ORIGINAL ARTICLE

Preservice Science Teacher Attitudes towards the Reconceptualized Family Resemblance Approach to the Nature of Science

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Abstract: *This study aimed to determine preservice science teachers' (PST) attitudes towards the Reconceptualized Family Resemblance Approach to the Nature of Science and to examine PST attitudes towards this approach according to grade levels. The study group consists of 75 people studying in the 3rd and 4th year of undergraduate education. The sample of the study was determined through 'purposive sampling'. The screening model, one of the quantitative research methods, was used in the research. The questionnaire consists of 70 items and 6 categories. The Cronbach's Alpha value of the scale, for which the reliability study was conducted, was determined as 0.73. To examine the distribution of the data, the Shapiro-Wilk test was performed as a normality test and the kurtosis and skewness values of the data were read. Independent sample t-test was applied on normally distributed 3rd and 4th grade PST data. According to the findings, it was determined that the PST was above the average and had a positive attitude. Although there is a difference between PST perspectives at two different grade levels for two questions of the scale, there is no significant change among PST for the entire performance.*

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Introduction

IN TODAY'S world, the importance given to science education has begun to increase again due to the growing needs of countries. Although it gained significant momentum about a decade ago, the emphasis that countries place on science education dates back much further. The competition between countries has intensified day by day, starting with the industrial revolution and continuing through the post-Cold War era, which marks a pivotal point close to the present day. Countries aiming to gain a competitive edge in this increasingly competitive environment have identified the inadequacy in science and mathematics learning as the root cause of developmental disruptions (Türkmen & Yalçın, 2001). Based on this realization, the objectives of science education have evolved over time. The goal now is to cultivate scientifically literate individuals, achieved through an understanding of the nature of science (Irzik & Nola, 2011). To foster scientific literacy, it is essential to comprehend scientific concepts and the essence of science education. Nonetheless, defining what science truly encompasses remains a topic of ongoing debate among scientists. Despite ongoing debates, the scientific community generally agrees on several aspects defining what science entails. One such perspective emphasizes that while scientific knowledge relies on experimentation and observation, it remains dynamic and subject to change. It integrates social and cultural elements, employing imagination and reasoning alongside observation, inference, theories, and laws. Another widely accepted view posits that the driving force behind science is curiosity, initiating a continuous and dynamic process. Furthermore, science is widely regarded as transcending political, geographical, and religious boundaries, welcoming diverse research and contributions (Türkmen & Yalçın, 2001). To achieve scientific literacy, individuals must possess specific attitudes, skills, and understandings. These include the ability to conduct research, question effectively, solve problems, make informed decisions, think critically, and continually engage in lifelong learning.

Science was born as a result of human beings' desire to satisfy their sense of curiosity by understanding the universe. Data obtained from experiments and observations can be verified and refuted by other researchers. While debates continue about the definition of science, some scientists argue that to understand what science is, it is necessary to understand what science is not. Addressing what science is not leads us to Pseudo-Science. Pseudo-Science mimics the methods and appearance of science, asserting that results obtained by chance and cannot be replicated should be considered scientific (Yardımcı, 2019). Proponents of this idea argue that alongside teaching the nature of science, it is crucial to explain what Pseudo-Science entails. However, merely informing students about

Pseudo-Science and advising them to avoid it is insufficient. When students seek to differentiate between examples of science and Pseudo-Science, they should be taught how to evaluate and analyze these examples from various perspectives. Teaching Pseudo-Science in this manner will also aid in understanding the nature of science (Park & Brock, 2023).

