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Abstract

It is clear that the steps that can bring a perspective to science and enlighten our path with new changes can be provided by academics who have grasped science and the nature of science. The aim of this research is to develop a scale by which the views of academics on the nature of science can be evaluated. The study was carried out with the voluntary participation of 682 academics at four different universities using a quantitative, methodological research design. As a result of the factor analysis, 19 items were grouped under five factors: "Definition of Science," "Systematicity and Reality," "Subjectivity in Science," "Openness to Change," and "Falsifiability in Science." These factors explained 52.709% of the total variance. The scale was found to be reliable with a Cronbach's alpha reliability coefficient of 0.615. The Nature of Science Scale for Academics is useful for determining how academics perceive science and its nature, considering the shift from a positivist-objective understanding of science to a subjective one, and the impact of post-modernism on the hierarchical structure of values within cultural codes.

Keywords: Academics, Nature of science, Postmodernism, Positivism

Introduction

The Turkish Academy has been criticized for various reasons in recent years and has been shown to be far from the desired level based on bibliometric data (ULAKBIM, 2016; TISK, 2015; Akçigit & Özcan-Tok, 2020; Damar, Özdağoğlu, and Özveri, 2020). This situation arouses curiosity about how academics view science. Consequently, it is crucial to elucidate the concept of science in academics' world of thought and to demonstrate which currents of thought feed and influence their approaches to science. Thoughts and philosophical currents, on which academics build their mental patterns providing a background for their studies and affecting their view of science as a conceptual framework have undergone a change over time. The world of thought, which was embellished with traditional and metaphysical elements and presented a haphazard picture in terms of subjective diversity in the Middle Ages, gained a regular and positive appearance by attaining rational features with the Enlightenment and objective and methodical qualities with positivism after the 19th century. After the mid-20th century, the objectivity of positivism was shaken by Einstein's theories of relativity and developments in quantum physics, as well as by post-modernism, which made its effects felt in many areas.

In the philosophy of science, Popper's (2010) approach of "No observation is independent of theory" and Kuhn's (1982) principle of "incommensurability" are the most important criticisms brought to the positivist understanding of science (Popper, 2010; Kuhn, 1982). The phenomenon of the nature of science has emerged due to the understanding that has developed through the criticism of positivism. An understanding that the subject which has been ignored in the face of objectivity of positivism should be at the center of epistemological theory unconditionally has brought many values together with the

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subject. Therefore, fields of history, philosophy, and sociology of science have gained importance along with the subject.

At the beginning of 20th century, positivists of the Vienna Circle argued that science was a process of cumulative progress based on objective, experimental, and universal laws and saw observation and logical verification as the basic tools of knowledge production. However, this approach began to be questioned over time. The fact that the subject in science began to be given more priority, unlike its position in positivism, is based on the assumptions that science is mutable and therefore it is impossible to reach absolute true knowledge - as post-positivists put it inspired by Kuhn-, that intuitive approaches expressing the subject's imagination and creativity have become important, that science progresses through revolutions rather than cumulatively, and that, in a way, the positivist understanding cannot be applied to all fields of science. The concept of the nature of science developed on these assumptions considers all sociocultural and other value judgments affecting the subject.

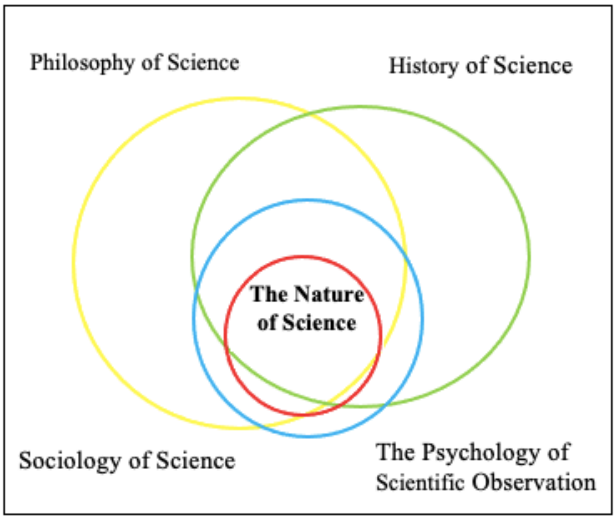

Figure 1. The Relationship Between the Nature of Science and Other Disciplines (McComas, Clough & Almazroa, 1998)

Thoughts on the nature of science have deepened with the development of philosophy of science, bringing about a broader questioning not only about what science is but also how it functions, how it gains meaning, and what values it is surrounded by. This questioning process not only defines science but also makes its conceptual, methodological, and cultural elements visible. The concept of "nature of science" contains a similarly multidimensional structure that is not fully agreed upon.

McComas and Olson (1998) examined eight declarations of international science standards and revealed the distinctive features of the nature of science. According to them, although scientific knowledge is reliable and durable, it does not have absolute certainty. Even though it is based on observation, experimental evidence, and logical reasoning, it is not obtained by a single method. It is also emphasized in this framework that observations are loaded with theory, i.e., they cannot be independent of preconceptions, and that science cannot be isolated from the socio-cultural context. Moreover, science progresses not only cumulatively but also revolutionarily, making it a dynamic process that distances it from constancy.

Similarly, Abd-El-Khalick et al. (1998) state that scientific knowledge is open to change and that even if it is based on experimental foundations, it contains subjectivity. According to them, scientific knowledge is based not only on observation but also on imagination, inference, and the creative human mind. Understanding the difference between inference and observation provides a deeper insight into what science is. Clarifying the distinction between hypothesis, theory, and laws is important in terms of correctly grounding the scientific thought structure.

