, there are generally scale adaptation studies, and there is not enough astronomy attitude scale for secondary school students in astronomy education, which has an important place, especially in science course.

Method

The model of this research is a scale development study consisting of scale development stages. The astronomy attitude scale was developed by applying the stages of scale development.

Study Group

Tavşancıl (2018) emphasized the factor analysis stage in the validity analyses of the scale and stated that the sample size for this stage should be at least five times the number of items in the scale. The population of this research is secondary school students studying in Turkey. Considering the recommendations in the literature, the sample of the research was selected in accordance with the literature; the study group of the research consists of 300 students from the 5th, 6th, 7th and 8th grade levels studying in 3 different secondary schools in Turkey in the first semester of the 2022-2023 Academic Year. A convenient sampling method was used as the sampling method. No descriptive information was collected from the students, and the participation of the students was voluntary, and consent forms were filled out. After the implementation phase of the research, although the total number of the sample was 483, 183 data were eliminated because the data obtained from 483 data groups were not healthy.

The study group of the experimental scale, which was formed as a result of expert opinion at the pre-test application stage of the research, consisted of 30 people who were thought to represent the sample.

Data Collection Tools

Before writing the scale items, scale development studies in the literature, attitude scale development studies, astronomy attitude scale adaptation and development studies, and studies in the field of astronomy were examined, respectively. After the literature review, it was seen that there was no astronomy attitude scale for secondary school students in the literature. Based on the scale studies in the literature, expert opinions and astronomy achievements in the field of Science Course, an item pool of 80 items was created for the astronomy attitude scale. Malhotra (2006) mentioned the necessity of writing clear and understandable question statements in order to obtain the information needed in the writing of the items and stated that poorly worded questions can be misunderstood and lead to response errors and non-response. A grammar teacher was included in the expert opinion group in order to get an opinion on whether the question statements were written clearly and comprehensibly in item writing.

In order to ensure the content validity of the astronomy attitude scale, the 80-item item pool was presented to the expert opinion and the opinions of 8 experts were obtained. The opinions received from the experts were analyzed by Lawshe Technique, and 48 items were removed from the item pool. As a result of the expert opinion, the remaining 32 items in the pool were randomly sorted, the scale items were formed, and a trial scale consisting of scale items, explanations and instructions was prepared. The trial scale was prepared as a 5-point Likert-type scale and used in the pre-testing phase. This is the stage in which the trial scale is applied to around 20 respondents selected from the sample group in order to correct spelling, spelling errors and misunderstood expressions (Karagöz & Bardakçı, 2020). The prepared trial scale was applied to 30 people who were thought to represent the sample and selected from the sample group. At this stage, no spelling errors were found as a result of the application and the reliability of the scale was tested by calculating the Cronbach's Alpha value.

The reliability-tested draft scale was applied to the study group of 483 people, and the data of 300 people were used by eliminating the unhealthy data and the validity and reliability analyses of the scale were performed with the data obtained. With the data obtained from the analyses, the scale was finalized after corrections and item deletions were made.

Data Collection

The astronomy attitude scale was collected from 483 students by going to 3 different secondary schools in the first semester of the 2022-2023 Academic Year and applying it for one lesson hour (40 minutes). However, due to the lack of healthy data in 183 scales in the data received from the students, a total of 300 data were eliminated from the data group and a total of 300 data were processed into the system.

Data Analysis

While creating the trial scale of the astronomy attitude scale, expert opinion was analyzed by applying the Lawshe Technique to ensure content validity, and the analyses related to the technique are detailed in the findings and interpretation section. The data obtained from the study group were processed into the SPSS Statistics 26 programme for the validity and reliability analyses of the astronomy attitude scale. AMOS programme was used for the confirmatory factor analysis phase of the scale.

The factor analysis method used to test the construct validity of the scale was introduced by Spearman in 1904 and allows a large number of variables that are thought to be related to each other to be expressed with a smaller number of variables or variables (Çolakoğlu & Büyükekşi, 2014). Another definition of factor analysis is the method that can explain these variables with a single factor (sub-dimension) by bringing together variables that are related to each other and thus reducing the variables so that the factor structure can be defined (Büyüköztürk, 2002). According to the results of the factor analysis, the analyses continue after the scale items are removed or added from the scale until the number of items sufficient to measure and the results appropriate to the data in the literature are obtained (Karakoç & Dönmez, 2014).

Within the scope of the reliability analyses of the scale, it is recommended that the reliability calculations should be presented in the study after the construct validity analyses of the scale are completed, and the reliability coefficients of both the whole scale and the factors (sub-dimensions) in the scale should be reported (Karakaya Özyer, 2021). In light of these recommendations, Cronbach's Alpha coefficient for the reliability analyses of the astronomy attitude scale was calculated for the whole scale and its three factors and presented in the results section. In addition to the reliability analysis, Split Half Method (Split Half Method) analysis was performed and presented in the results section. Split Half Test Reliability is the method in which the scale items are divided into two equal halves, and the coefficient calculated for the whole test using the Spearman-Brown formula based on the correlation between the two halves of the test gives the reliability power. This method shows the consistency between the test scores of the two halves of the test (Büyüköztürk, 2021).