The aim of teaching the nature of science extends beyond imparting scientific subjects and laws. It includes exploring the historical development of these subjects and laws to help students understand the interdisciplinary aspects encompassing history, psychology, sociology, and philosophy of science, as well as the processes through which scientists arrive at these conclusions (Türkmen & Yalçın, 2001). However, merely defining the nature of science was deemed insufficient. The dynamic and multifaceted nature of science precludes creating a definitive checklist to determine what qualifies as science. In response, the consensus view was introduced to provide a generalized understanding of science based on commonly accepted scientific characteristics. While some scientists endorse this consensus view, others argue it oversimplifies science, particularly by neglecting the diverse methods used to acquire scientific knowledge. Critics also contend that it fails to acknowledge variations among scientific disciplines; for instance, the methodologies in non-experimental cosmology differ significantly from those in experimental chemistry. To address these limitations, the "Family Resemblance Approach" was proposed as a means to account for the diverse practices and methodologies within scientific disciplines (Irzik & Nola, 2011). The family resemblance approach builds upon the consensus view and examines the relationships between scientific categories within this framework (Dagher & Erduran, 2023). This approach represents an evolution of the consensus view rather than a contradiction, as it emphasizes similarities and differences among scientific disciplines (Irzik & Nola, 2011). It argues that scientific fields can resemble each other in certain respects, akin to a family, while also maintaining distinct characteristics. The approach advocates for categorizing scientific disciplines based on evolving criteria rather than rigid definitions. For instance, not all activities involving observation qualify as science, and conversely, some non-observational activities may still be considered scientific (Irzik & Nola, 2011). The family resemblance approach is applicable across undergraduate education, STEM curricula, and textbooks, aiming to integrate nuanced perspectives into teaching practices (Irzik & Nola, 2023). Effective implementation in educational settings necessitates comprehensive theoretical and practical in-service training for educators on the nature of science. Educators equipped with such training and readiness can effectively utilize all three primary structures in teaching the family resemblance approach (Kurt & Kaya, 2023).

The family resemblance approach forms a whole by connecting each of the 3 main structures with each other. These structures;

1. A cognitive-epistemic and social institution,
2. The category and feature of science that gives meaning to this distinction is
3. Different scientific disciplines create family resemblances.

Science is often categorized into two domains: cognitive-epistemic science and science as a social institution. Cognitive-epistemic science encompasses the processes involved in acquiring scientific knowledge, including observation, experimentation, theorizing, and testing. This aspect of science can be further analyzed through four dimensions: practices, goals and values, methods and methodological rules, and scientific knowledge. On the other hand, science as a social institution operates within a framework that includes systems of reward and punishment, ethical norms (such as respect for research subjects, openness to new ideas, and intellectual honesty), and the allocation of financial resources. While the family resemblance approach does not exclusively belong to a specific conceptualization of the nature of science, it is essential to consider all three structures cognitive-epistemic science, science as a social institution, and the family resemblance approach to gain a comprehensive understanding of the complexities of scientific practice (Irzik & Nola, 2023).

Shortly after scientists introduced the family resemblance approach, Erduran and Dagher undertook an examination and expanded it into a comprehensive framework (Irzik & Nola, 2011). In 2014, Erduran and Dagher further redefined the family resemblance approach to the nature of science and developed the 'Family Resemblance Approach Wheel' to organize its categories (**Figure 1**). According to this reconceptualization, cognitive-epistemic science is categorized into "aims and values," "methods and methodological rules," "scientific practices," and "scientific knowledge." Meanwhile, science as a social institution encompasses a total of 11 categories, including "scientific value systems," "social validation and dissemination," "professional activities," "social values," "financial systems," "political power structures," and "social institutions and interactions" (Erduran & Dagher, 2014).

When examining each category individually, within the cognitive-epistemic system of science, the goals and values category encompasses principles such as accuracy, objectivity, consistency, and rationality. Scientific practices include activities such as observation, classification, explanation, discussion, and reasoning. The methods and methodological rules category consist of observational, investigative, and analytical methods, along with their respective protocols. Scientific knowledge encompasses theories, laws, and models as examples. In terms of professional activities, scientists engage in participating in conferences, presenting findings, writing articles, developing grant proposals, and securing funding. Scientific values