While presenting the epistemological foundations of science, Lederman (1992; 2007) argues that science is not only a knowledge production process but also a system of values. According to him, socio-cultural context and changeability are among the basic concepts in science, as well as observation, inference, theory, imagination, and creativity. While stating that science does not progress with a universal and fixed method and can be shaped by multiple approaches, he argues that it is an activity that involves subjectivity rather than objectivity.
These approaches are important in terms of understanding the rise of subjective understanding of science. The subjective understanding of science, together with the phenomenon of the nature of science, has created a structure that can reveal the changes in characteristics of scientific knowledge. In transition from the positivist-objective understanding of science to the subjective understanding of science, Table 1 summarizes some of the changes reflected in the characteristics of science and scientific knowledge.

Table 1. Comparison of approaches between the objective and subjective understanding of science

Objective Understanding of Science	Subjective Understanding of Science
Scientific knowledge is objective.	Scientific knowledge is subjective (theory-laden).
Observation and experiments are prerequisites for obtaining scientific knowledge.	Theory is a prerequisite for obtaining scientific knowledge.
Scientific knowledge is unchangeable.	Scientific knowledge is mutable.
Science is activity of conducting research on facts independent of human consciousness.	Science is product of human creativity and imagination.
It is independent of social and cultural values.	It is affected by social and cultural values in which human beings are located.
Scientific knowledge progresses by accumulating.	Scientific knowledge provides breakthroughs through scientific revolutions.
It employs methodology.	There is no single method.
Definitive knowledge is obtained through confirmations and evidence.	Knowledge that is currently valid is reached through falsification.
Theories are unproven information that has explanatory power.	Theories are as important as scientific laws and do not turn into laws.

This transformation in the philosophy of science has brought about not only a methodological but also an ontological and epistemological rupture. Science is no longer considered an objective activity that attempts to explain the external world, but a dynamic structure shaped by mental, cultural, and historical contributions of humans.

Today, academics' perceptions of scientific knowledge, methods, and research processes affect their epistemological preferences and the quality of the knowledge they produce, their understanding of scientific ethics, and their social responsibilities to a decisive extent. A systematic understanding of the beliefs and attitudes of academics, especially those working in higher education institutions, regarding the nature of science is critically important in terms of the quality of scientific education, research ethics, and interdisciplinary approaches. This is because there are important differences between an academic attitude that sees scientific knowledge as objective, universal, and unchangeable and an approach that evaluates knowledge as subjective, context-dependent, and open to interpretation. These differences are directly reflected in academic production styles and the social function of scientists. Therefore, development of a valid and reliable nature of science scale that considers different approaches defined in the philosophy of science literature and is structured in line with modern, post-positivist, and post-modern perspectives is necessary to measure and make sense of epistemological stances of academics. A scale to be developed with this intention should include basic aspects, e.g., observation, theory, falsifiability, subjectivity, openness to change, socio-cultural context, creative processes, and methodical diversity regarding the nature of science, and allow the conceptual analysis of academics' attitudes in the knowledge production process. This will eventually allow assessment of the pluralism and dynamism in today's understanding of science more healthily and scientifically in terms of understanding and transforming academic culture.

The notion of nature of science can be presented as a reliable indicator in revealing how individuals professionally involved in science perceive it today. This is because nature of science, with the power it gets from the depths of history, philosophy, and sociology, is a phenomenon that can show views of academics about science, values they rely on in their scientific engagements, and sub-elements of the image of science in their minds. The nature of science is a phenomenon that has inclusive qualities both in the face of deterioration of the hierarchical structure of epistemological elements e.g., subject-object and observation-theory after positivism, and in the face of deterioration of the hierarchical structure of values, e.g., truth-lie, knowledge-belief, physics-metaphysics, in post-modernism, the weight of which is felt thoroughly today. This study seeks to develop a scale that can reveal how academics view science through the phenomenon of the nature of science.

Scales Developed on the Nature of Science

The examination of the nature of science scales used in the theses conducted in Türkiye between 2009 and 2022 and those developed abroad and adapted to Turkish revealed 103 uses. The most preferred scale was the "Views of Nature of Science C (VNOS-C)" scale designed by Abd-El-Khalick and Lederman (2000), which was used 44 times. It was followed by VNOS-E (11 times), VNOS-D (9 times), and VNOS-B (6 times). The Nature of Scientific Knowledge Scale (NSKS) by Rubba (1976) was used 6 times. There were also other scales used in Türkiye: Young Children's Views of Science (YCVOS) (Lederman, 2007) (used twice); Scientific Attitude Inventory (SAI) (Moore, 1969) (three times); Views on Science-Technology-Society (VOSTS) (Aikenhead, Ryan & Fleming, 1987) (19 times); Nature of Science as Argument Questionnaire (NSAAQ) (Sampson & Clark, 2006) (used twice); Critical Incidents (CI) (Nott & Wellington, 1995) (used only once).