Within the scope of the item analyses of the scale, the significance level of the difference between the upper and lower 27% groups were examined. This method, which is also known as discrimination analysis, is explained as an analysis in which the total scores obtained from the scale are ranked from higher to lower, and the group of 27% with high scores is called the upper group, the group of 27% with low scores is called the lower group, and the difference between the averages of these groups is examined to see if it is significant (Karagöz & Bardakçı, 2020). In this context, the results of the Unrelated (Independent) Samples t-Test are presented in the findings and interpretation section.

Results

In order to ensure the content validity of the astronomy attitude scale, the analyses made at the expert opinion stage, exploratory and confirmatory factor analysis were performed for the suitability of the construct validity, and Cronbach's Alpha coefficient and Equivalent Halves Method Reliability calculations were made to test the reliability. Within the scope of item analyses, an Independent Samples t-test was calculated.

Findings Regarding the Content Validity of the Astronomy Attitude Scale

In order to ensure content validity, the method called Lawshe Technique is used to eliminate the items that do not serve the purpose in the scale by translating expert opinions into numerical data (Yurdugül, 2005).

Lawshe Technique:

- Formation of an expert group
- Preparing the candidate scale form and presenting it to the experts
- Analysing the data
  - Calculation of coverage validity rates
  - Calculation of the content validity index
- Content validity ratios consist of the stages of deciding the items that should remain on the scale and the items that should be removed from the scale by evaluating them according to the content validity criteria (Yeşilyurt & Çapraz, 2018).

The expert opinion form prepared by Lawshe Technique and Astronomy Attitude Scale (AAS) was presented to a group of 8 experts consisting of 3 experts in the field of astronomy education, one professor of educational sciences, two science teachers and one grammar teacher in order to collect opinions from the experts. As a result of the answers received from the experts, the content validity rates of the scale were calculated, and the content validity criterion was taken as 0.78 according to the number of experts at α=0.05 significance level. In the case of an 8-person expert group, the content validity criterion should be taken as 0.78 (Ayre & Scally, 2014). The 48 items with content validity rates below the content validity criterion were removed from the scale.

In the content validity phase, an item gain table was used to determine whether the scale items represented the gains in the Science curriculum used in the creation of the item pool. After the expert opinion, it was checked whether the content validity changed in the table related to the subject based on the curriculum, and it was seen that there were items that could represent each outcome in the astronomy attitude scale item pool and that the scope did not deteriorate according to the achievements in the curriculum. After the content validity analyses and controls, the remaining items in the pool were renumbered, and a 32-item trial scale was created. The analyses made after the piloting of the trial scale and its application to the target group are detailed in the following headings.

Findings on the Construct Validity of the Astronomy Attitude Scale

Grimm & Widaman (2012), in their study in which they examined the articles dealing with various aspects of construct validity in construct validity, stated that construct validity is a multifaceted process and that it is not a feature of the test but a feature of the inferences made from the scores or averages obtained from the test.

Exploratory factor analysis (EFA) findings of astronomy attitude scale

Exploratory factor analysis (EFA) is stated as a type of analysis that transforms groups into new variables by dividing a large number of variables into a certain number of groups, maximizing the relationship between variables within each group and minimizing the relationship between groups (Karagöz & Bardakçı, 2020).

In the exploratory factor analysis phase of the astronomy attitude scale, the vertical rotation method called "varimax" was used. The Varimax method is used in cases where it is thought that there is no relationship between factors. Although researchers mostly prefer this method in the literature, there may be scales in which there is a relationship between factors and "promax" and "direct oblimin" methods should be preferred in the analysis of these scales. Promax and Direct Oblimin are called oblique rotation methods, and they do not limit the factors to be unrelated (Reise et al., 2000). Since there is no relationship between the factors that may arise in the astronomy attitude scale, the varimax method was preferred (MacCallum et al. 1999).

In exploratory factor analysis, Kaiser-Meyer-Olkin (KMO) test and Bartlett's test are the tests that give information about the adequacy of the data obtained from the sample. Kaiser states that the value found is excellent as it approaches 1 and unacceptable if it is below 0.50 (excellent at 0.90s, very good at 0.80s, mediocre at 0.70s and 0.60s, very bad at 0.50s) (Tavşancıl, 2018).

KMO and Bartlett test results of the astronomy attitude scale as a result of the first rotation are given in Table 1.

Table 1. KMO and Bartlett's Test Results

Kaiser- Meyer - Olkin Measure of Sampling Adequacy		,942
Bartlett's Test of Sphericity	Approx. Chi-Square	4401,125
	Df	496
	Sig.	,000

As seen in Table 2, the KMO value was found to be .94, and this result shows that the adequacy of the sample is "excellent", as stated in the literature. Since p=0,000 < 005, Bartlett's test result is also significant. The findings show that the astronomy attitude scale is suitable for factor analysis, and the sample size of the application is sufficient.