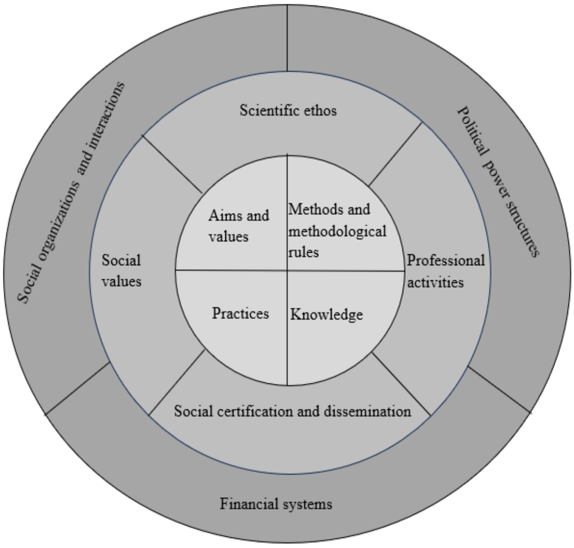

Figure 1. The Wheel of Family Resemblance: Science as a Cognitive-Epistemic and Social-Institutional System (*From Erduran & Dagher, 2014*)**.**

encompass elements such as skepticism, universality, impartiality, freedom, intellectual honesty, and respect for research subjects. Within the social institutional framework of science, the category of social validation and dissemination involves the critical review and community approval of scientific findings. Social values in science encompass considerations such as societal benefits, environmental respect, and power dynamics. Social institutions and interactions are exemplified by collaborations within research teams across different projects. Political power structures in science address how scientists navigate political environments to advance their research agendas. The financial systems category includes topics such as economic intermediation and funding within scientific endeavors (Dagher & Erduran, 2023). This summary organizes and describes each category within both the cognitive-epistemic and social institutional aspects of science as outlined by Dagher and Erduran (2023), aiming to provide a comprehensive view of the complexities involved in scientific practice.

The reason for applying the family resemblance approach in science education is its potential to support scientific reasoning in both scientific and social contexts (Dagher & Erduran, 2023). This potential makes teaching the reconceptualized family resemblance approach to the nature of science suitable for all grade levels. However, in this approach, teaching must be articulated vertically. Vertical articulation can be explained as the progressive advancement of teaching at each grade level, from simpler to more complex concepts. The nature of science is a field that facilitates students' understanding of science and guides teachers and researchers. However, teachers often struggle to incorporate nature of science teaching into their lessons, primarily due to the shortcomings of textbooks. The categories of the family resemblance approach should be clearly explained in textbook chapters. This alignment between content and activities can help students gain a deeper understanding of the nature of science (Okan & Kaya, 2023). Although these problems can be addressed through changes in the curriculum or through in-service training for teachers, it is also crucial to focus on preservice teacher education by delving deeper into the issue based on the existing literature, which highlights a number of studies conducted with preservice teachers.

One of the studies in the literature involves a workshop conducted by Cullinane and Erduran with Irish preservice science teachers in 2022. The study aimed to familiarize prospective teachers with the categories of the reconceptualized family resemblance approach to the nature of science and enable them to develop lesson plans accordingly. Following the workshops, it was observed that activities aligned with this approach positively impacted the interest and knowledge of prospective teachers. Their motivation increased, and although they varied in levels of proficiency, prospective teachers showed improvement in integrating the approach's categories into their lessons. Similarly, Barak et al. (2023) suggested that encouraging preservice teachers to draw or verbally and in writing explain their understanding could help them articulate what they have learned and how they intend to convey it. In another study by Voss et al. (2023), it was emphasized that teaching the family resemblance approach should not only equip preservice teachers with the skills to teach the nature of science but also guide them in helping students connect these criteria to various aspects of science. Erduran et al. (2021) conducted a comparative study with Turkish and British preservice teachers to evaluate their perception of the family resemblance approach in different national contexts. They found that group discussions facilitated understanding of the approach's categories among prospective teachers and suggested that teaching family resemblance to secondary school students could similarly benefit from group discussions. Lastly, Wu and Erduran (2024) examined scientists' perspectives on the family resemblance approach, noting that while scientists could elaborate on cognitive-epistemic aspects, their explanations regarding the social institutional aspect were often inadequate based on data from open-ended interviews.