There were also 38 scales developed locally and used in the theses on the nature of science in Türkiye between 2009 and 2022. These scales had been developed by different researchers and used especially in studies on science education, teacher candidates, and students. In this context, the most commonly used scale was the "Nature of Science Beliefs Scale (NOSBS)," which was developed by Özcan and Turgut (2014) and employed 16 times. It was followed by "Understanding the Nature of Science Scale (UNOSS)" by Can (2008) (6 times), "Nature of Science Scale (NOSS)" by Özgelen (2012) (5 times), and "A Conceptualized Family Resemblance Approach to the Nature of Science Scale (CFRA-NOS)" by Erduran & Dagher (2014) (5 times). Apart from these, VTSKS by Çoban and Ergin (2008) was used twice, the NOFSVT test by Yalaki, İrez, Doğan & Çakmakçı (2014) was used twice, and the scales developed by Muşlu (2008) and Hacıeminoğlu (2010) were used once each.

When the sample groups included in the postgraduate theses' studies on nature of science in Türkiye were examined, a total of 141 studies were found. The majority of these studies had been conducted with prospective teachers (56 theses). While primary and secondary school students were included in 51 studies, high school students constituted the sample group in 18 theses. The number of theses on currently working teachers was 15. Only one thesis study on preschool children was identified. This suggests that the nature of science research in the field of educational sciences and the scales created/adapted in this direction are far from revealing the views of the academics in Türkiye on the nature of science.

Method

Type of the Study: This study is methodological, cross-sectional, quantitative, and field research.

Study Setting: The research spanned from November 2019 to March 2020 and involved voluntary participation of 682 academics from four universities in the Central Anatolia Region.

Sample Selection: This research was planned as a thesis study and the research sample was calculated accordingly (Sarıkaya, 2023). 682 academics from four different universities participated in the study. The sample size of 682 academics was deemed sufficient for conducting both exploratory factor analyses

(EFA) and confirmatory factor analyses (CFA). The universities where the research would be conducted were determined after the categorical scientific field and academic title variables were standardized, thus ensuring similarity between the sample groups, which would be subjected to EFA and CFA. There are different approaches in the literature for the number of samples in factor analysis (FA). Tabachnick and Fidell (2013) recommended that a sample comprising 300 individuals sufficed for conducting FA. Comrey and Lee (1992) accepted 100 subjects as poor, 300 subjects as good, and 1000 subjects as excellent. Although there is no consensus in the literature regarding the number of observations in the data matrix, it is accepted as a good approach to have between 5 and 10 observations per variable. In our study, EFA was performed with a sample size of more than five times the 35 items on the scale (n=236). The number of observations in CFA (n=482) was more than twice the number of observations in EFA (n=236).

Steps Followed in the Research: In this research, which is a scale development study, the steps of the Lawshe method were followed (Lawshe, 1975). For this purpose, a pool of 57 items was initially generated, which were then evaluated by experts in their respective fields. Following expert assessments, the item count was trimmed down to 35, establishing the scale's scope. Afterward, the 35-item draft scale was applied to 236 academics at a university in the Central Anatolia Region and determined as explanatory with 19 items and 5 sub-dimensions. The scale was validated and its reliability was demonstrated based on responses from 446 academics from three other universities in the same region (Figure 2).

Literature review
↓
Creation of the item pool
↓
Preparation of expert evaluation form
↓
Calculating content validity ratios
↓
Obtaining the draft scale (data collection tool)
↓
Application of the draft scale
↓
EFA
CFA
Reliability Analysis
↓
Finalizing the Nature of Science Scale for Academics

Figure 2. Steps Followed in the Research

Creation of the Item Pool: An item pool consisting of 57 propositions reflecting the philosophy of science approaches of philosophers, e.g., the Vienna Circle, Popper, Kuhn, Feyerabend, and Lakatos, was created. This 57-item pool was transformed into an "Expert Evaluation Form" and was submitted to experts for evaluation. These experts consisted of academics from the field of philosophy of science, who had conducted studies on the nature of science, and those who had held high-level administrative positions (rectors, deans) in higher education institutions. The experts, consisting of 40 people, were asked to evaluate each item in the pool using one of the following options: "The proposition measures the targeted structure", "The proposition is related to the structure but unnecessary", or "The proposition cannot measure the targeted structure".

Content Validity: The validity of the scale is contingent upon the relationship between the measured attributes and the scale items. Content validity indicators and rates demonstrate the items' ability to measure (Turgut & Baykul, 1992). The content validity ratio (CVR) is calculated as the ratio of experts who affirmed that "the item measures the targeted structure" (deemed "appropriate") to the total number of experts who evaluated this proposition.

Propositions with a CVR value of zero or less (negative) are removed from the pool. The significance of the propositions with positive CVR values is determined by using statistical criteria. To determine the statistical significance of the obtained CVRs, while cumulative normal distribution had been utilized in the literature before related to the content validity criteria, the minimum values (content validity criteria) of the CVRs were converted into a table at α=0.05 for ease of calculation. Consequently, the minimum values for the number of experts also give the statistical significance of the item (Veneziano & Hooper 1997) (Table 2).

Table 2. Content validity criteria at α=0.05 for content validity ratios

Number of experts	Minimum value	Number of experts	Minimum value
5	0.99	13	0.54
6	0.99	14	0.51
7	0.99	15	0.49
8	0.78	20	0.42
9	0.75	25	0.37
10	0.62	30	0.33
11	0.59	35	0.31
12	0.56	40+	0.29

The content validity ratios of 57 items developed in our study are shown in Table 3.