Table 2. Total Variance Explained 1

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11,701	36,564	36,564	11,701	36,564	36,564	6,718	20,993	20,993
2	2,291	7,161	43,725	2,291	7,161	43,725	3,783	11,823	32,816
3	1,428	4,464	48,188	1,428	4,464	48,188	2,860	8,938	41,754
4	1,207	3,773	51,961	1,207	3,773	51,961	2,618	8,183	49,937
5	1,069	3,340	55,301	1,069	3,340	55,301	1,717	5,365	55,301

The table of variance explained as a result of the first rotation of the astronomy attitude scale is given above. As a result of the first rotation for AAS, 5 significant factors with eigenvalues of 1 and higher than 1 were found. Eigenvalue is a coefficient that is taken into consideration both in calculating the variance explained by the factors and in deciding the number of significant factors. Factors with an eigenvalue greater than 1 are considered significant. In the "percentage of total variance" value, which is one of the other criteria that can be used in determining the number of factors, it is stated that the maximum number of factors will be reached when the contribution of each additional factor to the explanation of total variance falls below 5%. For this reason, the contribution of factors 3, 4 and 5 to the explanation of the total variance was not found to be sufficient in line with these explanations (Yaşlıoğlu, 2017).

Another important criterion for determining these factors is the Scree Plot. The graph is obtained by connecting the points found as a result of matching the factors with their eigenvalues. The factor with high acceleration and rapid decreases in the graph gives the number of essential factors (Büyüköztürk, 2021). The graph line is obtained from the line drawn along the eigenvalues, and the point on the line where there is a deviation gives information about where the break is. The number of points on this break is evaluated when determining the number of factors (Williams et al., 2010).

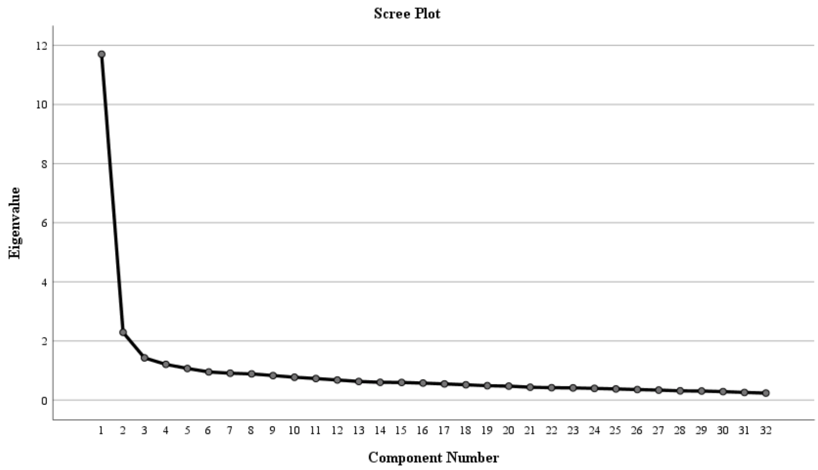

Figure 1. Astronomy attitude scale scree plot.

When the line graph is examined, it is called the elbow point, where the rapid decline is experienced, and the graph line starts to progress linearly. According to the line graph, the elbow point appears after the 3rd factor, and accordingly, the line graph shows that the astronomy attitude scale may have a 3-factor structure.

In addition to the mentioned information, factor analysis enables us to reach a meaningful structure by reducing variables in order to make sense of the factors. The rotated Component Matrix table will be a reference for reducing the variables.

Table 3. Rotated Component Matrix 1

	Component				
Item	1	2	3	4	5
Aas20	,708				
Aas14	,686				
Aas22	,665			,312	
Aas17	,654				
Aas31	,648				
Aas15	,642				
Aas26	,616				
Aa12	,614				,424
Aas32	,590	,314			

Aas30	,565			,406	
Aa7	,562				
Aas3	,558		,319	,333	
Aas11	,516				,441
Aas24	,500	,460			,311
Aas28	,493	,426			
Aas6	,493	,397			
Aas25	,412	,370	,361		
Aas18		,694			
Aas27		,677			
Aas13		,639			,305
Aas19	,446	,547			
Aas5		,413	,309	,365	
Aas21			,746		
Aas10			,719	,341	
Aas23			,587		
Aas16		,521	,551		
Aas1				,640	
Aas4	,400			,564	
Aas9		,466		,524	
Aas29		,303		,505	
Aas8			,308		,595
Aas2		,320			,567

When we look at the rotated components matrix table, the items give load values in 5 factors. The items should be grouped under that factor by looking at which factor has a high loading value. There may also be cases where items have high loading values under two factors.

The difference between the highest loading value of an item in the factors and the next highest loading value is expected to be as high as possible. It is recommended that the difference between the two highest loadings should be at least 0.10. In a multi-factor structure, an item that gives a high loading value in more than one factor is defined as an overlapping item and can be considered to be removed from the scale (Büyüköztürk, 2021).

Looking at the rotated components matrix table, items 5, 6, 9, 11, 16, 24, 25 and 28 are considered to be overlapping. These items were removed from the scale and the astronomy attitude scale was subjected to rotation again.