Teaching the nature of science begins with formulating widely accepted general explanations and culminates with the family resemblance approach (Irzik & Nola, 2023). Given that the primary goal of science education is to cultivate scientifically literate individuals, teaching the nature of science becomes imperative. The family resemblance approach to the nature of science contributes to this goal directly and indirectly supports the development of scientific literacy. Therefore, the attitudes of preservice science teachers, who will shape the scientific literacy of future generations, toward the family resemblance approach are crucial. While there are existing studies on the application of the family resemblance approach in the literature, there is a lack of model studies specifically examining attitudes toward different grade levels. Consequently, the main objective of this study is to assess the attitudes of prospective science teachers toward the reconceptualized family resemblance approach to the nature of science and to compare these attitudes across various grade levels. To achieve this goal, the study seeks answers to the following questions:

RQ 1. What is the level of pre-service science teachers' attitudes towards the reconceptualized family resemblance approach to NOS?
RQ 2. Is there a significant difference between preservice science teacher attitudes towards the reconceptualized family resemblance approach to the nature of science according to their grade levels?

Method

Research Design

In this research, which aims to examine the attitudes of 3rd and 4th grade science education students toward the family resemblance approach to the nature of science, the screening model, one of the quantitative research methods, was employed. The purpose of this method is to describe and uncover the current situation (Büyüköztürk et al., 2020).

Study Group

While the population of the research consists of all students in the Science Teaching Program studying at the Faculties of Education in Turkey in the 2023-2024 academic year, the sample was selected from 3 universities located in one of the metropolitan cities in Turkey, which was in line with the purpose. A total of 84 Science students, 38 (48.7%) of whom were third-year undergraduate students and 40 (51.3%) of whom were fourth-year undergraduate students, were selected through 'purposive sampling'' to form the study group in the Science Teaching Program of the Faculty of Education at the selected university. His knowledge is that of a preservice teacher. When the incorrectly filled scales were eliminated, the final study group was conducted with a total of 75 preservice science teacher, 37 of whom were from the third grade (49.3%) and 38 from the fourth grade (50.7%).

Table 1. Positive and Negative Items on the Scale (Kaya et al., 2019)

Category	Example	#	Positive and Negative Items in the Scale	
			Positive	**Negative**
Aims and Values	*The diversity of scientists solving a problem together means less biased results. (Positive item)*	7	2,30,40,5,1,69	46.56
Scientific Practices	*Each branch of science has a different nature. (Positive item)*	13	4,5,15,19,23,33,38 57,61, 63	26,52,64
Scientific Method	*Different branches of science such as physics, biology and chemistry have the same applications. (Negative item)*	9	11,22,24,28	8,25,37,49, 60
Scientific Knowledge	*Scientific knowledge does not change. (Negative item)*	9	10,30,44,50, 54	3,16,43,66
Social Institutional Aspects	*Scientists must respect the environment. (Positive item)*	16	7,9,14,32,34,41 45,48,53,58,67,70	13,18,36,39
Educational Applications	*Science teaching should state that laws are certain and unchangeable. (Negative item)*	16	1,6,12,17,21,27,29 31,42,55,59,62,65	35,47,68

Purposive sampling includes individuals who have certain characteristics and are most suitable for the purpose of the research (Büyüköztürk et al., 2020). The reason for working with undergraduate third and fourth grade preservice science teacher within the scope of the study is that the preservice teacher at these grade levels is taking or have taken courses such as laboratory practices, interdisciplinary science teaching, and the nature and teaching of science throughout the process, in order to have cognitive competence about the nature of science (The Council of Higher Education, 2018).

Data Collection Tools

Reconceptualized Family Resemblance Approach to Nature of Science (RFN)' scale, developed by Kaya et al. in 2019, was used as a data collection tool in the study. The name of the scale has been translated as the 'Reconceptualized Family Resemblance Approach to the Nature of Science (FRA)' scale. Since the original language of the scale is English, a Turkish translation study was made. During the adaptation process of the translation study, help was received from expert researchers and its linguistic validity was checked.