Table 3. Content validity ratios of the items

Number	Item	Appropriate	Appropriate but needs correction	Should be removed	CVR
1	Science is the activity of solving existing problems to make life livable.	33	6	1	0.65
2	Science is the accumulation of knowledge that explains the world we live in.	33	7		0.65
3	Science is discovering new things.	32	7	1	0.60
4	Scientific knowledge is specific to scientists.	23	9	8	0.15
5	Science refers to seeking the objective reality of this world on the basis of the knowledge that has been experienced so far.	30	8	2	0.50
6	The pursuit of objectivity in science is futile.	16	9	15	-0.20
7	Science advances with proofs and validations.	34	4	2	0.70
8	Science advances through the accumulation of certain immutable laws.	28	9	3	0.40
9	No matter how diverse the fields of science are, only one scientific method is used.	17	13	10	-0.15
10	Scientists cannot have an absolutely objective point of view.	26	6	8	0.30
11	A scientific activity cannot be carried out without reasoning.	29	3	8	0.45
12	The results of science should be in accordance with the general opinion of society.	23	9	8	0.15
13	No scientific law is immutable.	37	2	1	0.85
14	Inaccurate information obtained from the research results of scientists slows down the progress of science.	28	4	8	0.40
15	Science need not be internally consistent.	16	6	8	-0.20
16	It is not the business of science to make assumptions about a subject that we cannot directly observe.	27	6	7	0.35
17	It is not right for science to penetrate every field of human beings.	22	11	7	0.10
18	In order for a piece of knowledge to be scientific, it has to be methodical.	30	6	4	0.50
19	Scientific knowledge is a set of beliefs accepted by scientists.	15	11	14	-0.25
20	Scientists' final findings from research need not be universal.	25	5	10	0.25

21	Science provides radical changes with sudden leaps and revolutionary breakthroughs.	29	9	2	0.45
22	Confirmed theories provide an absolute basis for larger theories based on the principle of induction.	30	5	5	0.50
23	Hypotheses, theories, and laws that emerge from experience in science are subjective and internal because they are mental.	22	9	9	0.10
24	In science, we should act according to the national and local understandings of our country.	23	5	12	0.15
25	Scientific generalizations cannot be valid unless proven by observation and experiment results.	25	13	2	0.25
26	The characteristic that makes a piece of knowledge scientific is its potential to be refuted.	28	11	1	0.40
27	Science should not exceed its own limits with the authority it receives from its technological achievements.	28	3	9	0.40
28	Knowledge of truth is closed to scientific methods.	19	2	19	-0.05
29	A theory or hypothesis, no matter how plausible it may seem, cannot be valid unless it is proven by facts.	32	8		0.60
30	A claim that cannot be directly tested cannot be scientific.	26	11	3	0.30
31	The objective world is limited to what takes place in the human mind.	24	10	6	0.20
32	The most reliable knowledge in a field is scientific knowledge, thanks to its method.	26	9	5	0.30
33	Theories precede all observational propositions.	32	5	3	0.60
34	The effort of science to explain universal laws can never be enough to change universal events.	20	6	14	-1
35	If results from an experiment contradict theories, they should be abandoned immediately.	26	4	10	0.30
36	Reason receives its laws from nature.	20	10	10	-1
37	Scientists, like everyone else, cannot get rid of their life values, beliefs, and moral norms.	29	7	4	0.45
38	New observations by scientists who believe in different theories in a field of science will also be different.	24	11	5	0.20
39	It is not correct to act only according to the data of the objective world and not to mention supernatural powers (God, angels, etc.) in scientific explanations.	21	3	16	0.05
40	The fact that an explanation that is not factual in terms of content is logical in terms of form does not give it a scientific characteristic.	32	6	2	0.60
41	The knowledge obtained through the scientific method has no superiority over the knowledge coming from an intuitive, superhuman, and divine ability to know.	20	9	11	-1
42	Scientific knowledge is the common product of societies with various religions, languages, history, geography, and culture.	33	4	3	0.65
43	The scope of the scientific method is limited to material fields.	26	9	5	0.30
44	The job of science is to detect objects that exist beyond the field of observation.	19	12	9	-0.05
45	Scientists should be able to predict the possible outcomes of their experiments.	26	5	9	0.30
46	Two contradictory propositions in science can also be accepted as true.	21	7	12	0.05
47	A scientist should not see any harm in the repetition of his/her research related to the field he/she studies, exactly or partially, by scientists from other nations.	29	4	7	0.45
48	It is more difficult to verify a theory than to disprove it.	32	4	4	0.60
49	Science is the match between the design in the mind with the object or phenomenon in the outside world.	18	14	8	-0.1
50	Science progresses by trial and error, assumptions, and falsifications.	35	4	1	0.75
51	What makes natural phenomena intelligible is reason.	31	2	7	0.55
52	Anything that is not expressed through propositions from a scientific point of view has no meaning.	26	8	6	0.30
53	Progress in science is not continuous.	22	6	12	0.1
54	No error or deviation can be permanent in science.	32	7	1	0.60
55	It cannot be expected that the method followed in a study will be accepted by everyone.	32	4	4	0.60
56	It is undesirable for scientific research to raise new problems.	27	3	10	0.35
57	The source of true knowledge is observation and experimentation.	34	1	5	0.70

The Content Validity Index (CVI) serves to determine the validity of the scale. It is calculated by dividing the mean value of the Content Validity Ratios (CVR) by the number of scale items and is determined at $\alpha=0.05$. Items with insignificant CVRs are removed from the scale and only propositions that are significant at $\alpha=0.05$ are included. For content validity of the scale, CVI≥CVR or CVI/CVR≥0 should be ensured. In our study, CVI=0.497, and as a result of the evaluations performed by 40 experts, CVR≥0.29. For this reason, the scale's content validity was statistically significant, and a 35-item draft scale was obtained by removing 22 items from the 57-item pool.