Table 4. Total Variance Explained 2

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8,885	37,019	37,019	8,885	37,019	37,019	6,291	26,211	26,211
2	1,870	7,793	44,812	1,870	7,793	44,812	3,093	12,888	39,099
3	1,307	5,446	50,258	1,307	5,446	50,258	2,639	10,994	50,094
4	1,108	4,618	54,877	1,108	4,618	54,877	1,148	4,783	54,877

As a result of the second rotation, four factors with eigenvalues greater than 1 and 1 were found. The four factors explain 54% of the scale items. The contribution of the 4th factor to the explanation of the total variance is below 5%. In order to reach values appropriate to the literature, the Rotated Component Matrix table, which is the next step, should be examined.

Table 5. Rotated Component Matrix 2

Item	Component 1	2	3	4
Aas22	,729			
Aas31	,706			
Aas17	,693			
Aas14	,688			
Aas20	,673			
Aas15	,656			
Aas12	,653			,336
Aas30	,649			
Aas3	,621		,407	
Aas32	,617	,332		
Aas7	,614			
Aas26	,605			
Aas4	,514			
Aas1	,388	,378		
Aas13		,759		
Aas27		,727		

Aas18		,699		
Aas19	,461	,513		
Aas2		,479		,392
Aas10			,797	
Aa21			,745	
Aas23			,611	
Aas29	,343	,392		-,585
Aas8			,391	,496

After the second rotation, there were overlapping items in the astronomy attitude scale, which were defined as less than 0.10 between two high-factor loadings. These items are items 1, 2 and 19. Since these items showed high loading values in more than one factor, they were removed from the scale, and the scale was subjected to rotation again.

Table 6. Total Variance Explained 3

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8,026	38,217	38,217	8,026	38,217	38,217	5,591	28,340	28,340
2	1,730	8,240	46,457	1,730	8,240	46,457	2,580	12,288	40,628
3	1,278	6,087	52,544	1,278	6,087	52,544	2,445	11,645	52,272
4	1,061	5,051	57,595	1,061	5,051	57,595	1,118	5,322	57,595

In the explained variance table, there is no factor with an eigenvalue below 1. At the same time, there is no factor whose contribution to the total variance is below 5%. When the explained variance table values are examined, it is seen that there is no incompatible value in this step of the analysis. However, the analysis was continued by checking whether there were any overlapping items in the rotated components matrix table, which is a criterion for determining the number of factors from the table below.

Table 7. Rotated Component Matrix 3

	Component			
Item	1	2	3	4
Aas22	,728			
Aas31	,703			
Aas17	,702			
Aas14	,693			
Aas20	,674			
Aas15	,657			
Aas12	,651			-,352
Aas30	,645			

Aas7	,626			
Aas3	,623	,412		
Aas32	,621	,308		
Aas26	,598			
Aas4	,523			,356
Aas10		,796		
Aas21		,760		
Aas23		,636	,318	
Aas8	,303	,449		-,426
Aas13			,776	
Aas27			,726	
Aas18			,723	
Aas29	,341		,352	,653

When we look at the rotated components matrix table after the third rotation in the factor analysis stage of the astronomy attitude scale, it is observed that the 8th item has a loading value of 449 in the 2nd factor and 426 in the 4th factor. The difference between the two highest loading values of item 8 is less than 0.10, and this item shows that it is an overlapping item. For this reason, since the 8th item should have been removed from the scale, the item was removed from the scale, and the scale was re-analyzed.

The analyses of the astronomy attitude scale after the fourth rotation are tabulated and interpreted below.

Table 8. Total Variance Explained 4

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7,786	38,928	38,928	7,786	38,928	38,928	5,802	29,010	29,010
2	1,702	8,508	47,436	1,702	8,508	47,436	2,587	12,934	41,944
3	1,254	6,268	53,704	1,254	6,268	53,704	2,352	11,761	53,704

As a result of the fourth rotation, the number of factors of the astronomy attitude scale was shaped as 3. All three factors have an eigenvalue greater than one, and their contribution to the variance explained is more than 5%. The variance explained by three factors is 53,704%. In single-factor scales, it is considered sufficient for the variance explained to be 30% or more of the total variance, while in multi-factor scales, the variance explained is expected to be higher (Büyüköztürk, 2021). When the explained variance of the factor structure falls below 50% of the total variance, if it explains less than half of the variable variance, it is not possible to talk about its representativeness (Yaşlıoğlu, 2017).

Table 9. Rotated Component Matrix 4

Item	1	2	3
Aas22	,731		
Aas31	,705		
Aas17	,699		
Aas14	,683		
Aas20	,671		
Aas15	,656		
Aas12	,647		
Aas30	,641		
Aas7	,629		
Aas3	,628		
Aas32	,618		
Aas26	,588		
Aas4	,521		
Aas13		,760	
Aas18		,744	
Aa27		,720	
Aas29		,490	
Aas10			,790
Aas21			,779
Aas23			,648

As a result of the fourth rotation, there were no overlapping items in the astronomy attitude scale. As a result of the factor analysis, 13 items were collected in the first factor, four items in the second factor and three items in the third factor.

Since 1 item (item 29) was removed from the astronomy attitude scale in the confirmatory factor analysis, the factor structure of the scale after item removal was examined by performing EFA again. The EFA results repeated in the CFA process are given below.