The scale is a five-point Likert-type attitude scale consisting of 70 items and response groups of 'Strongly Disagree (1), 'Disagree (2)', 'Not Sure (3)', Agree (4)' and 'Strongly Agree (5)'. There are 6 categories in the scale (Aims and Values, Scientific Practices, Scientific Method, Scientific Knowledge, Social-Institutional Aspects, Educational Applications) and while the positive items were scored as 5,4,3,2,1, reverse coding was done to score the negative items. The scale contains 49 positive and 21 negative items. Exploratory factor analysis was performed to determine the validity of the scale and the

KMO value was found to be 0.714. The scale consists of 6 categories. These categories; Aims and Values, Scientific Practices, Scientific Method, Scientific Knowledge, Social Institutional Aspects and Educational Practices (**Table 1**).

When the average of the answers given by the preservice teacher to the scale was examined, the value was found to be 3.59. This value was evaluated according to the table prepared for the five-point Likert-type scales in Bukhari's 2023 study. According to the table ' The Internal Level of the 5-Point Likert Scale' in this study ; The arithmetic mean value in the range of 1-1.80 points is 'Strongly Disagree', the arithmetic mean value in the range of 1.81-2.60 points is 'I Disagree', the arithmetic mean value in the range of 2.61-3.40 points is 'Neutral', the arithmetic mean value in the range of 3.41-4.20 points corresponds to the statement 'I Agree', and the arithmetic mean value in the range of 4.21-5.00 points corresponds to the statement 'Strongly Agree'.

The value of 3.59 found in this study corresponds to the score range of the statement 'I Agree' since it is in the range of 3.41-4.20. Accordingly, if the arithmetic mean of the preservice teacher for the questions in the scale items is above 3.41, their attitudes will be considered above average. The reliability study of the scale was conducted and the Cronbach's Alpha value for the entire scale was found to be 0.73. The reliability coefficients of the scale categories vary between 0.71 and 0.77. A reliability coefficient of 0.70 or higher is considered sufficient (Büyüköztürk, 2020).

Application Process

Since the aim of the study was to examine the attitudes of prospective science teachers towards the reconceptualized family resemblance approach to the nature of science and the changes in these attitudes according to grade levels, the study group was determined first. The 'Reconceptualized Family Resemblance Approach to the Nature of Science' scale, the data collection tool whose adaptation process was completed with language validity, was reproduced according to the sample size and distributed to 3rd and 4th year undergraduate students in the classroom environment at appropriate times. The process of students completing the scale took an average of 15-20 minutes.

Data Analysis

The data of the research were collected in the fall semester of the 2023-2024 academic year. The data were obtained from the preservice teacher responses to the scale and analyzed with the SPSS 25 program. To determine the technique to be used in data analysis, the normality test (**Table 2**) was first

Table 2. Normality Test.

	Kolmogorov-Smirnov			Shapiro-Wilk		
Grade Level	Statistics	df	p	Statistics	df	p
3rd Grade	0.106	37	0.200	0.978	37	0.675
4th Grade	0.068	38	0.200	0.974	38	0.512

Table 3. Independent Sample T-Test Results for the RFN Scale.

	Grade Level	n	x̄	sd	df	t	p
FRA	3rd grade	37	3.6146	0.18999	73	1.105	0.273
	4th grade	38	3.5709	0.14999			

performed. Since the number of participants in both groups was less than 50, the Shapiro-Wilk test was taken into account (Büyüköztürk, 2020).

Shapiro-Wilk test was calculated separately for third ($p = 0.675$ $p > 0.05$) and fourth ($p = 0.512$ $p > 0.05$) undergraduate grades. As a result of the normality test, kurtosis and skewness values were read. The kurtosis value (0.155), skewness value (0.811) for third-year undergraduate students, and the kurtosis value (-0.576) and skewness value (1.194) for fourth-year undergraduate students are between ±1.5, indicating that the data is normally distributed (Tabachnick and Fidell, 2013).