Data Analysis: The data obtained from face-to-face interviews from 682 academics were analyzed on appropriate statistical software. The Analysis of Moment Structures (AMOS) software was used for CFA. Table 4 summarizes the statistical analyses performed.

Table 4. Statistical analyses used in this research

Aspects studied		Statistical analyses used
Socio-demographic Results		Frequency, percentage, mean, median Pearson, Chi-Square ($p<0.05$ significance level)
Content validity		CVR CVI
Construct validity	EFA	Kaiser-Meyer-Olkin (KMO) Bartlett's test of sphericity Varimax rotation
Construct validity	CFA	Chi-Square (Chi-Square Goodness of Fit) RMSEA (Root Mean Square Error of Approximation) NFI (Normed fit Index) CFI (Comparative Fit Index) TLI (Tucker-Lewis Index), GFI (Goodness of Fit Index) AGFI (Adjusted Goodness-of-fit Index)
Reliability		Cronbach's alpha analysis

Results

Socio-demographic findings: The average age of the academics involved in the study was 38.4±9.7 years. The age groups of the participants were 43.1%, 24-34; 31.1%, 35-44; 16.9%, 45-54; 8.9%, ≥55. The mean work experience as an academic was 11.6±9.52 years. The groups according to participants' academic experience were 26.2%, 1-4 years; 42.5%, 5-14 years; 17.6%, 15-24 years; 13.6%, ≥25 years. Of the academics in the research group, 34.6% worked at one university (AuthorsInstitution), 33.4% at Sivas Cumhuriyet University, 18.2% at KaramanoğluMehmetbey University, and 13.8% at Kırıkkale University. The distribution of academics according to their categorical fields of science was 21.8%, medicine; 0.6%, law; 19.2%, architecture and engineering; 10.1%, economics and administrative sciences; 5.4%, health sciences; 5.9%, social sciences; 8.7%, pharmacy, veterinary, and dentistry; 10.4%, educational sciences. Regarding the academic titles of the participants, 13.5% were Professors, 14.4% were Associate Professors; 27.0% were Dr. Faculty Members, 1.9% were Lecturers, 0.6% were Lecturer Dr., 22.4% were Research Assistants, and 20.2% were Research Assistant Dr. (Table 5).

Table 5. Distribution of academics by gender, age, years of academic experience, universities, categorical fields of science, and academic titles

Gender	N	%
Female	304	44.6
Male	378	55.4
Age		
24-34	294	43.1
35-44	212	31.1
45-54	115	16.9
≥55	61	8.9
Academic experience (year)		
1-4	179	26.3
5-14	290	42.5
15-24	120	17.6
≥25	93	13.6

Categorical fields of science	N	%
Medicine	149	21.8
Law	4	0.6
Architecture and Engineering	131	19.2
Basic Sciences	122	17.9
Economics and Administrative Sciences	69	10.1
Health Sciences	37	5.4
Social Sciences	40	5.9
Pharmacy, Veterinary and Dentistry	59	8.7
Educational Sciences	71	10.4
Academic title		
Professor Dr.	92	13.5
Associate Professor Dr.	98	14.4

University					
AuthorsInstitution	236	34.6	Dr. Faculty Member	184	27.0
Sivas Cumhuriyet University	228	33.4	Lecturer	13	1.9
Karamanoğlu Mehmet Bey Univ.	124	18.2	Lecturer Dr.	4	0.6
Kırıkkale University	94	13.8	Research Assistant	153	22.4
Total	**682**	**100**	Research Assistant Dr.	138	20.2
			Total	**682**	**100**

Construct validity: FA employed both to ensure the integrity of the scale and eliminate unrelated variables is used to reflect the degree of originality of the theoretical structure underlying the provided information (Erdoğan, Nahcivan & Esin, 2014). EFA was performed in the first stage for the validity analysis of the scale. Prior to the EFA, the Kaiser-Meyer-Olkin (KMO) test was conducted to assess whether the sample size was sufficient for FA. The KMO value was 0.871. In the literature, KMO values are interpreted as 0.90-1.00, excellent; 0.80-0.89, pretty good; 0.70-0.79, good; 0.60-0.69, moderate; 0.50-0.59, weak; <0.50, unacceptable (Altunışık, Coşkun, Bayraktaroğlu & Yıldırım, 2010; Sharma, 1996). Accordingly, it was found that the sample size of the study was appropriate to perform FA. Bartlett's test of sphericity indicated that correlation between the variables was adequate and the data structure was suitable for factor analyses. It was determined that the data set we obtained in our study was suitable for performing FA ($\chi 2$=363.275 and $p<0.001$) (Table 6). Principal component analysis and Varimax, one of the orthogonal rotation methods, were used as factorization methods to determine the factor pattern of the Nature of Science Scale for Academics (NOSSFA). There is no full consensus on the definition and nature of science in the literature, and the sub-dimensions of the nature of science have not yet been clearly defined. For this reason, the Varimax rotation method was preferred in this study. In this way, independence between the factors was preserved, the distribution of variables to factors was revealed more clearly, and the interpretability of the obtained factor structure was tried to be increased. The factor load value must be at least 0.32 to determine that a proposition measures the factor in which it is included. A proposition with a factor load of 0.30-0.60 measures the structure at a moderate level, and a proposition with a factor load >0.60 measures the structure at a high level (Tabachnick & Fidell, 2013). In the EFA conducted to ascertain the scale's factor pattern, a threshold of 0.30 was set for acceptable factor loading values. In the analysis performed for the five factors, 16 items whose explained variances were not greater than 30% and which were among the overlapping items group and had a factor load difference of more than 0.100 units from that of other items in the group were removed from the scale. The 5th and 31st items were determined as reverse items and reverse-coded. After conducting EFA following the removal of overlapping items, it was found that the factor loadings met the desired criteria and no items overlapped. The factor loads of the items ranged between 0.526 and 0.819, which was considered a good level (Table 6). As a result of Varimax rotation, the propositions were grouped under five factors (dimensions). These factors explained 52.709% of the total variance. Since variance rates ranging from 40-60% were considered ideal (Cliff, 1998), the contribution of each factor to the total variance was adequate.