Table 10. Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7,534	39,650	39,650	7,534	39,650	39,650	5,800	30,528	30,528
2	1,685	8,869	48,519	1,685	8,869	48,519	2,374	12,494	43,022
3	1,233	6,489	55,008	1,233	6,489	55,008	2,277	11,986	55,008

In the EFA results made after the item was removed in the CFA phase, the contribution of the three factors explaining the scale to the percentage of the variance explained is 55.808%. It is seen that the contribution of the factors to the percentage of variance explained increased with the item removal.

Table 11. Rotated Component Matrix

Item	1	2	3
Aas22	,732		
Aas31	,710		
Aas17	,709		
Aas14	,690		
Aas20	,668		
Aas15	,657		
Aas12	,652		
Aas30	,650		
Aas7	,630		
Aas3	,628		
Aas32	,628		
Aas26	,596		
Aas4	,533		
Aas13		,801	
Aas18		,772	
Aas27		,634	
Aas10			,772
Aas21			,741
Aas23			,731

When the values found in the rotated components matrix table from the EFA results made after the item removed in the CFA phase were analyzed, no overlapping item was observed. As a result of the factor analysis, the astronomy attitude scale was explained by three factors with eigenvalues greater than 1. In the EFA phase, a total of 12 overlapping items were removed from the scale and in the CFA phase, one more item was removed, and the EFA of the astronomy attitude scale was completed after the repeated EFA. After the reliability of the scale, the reliability of each factor formed in the scale was calculated, and the naming of the factors was completed, the confirmatory factor stage was started.

The factors explained after the EFA phase of the astronomy attitude scale were named by taking expert opinion, and the first factor was named the "affective domain", the second factor was the "psychomotor domain", and the third factor as the "cognitive domain"

Confirmatory factor analysis (CFA) findings of the astronomy attitude scale

Confirmatory factor analysis (CFA) is an analysis method that is frequently used in the scale development process and provides important conveniences. This method is a process of creating factors (sub-dimensions), also called latent variables, based on observed variables through a previously created model. It is generally used in scale development and validity analyses or aims to verify a predetermined structure with analyses such as exploratory factor analysis (Yaşlıoğlu, 2017).

CFA was conducted to analyze whether the factors that emerged as a result of EFA of the astronomy attitude scale were adequately represented by the variables. In CFA, it is decided whether the model is compatible with the theory according to the results of various fit indices, not according to the results of a single test. These fit indices are χ2, χ2 /sd, GFI, AGFI, RMSEA, RMR, SRMR, which are used to evaluate model fit in research (İlhan & Çetin, 2014).

Table 12. Valid Fit Indices for CFA

Indexes of Fit	Perfect Fit Criteria	Acceptable Fit Criteria
χ2 /sd	0≤ χ2 /sd≤2	2≤ χ2 /sd≤3
AGFI	,90≤AGFI≤1,00	,85≤AGFI≤,90
GFI	,90≤GFI≤1,00	,90≤GFI≤,95
CFI	,95≤CFI≤1,00	,90≤CFI≤,95
NFI	,95≤NFI≤1,00	,90≤NFI≤,95
RMSEA	,00≤RMSEA≤,05	,05≤RMSEA≤,05

Çapık (2015). The Use of Confirmatory Factor Analysis in Validity and Reliability Studies. Anatolian Journal of Nursing and Health Sciences. 17. 196-205. adapted from the source named.

At the beginning of the CFA for the astronomy attitude scale, corrections were made because the model fit indices were not at the desired level. Firstly, when the standardized regression coefficients giving factor loadings for CFA were examined, the 29th item of the scale was removed from the scale due to its low standardized regression value and the analysis was repeated. Standardized regression values show the power of observed variables to predict latent variables, in other words, factor loadings. A standardized regression coefficient greater than 0.60 indicates that the power to predict latent variables is high. Factor loadings that are not significant are removed from the analysis (Karagöz & Bardakçı, 2020). From this point of view, the low regression value of 29 items was removed from the scale because it showed that the power to predict latent variables was also low. The table for the standardized regression coefficients of the astronomy attitude scale as a result of the analysis is given below:

Table 13. Standardized Regression Coefficients

Item	Value (coefficient)
Aas32	,729
Aas31	,737
Aas39	,740
Aas26	,603
Aas22	,731
Aas20	,632
Aas17	,700
Aas15	,629
Aas14	,590
Aas12	,640
Aas7	,611
Aas4	,607
Aas3	,674
Aas27	,627

Aas18	,663
Aas13	,720
Aas23	,741
Aas21	,731
Aas10	,614

Since the fit values were not at the desired level after repeated analyses, covariances were drawn between the items in the scale with high Modification Index (MI) values. Modification Index (MI) values provide researchers with information about corrections for better fit. In order to correct the model, fit, covariances should be drawn between pairs with large MI values (Karagöz & Bardakçı, 2020). In this context, three covariances were drawn between 6 items in total and the following results were obtained in the fit indices.