Results

This section includes the quantitative findings of the analyzed data regarding the "Reconceptualized Family Resemblance to the Nature of Science (FRA)" scale. Independent sample t-test analysis was conducted to reveal whether there was a significant difference between the attitudes of third and fourth grade preservice science teacher towards the reconceptualized family resemblance approach to the nature of science. As a result of the test, there was no statistically significant difference between third and fourth grade preservice science teacher RFN attitudes, $t(73) = 1.105$, $p > 0.05$. While the arithmetic mean value of the third graders was found to be 3.61, the arithmetic mean value of the fourth graders was found to be 3.57 (**Table 3**).

Since there was no significant difference between grade levels in the overall scale, 6 categories and 70 items in the scale were examined one by one. Aims and Values; $t(73) = -1.386$, $p < 0.05$, Scientific Practices; $t(73) = 1.136$, $p < 0.05$, Method; $t(73) = 1.954$, $p < 0.05$, Scientific Knowledge; $t(73) = -5.37$, $p < 0.05$, Social-Institutional Aspects; $t(73) = 0.912$, $p < 0.05$

Table 4. Independent Sample T-Test Results for RFN Scale Questions.

Question 46: Scientific facts are not affected by the prejudices and individual subjective prejudices of scientists.

	Category	Grade Level	n	x̄	ss	df	t	p
Question 46	Aims and Values	3rd Grade	37	2.2162	1.03105	73	-3.223	0.002
		4th Grade	38	3.0526	1.20690			

Table 5. Independent Sample T-Test Results for RFN Scale Questions.

Question 24: Diversity of methods contributes to scientific understanding.

	Category	Grade Level	n	x̄	ss	df	t	p
Question 24	Method	3rd Grade	37	4.4595	0.50523	73	3.387	0.001
		4th Grade	38	4.0000	0.665760			

and Educational Applications; As a result of examining 6 categories as $t(73) = 1.023$, $p < 0.05$, no significant difference was found between third and fourth grade levels in any category.

In the following process, analysis was made for each question in the scale. According to the analysis results, questions with a significant difference between the two grade levels in the scale are included in this section. In the 46th question belonging to the purpose and values category, a significant difference was observed between the RFN attitudes of the third and fourth graders. $t(73) = -3.223$, $p < 0.05$. The arithmetic mean of the third graders was 2.21, and the arithmetic mean of the fourth graders was 3.05 (**Table 4**). This revealed that there was a statistically significant difference in the attitudes of third and fourth grade preservice science teacher towards the 46th question towards the 4th graders.

In the 24th question of the method category, a significant difference was observed between the third and fourth graders' attitudes towards FRA, $t(73) = 3.387$, $p < 0.05$. While the arithmetic mean of the third graders was found to be 4.45, the arithmetic mean of the fourth graders was found to be 4.00 (**Table 5**). This revealed that there was a statistically significant difference in the attitudes of third and fourth grade preservice science teacher towards the 24th question towards the 3rd graders.

A column chart was created for the arithmetic means of the items of the scale (**Figure 2**). According to the table 'The Internal Level of the 5-Point Likert Scale' in Bukhari's study in 2023, values were assigned to the x-axis and the column chart was completed. According to the table in