Table 6. Results of EFA for the dimensions of the Nature of Science Scale for Academics at Universities

	Dimensions and items	**Rotated Factor Loads**	**Explained variance**
Definition of Science	1. Science is the activity of solving existing problems to make life livable.	0.755	16.622
	2. Science is the accumulation of knowledge that explains the world we live in.	0.819	
	3. Science is discovering new things.	0.779	
	4. Science refers to seeking the objective reality of this world on the basis of the knowledge that has been experienced so far.	0.737	
	5. Science advances with proofs and validations.	0.685	
Systematicity and Reality	12. In order for a piece of knowledge to be scientific, it has to be methodical.	0.730	10.208
	15. The characteristic that makes a piece of knowledge scientific is its potential to be refuted.	0.540	
	17. A theory or hypothesis, no matter how plausible it may seem, cannot be valid unless it is proven by facts.	0.548	

	19. The most reliable knowledge in a field is scientific knowledge, thanks to its method	0.526	
	23. The fact that an explanation that is not factual in terms of content is logical in terms of form does not give it a scientific characteristic.	0.619	
Openness to Change	11. It is not the business of science to make assumptions about a subject that we cannot directly observe.	0.606	8.789
	21. If results from an experiment contradict theories, they should be abandoned immediately.	0.697	
	34. It is undesirable for scientific research to raise new problems.	0.688	
Falsifiability in Science	28. It is more difficult to verify a theory than to disprove it.	0.650	8.238
	29. Science progresses by trial and error, assumptions, and falsifications.	0.663	
	30. What makes natural phenomena intelligible is reason.	0.658	
Subjectivity in Science	7. Scientists cannot have an absolutely objective point of view.	0.597	8.221
	22. Scientists, like everyone else, cannot get rid of their life values, beliefs, and moral norms.	0.722	
	35. The source of true knowledge is observation and experimentation.	0.578	
	Kaiser-Meyer-Olkin=0.871 **Bartlett's Test of Sphericity**; χ^2 =363.275; p<0.001		**Total Explained Variance** 52.709

The "Definition of Science" factor consisted of items 1, 2, 3, 4, and 5, and it explained 16.622% of the total variance. The "Systematicity and Reality" factor consisted of items 12, 15, 17, 19, and 23 and it explained 10.208% of the total variance. The "Openness to Change" factor consisted of items 11, 21, and 34, and it explained 8.789% of the total variance. The "Subjectivity in Science" factor consisted of items 7, 22, and 35, and it explained 8.238% of the total variance. The "Falsifiability in Science" factor consisted of items 28, 29, and 30, and it explained 8.221% of the total variance.

CFA was carried out with a different sample group consisting of 446 academics with the same characteristics to confirm the results obtained from the EFA. First, the categorical scientific field and academic title variables were standardized, and then the universities where the research would be conducted were identified. This provided similarity between the sample groups, which were subjected to EFA and CFA. Based on the findings from the CFA, it was established that the structural equation modeling result for the scale was significant at p<0.001 level, indicating its association with the 19-item structure comprising the Nature of Science Scale for Academics. The goodness of fit of the structure, which consists of five factors with EFA, was improved. Variables that reduced the rate of fit were determined while the structure was improved, and new covariances were identified for those with elevated covariance among residual values (e6-e7; e15-e16) (Table 7).

Table 7. Goodness-of-fit indices of the Nature of Science Scale for Academics at Universities according to multi-factor model CFA

RMSEA	NFI	CFI	IFI	GFI	TLI	AGFI	$\chi2$	$\chi2/df$
0.049	0.849	0.900	0.901	0.944	0.879	0.925	370.867	2.612
RMSEA	NFI	CFI	IFI	GFI	TLI	AGFI	$\chi2$	$\chi2/df$
0.048	0.864	0.916	0.917	0.951	0.897	0.934	332.661	2.376

The first calculated fit indices and those obtained in the analyses repeated after the improvements are given in Table 6. The fit indices of the Nature of Science Scale for Academics at Universities according to multi-factor model CFA were RMSEA=0.048, GFI=0.951, AGFI=0.934; CFI=0.916; $\chi2$=332.661 (p<0.001). These values indicated an excellent fit between the model and the data (Table 8).

Table 8. The fit indices used in CFA and the results

Fit indices	Good fit	Acceptable fit	Results obtained	Evaluation
χ^2/df	$0 \le \chi^2/df \le 2$	$2 \le \chi^2/df \le 3$	2.376	Acceptable fit
RMSEA	0≤RMSEA≤.05	0.05≤RMSEA≤0.08	0.048	Good fit
NFI	0.95≤NFI≤1.00	0.90≤NFI≤.95	0.864	Poor fit
IFI	0.95≤IFI	0.90≤IFI	0.917	Acceptable fit
GFI	0.90≤GFI	0.85≤GFI	0.951	Good fit
AGFI	0.90≤AGFI	0.85≤AGFI	0.934	Good fit

(Source: Schermelleh-Engel, Moosbrugger&Müler, 2003; Kline, 2011)

The model illustrates the CFA for the Nature of Science Scale for Academics, highlighting a multi-factor model with five distinct factors (Figure 3). Each factor represents a specific dimension of how academics perceive the nature of science.