Table 14. ASS Cohesion Indices

Fit Indexes	Good Fit Criteria	Acceptable Fit Value	Model	Fitting in
χ2 /sd	0≤ χ2 /sd≤2	2≤ χ2 /sd≤3	1,907	Perfect
AGFI	,90≤AGFI≤1,00	,85≤AGFI≤,90	,886	Acceptable
GFI	,90≤GFI≤1,00	,90≤GFI≤,95	,913	Acceptable
CFI	,95≤CFI≤1,00	,90≤CFI≤,95	,941	Acceptable
NFI	,95≤NFI≤1,00	,90≤NFI≤,95	,885	Acceptable
RMSEA	,00≤RMSEA≤,05	,05≤RMSEA≤,05	,055	Perfect

When the CFA fit indices are examined as a result of the drawn covariances, it is understood that all indices show an acceptable and perfect fit according to the literature.

In the image below, the model formed after the procedures performed in the CFA analysis phase of the astronomy attitude scale is given. The model includes factors, sub-dimensions and items.

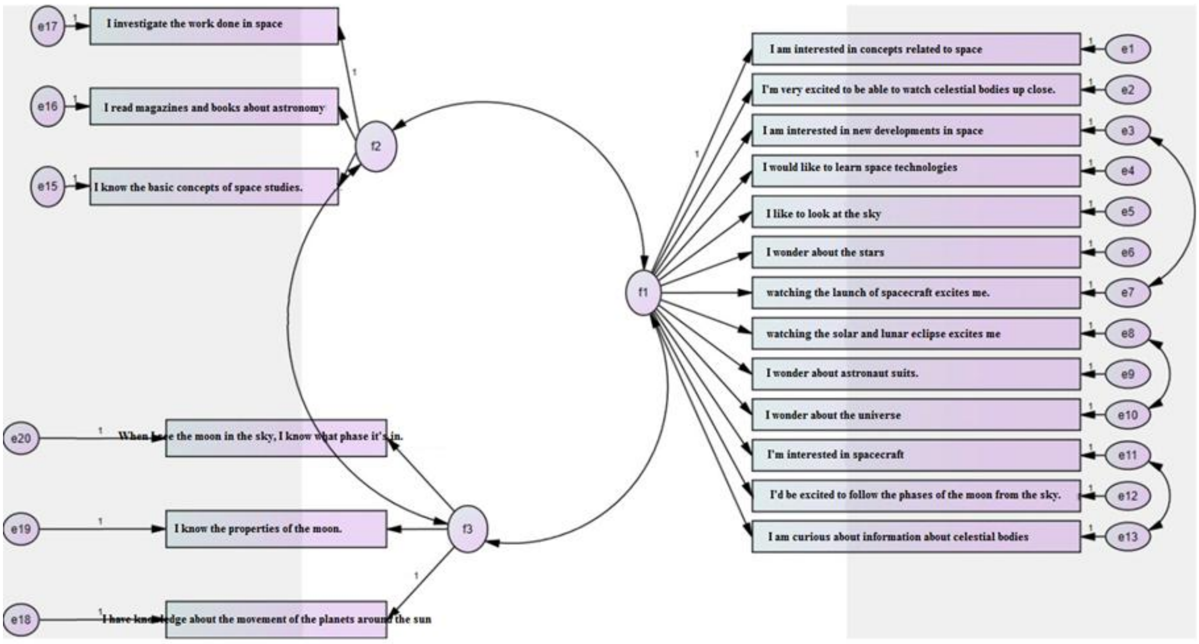

Figure 2. Path diagram of the astronomy attitude scale as a result of confirmatory factor analysis.

In the path diagram, f1 is the cognitive domain dimension, f2 is the psychomotor domain dimension, and f3 is the affective domain dimension. As a result of CFA, the astronomy attitude scale was explained as a scale of 19 items with three factors.

Findings on the Reliability of the Astronomy Attitude Scale

Reliability analyses related to the scale are presented and interpreted in tables under this title. As a reliability analysis, Cronbach's Alpha coefficient and Equivalent Half Method were tested for the astronomy attitude scale. Cronbach's Alpha value takes a value between 0 and 1, and as the value approaches 1, the internal consistency of the scale increases. It is stated that it is compulsory to calculate and report Cronbach's Alpha coefficient as the internal consistency reliability coefficient in Likert-type scales (Gliem & Gliem, 2003). After the analyses, Cronbach's Alpha values of the astronomy attitude scale were calculated close to 1 based on the data in the literature, and it was reported that the internal consistency of the scale was sufficient and good.

Table 15. Cronbach "s Alpha Reliability Result of the Whole Astronomy Attitude Scale after the Trial Application

Cronbach's Alpha	N of Items
,930	32

Table 16. Cronbach "s Alpha Reliability Result of the Astronomy Attitude Scale After EFA and CFA

	Cronbach's Alpha	N of Items
AAS	,914	19
Affective Domain	,911	13
Psychomotor Domain	,713	3
Cognitive Domain	,735	3

Cronbach's Alpha reliability coefficient for the whole astronomy attitude scale was found to be ,914; Cronbach's Alpha reliability coefficient for the affective domain factor was found to be ,911; Cronbach's Alpha reliability coefficient for the psychomotor domain factor was found to be ,713; and Cronbach's Alpha reliability coefficient for the cognitive domain factor was found to be ,735. Since the reliability coefficients of the scale are close to 1, the reliability of the astronomy attitude scale can be explained as adequate and good.