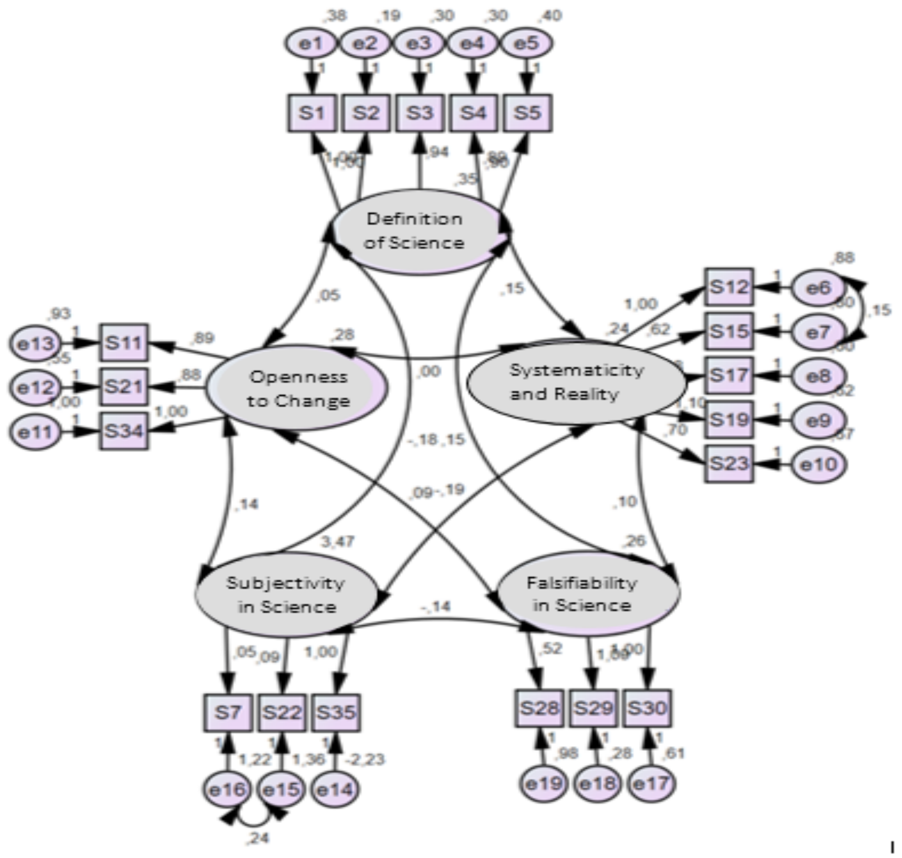

Figure 3. Multi-factor model CFA of the Nature of Science Scale for Academics at Universities

Definition of Science: Items S1 to S5 are loaded onto this factor with significant factor loadings (0.35, 0.89, 0.90, and 1.00, respectively). The error variances (e1 to e5) are relatively small, indicating that the items are well-represented by this factor. **Openness to Change:** Items S11, S21, and S34 load onto this factor, with loadings of 0.89, 0.88, and 1.00, respectively. The error variances (e11 to e13) are also small, showing good representation of the items. **Systematicity and Reality:** Items S12, S15, S17, S19, and S23 load onto this factor, with loadings ranging from 0.70 to 1.00. The error variances (e6 to e10) indicate that the items have a strong relationship with the factor. **Subjectivity in Science:** Items S7, S22, and S35 load onto this factor, with loadings of 1.22, 1.36, and-2.23, respectively. The error variances (e14 to e16) suggest some variability, but the items generally align well with the factor. **Falsifiability in Science:** Items S28, S29, and S30 load onto this factor, with loadings ranging from 0.52 to1.00. The error variances (e17 to e19) indicate a good fit for these items with the factor.

The model shows significant factor loadings and small error variances, indicating well-defined and reliable items and factors. This multi-factor model provides a comprehensive framework for understanding how academics perceive various dimensions of the nature of science, making it valuable for educational and research purposes. Understanding these dimensions and their interrelationships offers insights into how academics view science. The Nature of Science Scale for Academics, validated by this CFA, provesto be a reliable instrument for these purposes. (Figure 3).

Reliability: Cronbach's α is used as an internal consistency criterion in determining the reliability level of Likert-type scales. This coefficient ranges between 0 and 1, with high values indicating that propositions are in harmony with each other and capable of measuring elements of the same quality. Confidence levels according to α values are as follows: $\alpha<0.40$, the scale is unreliable; $0.40\leq\alpha<0.60$, the scale has low reliability; $0.60\leq\alpha<0.80$, the scale is quite reliable; $0.80\leq\alpha<1.00$, the scale is highly reliable (Tezbaşaran, 1996). The Nature of Science Scale for Academics exhibited a Cronbach's alpha reliability coefficient of 0.615, signifying a reasonably reliable measure.

Discussion

There are scales developed under the concept of Nature of Science in the literature. One of them is the Test on Understanding Science (TOUS) scale, which was developed by Cooley and Klopfer in 1961 to measure the nature of science and the concept of science (Cooley & Klopfer, 1961).