Hajjar (2018) stated that the split-half method is applied by using the Spearman-Brown correction formula when determining reliability in very long tests and stated that it will be applied at one time in very long tests. It is a method in which the scale is divided into two equal parts, and the reliability is estimated by the correlation between the scores of the individuals in the study group after the application of both halves to the study group at the same time (Ercan & Kan, 2004). Equivalent halves reliability results of the astronomy attitude scale are presented in the table below.

Table 17. AAS Equivalent Halves Method Reliability Result (Split Half Method)

Cronbach's Alpha	Part 1	Value	,833
		N of items	10[a]
	Part 2	Value	,837
		N of items	9[b]
		Total N of items	19
Correlation Between Forms			,850
Spearman-Brown Coefficient		Equal Length	,919
		Unequal Length	,919
Guttman Split-Half Coefficient			,918

a. items: I am curious about information about celestial bodies, I am excited to follow the phases of the Moon in the sky, I am interested in spacecraft, I can understand which phase the Moon is in when I see it in the sky, I am curious about the universe, I research studies in space, I enjoy watching solar and lunar eclipses, I am excited to watch the launch of spacecraft, I read magazines and books about astronomy, I am curious about the stars.

b. items: I am curious about the stars, I know the properties of the Moon, I enjoy watching the sky, I have knowledge about the movements of the planets around the Sun, I would like to learn space technologies, I know the basic concepts related to space studies, I enjoy designing technological tools related to the sky and space, I am interested in new developments related to space, I am excited to watch celestial bodies closely, I am interested in concepts related to space.

When the number of total scores of the items belonging to part 1 in the scale and the number of total scores of the items belonging to part 2 is equal, the Spearman-Brown coefficient in the Equal Length row should be taken into consideration; when the number of total scores of the items is not equal, the Spearman-Brown coefficient in the Unequal Length row should be taken into consideration (Karagöz & Bardakçı, 2020). In the astronomy attitude scale, since the total scores of the items in the two halves are not equal, the Spearman-Brown coefficient in the Unequal Length row is taken as the Equivalent Halves Reliability value of the scale with a coefficient of ,919. Since the Spearman-Brown coefficient of the astronomy attitude scale is very close to 1, the two halves of the scale are considered to be highly reliable.

Astronomy Attitude Scale Independent (Unrelated) Samples T-Test

2 Independent Samples t-Test, which is frequently preferred in comparing group averages, is used when the sample size is large (Derrick & White, 2017). Below, the t-test results of the astronomy attitude scale are presented and interpreted in a table.

Table 18. Group Statistics

Group	N	Mean	Std. Deviation	Std. Error Mean
1 (upper %27)	81	89,1852	3,21369	,35708
2 (lower %27)	81	54,0741	10,87747	1,20861

As seen in Table 19, the mean total score of the upper 27% group was 89.1852, while the mean total score of the lower 27% group was 54.0741.

Table 19. Independent Samples T-Test Results

Levene's test for Equality of Variances		t-test for Equality of Means						
F	Sig.	t	df	Sig (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
55,724	,000	27,860	160	,000	35,11111	1,26025	32,62224	37,59999
		27,860	93,860	,000	35,11111	1,26025	38,60880	37,61342

In Table 19, the Sig (2-tailed) value is examined as the expression of the differences between the total scores of the lower and upper 27% groups in the previous table. Sig (2-tailed) value is also expressed as the "p" significance value, and the "p" significance level is mostly used in decision-making in hypothesis testing in computer and statistical programs (Büyüköztürk, 2021). When $p<0.05$, there is a significant difference between the total scores of the lower and upper groups. There is a significant difference between the lower and upper groups formed by ranking the total scores obtained in the astronomy attitude scale since $p=.000<0.05$. According to the results of the Independent Samples T-Test, which is a reference for making comments on the discrimination of the scale, the astronomy attitude scale is considered sufficient to distinguish the lower and upper 27% groups.

Discussion

In this study, by following the scale development steps, a valid and reliable astronomy attitude scale for secondary school students, which is a scale needed in the literature, was developed, and the literature supported the findings of the scale. Kurnaz, Bozdemir and Çevik (2016) support that this study will contribute to the literature by stating that reliable and valid measurement tools for astronomy are very rare and achievement tests are frequently used as measurement tools. Keçeci (2021) stated the principles that researchers can use in the scale development process, and these principles were followed in order while developing the astronomy attitude scale.

In order to reach a consistent result and to establish a standard in scale development studies, it is considered appropriate to apply EFA first and then CFA (Orcan, 2018). As stated in the astronomy attitude scale, in order to reach a consistent result, the structure was revealed by applying EFA and the structure was confirmed by CFA. After EFA, ATÖ was explained with a 3-factor structure consisting of 20 items and named by taking expert opinion, namely affective, psychomotor and cognitive domain nomenclature. The structure revealed in the EFA phase was analyzed to be confirmed by CFA and the fit values explained in CFA were found as $\chi2$ /sd=1,907; GFI=,913; CFI=,941; NFI=,885; RMSEA=,055. The fit values given by Çapık (2015) in their study also support that the fit values of the astronomy attitude scale are acceptable and excellent. After CFA, the astronomy attitude scale was confirmed as a scale consisting of 19 items with three factors.

The Cronbach's Alpha reliability coefficients of the scale, whose construct validity was tested with EFA and CFA and found valid, were explained as ,914 for the whole scale; ,911 for the affective domain factor, which is the first factor; ,713 for the psychomotor domain factor, which is the second factor; and ,735 for the cognitive domain factor, which is the third factor. The reliability analyses of the scale overlap with the data found in Kılıç (2016) study, and according to the range of values found in the study, it is seen that the entire astronomy attitude scale is highly reliable, the affective domain dimension is highly reliable, the psychomotor domain dimension is moderately reliable, and the cognitive domain dimension is moderately reliable.

For reliability analysis, Hajjar (2018) stated that the Split Half Method was applied using the Spearman-Brown correction formula when determining reliability in very long tests, and in this study, the Split Half Method value of the astronomy attitude scale was tested, and the Spearman-Brown reliability coefficient was found to be .919. The Spearman-Brown reliability coefficient of the scale was found to be very close to 1, and it was concluded that the reliability determined according to the correlation between the two halves of the scale was at a high level.

If it has been determined that the scale has content validity, validity can be estimated by testing the significance of the difference between the averages of the scale scores in the upper and lower groups. In testing this significance, an Independent Samples T-test is performed, and if the p-value is significant as a result of the test, it is decided that the scale is valid (Tavşancıl, 2018). According to the T-test results, it was concluded that there was a significant difference between the lower and upper 27% groups formed by ranking the total scores obtained from the scale since $p=.000<0.05$, and the scale with a significant p-value is supported to be valid as stated in Tavşancıl's (2018) study.

The astronomy attitude scale, whose validity and reliability analyses were proved according to the data in the literature and previous studies, was presented to the literature as a contribution to the use of researchers.

Conclusions

This study developed an astronomy attitude scale needed in the literature. Nilsen & Angell (2014) stated in their study that the T.I.M.S.S. (Trends in International Mathematics and Science Study) research in 2011 showed that the decline in Norwegian 8th-grade students' science achievement was reversed and that astronomy was the only subtopic that contributed significantly to this reversal. In their study, they examined the factors that influenced the learning process and may have led to this rise: attitude towards astronomy, the application of astronomy discourse, and the characteristics and impact of conceptual understanding of astronomy. When they investigated these three factors with questionnaires and interviews, they stated that students' attitude towards astronomy is important for their conceptual understanding of the subject. For this reason, as frequently stated in the literature, there is a need for studies, measurement tools and especially attitude scales for astronomy in astronomy education, although the field of education is the general scope.

With this study, the variables affecting the astronomy attitudes of students can be described by collecting demographic characteristics together with the astronomy attitude scale in future studies. With the scale developed in the research, research can be conducted to reveal the astronomy attitudes of secondary school students. With the astronomy attitude scale, research can be carried out with samples from different countries. The developed scale can be used to determine students' attitudes towards the course at the stage when astronomy subjects are taught in the Science course. Adaptation studies can be carried out for different levels of this scale for secondary school students. The scale developed in the research can be used in studies that accept astronomy attitude as a variable in order to reveal the change in the attitude of the sample at the beginning and at the end. In cases where it is concluded that students have negative attitudes as a result of the application of the astronomy attitude scale, activities that can change students' negative attitudes towards astronomy into positive attitudes can be organized. The samples to which the scale is applied can be expanded, and it can be examined whether the data obtained from two different samples will give different results on attitude.

Policy Implications

The findings of this study emphasize the need to integrate structured and validated measurement tools, such as the Astronomy Attitude Scale, into science curricula to increase students' engagement in astronomy education. Given the important role that attitudes play in shaping students' conceptual understanding and academic achievement in astronomy (Nilsen & Angell, 2014), there is a need to incorporate evidence-based measurement tools into national educational policies. To improve astronomy education, it is crucial to develop policies that encourage the adaptation of the Astronomy Attitude Scale to different educational levels (Kırık, 2024). This will provide a more comprehensive understanding of students' attitudes and inform teaching strategies tailored to different learning environments. Furthermore, teacher training programmes should emphasize the importance of developing positive attitudes towards astronomy through innovative teaching methods, hands-on activities and interdisciplinary approaches. In addition, educational policymakers should support large-scale research initiatives that administer the Astronomy Attitude Scale across different regions and demographic groups. This will facilitate cross-cultural comparisons and allow for identifying best practices in astronomy education. By implementing these policy recommendations, education stakeholders can foster a more scientifically literate society, increase student enthusiasm for astronomy, and ultimately contribute to the development of future generations with a stronger foundation in science and technology.

Conflict of Interest

No potential conflict of interest was declared by the authors.

Funding Details

No funding or grant was received from any institution or organization for this research.

Ethical Statement

This research was discussed at the meeting of Gazi University Ethics Committee dated 09.03.2023, numbered 04 and found ethically appropriate with the decision numbered 2023/264

Credit Author Statement

The authors contributed equally to this research.

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