Another instrument is the “Views of Nature of Science Questionnaire” (VNOS), developed by Lederman, Abd-El-Khalick, Bell, and Schwartz to measure the understanding of secondary school students, prospective teachers, and teachers about the nature of science (Lederman et al., 2002). The aim of the Scientific Attitude Inventory (SAI) scale, developed by Moore, is to measure attitudes toward science (Moore, 1969). The Scientific Attitude Scale (SAS), developed by Billeh and Zakhariades, includes six dimensions: rationality, curiosity, open-mindedness, avoiding superstitions, objectivity and intellectual honesty, and deferred judgment (Billeh & Zakhariades, 1979).

The sub-dimensions on the Nature of Science Scale (NSS), developed by Muşlu (2008) in the doctoral thesis, are “science,” “structure of scientific knowledge,” and “scientific method”. The Nature of Science Scale for Academics, developed in our study, is different from the Nature of Science Scale developed by Muşlu in terms of the “openness to change,” “falsifiability in science,” and “subjectivity in science” sub-dimensions.

The “Understanding the Nature of Science Scale” (NSS), which Can (2008) developed in the doctoral thesis, titled “Factors Affecting Elementary School Students’ Understanding of the Nature of Science,” consists of three sub-dimensions: “science,” “scientific knowledge,” and “scientist”. This study aims to measure students’ understanding of science, scientific knowledge, and scientists. The “definition of science” sub-dimension on the Nature of Science Scale for Academics has some common semantic items with the “science” sub-dimension on the Understanding the Nature of Science Scale, and the “systematicity and reality,” “subjectivity in science,” and “falsifiability in science” sub-dimensions have common semantic items with the “scientific knowledge” sub-dimension, independent of the target audience.

The “Nature of Science Questionnaire” (NSQ), developed by Hacıeminoğlu (2010) aims at revealing primary school students’ views on the nature of science and includes four sub-dimensions: “changeability of science,” “experimental science,” “imagination and creativity,” and “observation and inference”. There are some similarities between the “changeability of science” sub-dimension on the NSQ and the “openness to change” sub-dimension of the Nature of Science Scale for Academics, and between the “imagination and creativity” sub-dimension and the “subjectivity in science” sub-dimension.

Another scale, namely the Nature of Science Scale (NSS), was developed by Özgelen (2013) for prospective teachers. The Nature of Science Scale consists of the sub-dimensions of “characteristics of scientific knowledge and scientists,” “openness to change,” “subjectivity and technology,” “social-cultural structure of science," and "place of theories in science". There are some similarities between sub-dimensions of the Nature of Science Scale by Özgelen and the Nature of Science Scale for Academics, developed in this study, in terms of the meaning of the items: "characteristics of scientific knowledge and scientists" sub-dimension vs. "definition of science" sub-dimension; "openness to change" sub-dimension vs. "openness to change" sub-dimension; "subjectivity and technology" and "social-cultural structure of science" sub-dimensions vs. "subjectivity in science" sub-dimension.

The "Nature of Science Beliefs Scale" (NSBS), developed by Özcan (2014) in the master's thesis study, consists of seven sub-dimensions: "change in scientific knowledge," "observation and inference," "scientific method," "creativity and imagination," "recognitions and limits in science," "socio-cultural impact," and "scientific laws and theories". This scale is similar to the Nature of Science Scale for Academics in terms of meaning of the items constituting the sub-dimensions.

When the scales developed with the "nature of science" title in Türkiye were examined formally, independent of the target audience, it was found that they had three to seven sub-dimensions.

The "Views toward Scientific Knowledge Scale," developed by Çoban and Ergin (2008), consists of three sub-dimensions and a total of 16 items. The "Nature of Science Scale," developed by Muşlu (2008), consists of three sub-dimensions and 10 items. The "Understanding the Nature of Science Scale," developed by Can (2008), consists of three sub-dimensions and a total of 40 items. The "Nature of Science Questionnaire," prepared by Hacıeminoğlu (2010), consists of four sub-dimensions and 13 items. The "Nature of Science Scale," developed by Özgelen (2013), consists of five sub-dimensions and 19 items. The "Beliefs toward the Nature of Science Scale," developed by Özcan (2014), consists of seven sub-dimensions and a total of 37 items.

The Nature of Science Scale for Academics, devised in this study, aligns with other scales in the literature concerning the sub-dimensions (5) and the number of items (19) dedicated to the nature of science.

The nature of science studies and scales in the field of educational sciences generally focus on students, prospective teachers, and teacher groups, and therefore, the scales in the literature do not fully reflect the views of academics in Türkiye about the nature of science. The Nature of Science Scale for Academics plays a crucial role in addressing this gap.

Conclusion

The Turkish Academy has been criticized for various reasons lately, and bibliometric data show that the desired level has not been achieved in the academic field. It is thought that these problems should be addressed primarily on a philosophical basis. In this context, it is important to reveal how academics view science. The Nature of Science Scale for Academics developed in this research can be used to reveal the views of academics about science and the nature of science through a comprehensive framework. The originality of the Nature of Science Scale for Academics is that it can be used to determine how academics perceive science and the nature of science in the face of both the change caused by the transition from the positivist-objective understanding of science in the philosophy of science to the understanding of subjective science in the hierarchical structure of epistemological elements and the deterioration of the hierarchical structure of values in cultural codes with the effect of post-modernism. Determination of the views of academics on the nature of science in larger sample groups will contribute to revealing the problems that cause bottlenecks in the philosophical ground of the Turkish Academy.

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