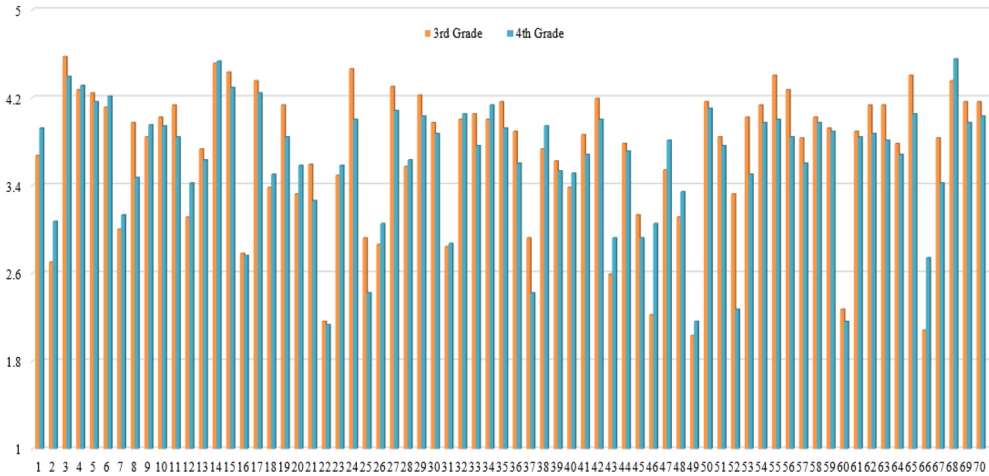

Figure 2. Number of Items Corresponding to Attitude Score Ranges.

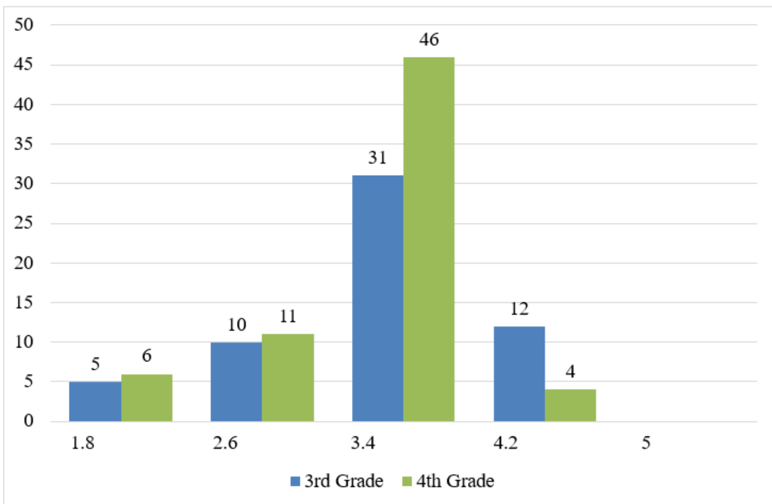

Figure 3. Number of Items Corresponding to Attitude Score Ranges.

Bukhari's study, there are no items in the scale between 1-1.80 that belong to the attitude of 'Strongly Disagree'. The scale includes 5 items in the 3rd grade, 6 items in the 4th grade, and 3 items (22, 49, 60) that are common to both grade levels, regarding the 'Disagree' attitude, in the range of 1.81-2.60. The scale includes 11 items belonging to the 'Neutral' attitude in the 3rd grade, 10 items in the 4th grade, and 5 items (2, 7, 16, 26, 48) that are common to both grade levels, in the range of 2.61-3.40. In the scale, there are 31 items belonging to the 'I Agree' attitude in the 3.41-4.20 range, 31 items in the 3rd grade, 10 items in the 4th grade and 29 items common to both grade levels (1, 5, 6, 9, 10, 11, 13, 19, 23, 28, 32, 33, 34, 35, 36, 38, 39, 41, 42, 44, 47, 50, 53, 54, 58, 62, 63, 69, 70).

The scale includes 12 items in the 3rd grade, 4 items in the 4th grade, and 4 items (4, 14, 15, 68) that are common to both grade levels, belonging to the 'Strongly Agree' attitude, in the range of 4.21-5.00 (**Figure 3**). The attitude in which preservice teacher arithmetic average scores of the items in the scale are most concentrated is the 'I Agree' attitude. Among the 3rd grade preservice science teacher in the entire scale, the 3rd item belonging to the 'Scientific Knowledge' category has the highest arithmetic mean ($\bar{x}$= 4.57), while the 49th item belonging to the 'Method' category has the lowest arithmetic mean ($\bar{x}$= 2.03) has. Among the 4th grade preservice science teacher in the entire scale, the 68th item belonging to the 'Educational Applications' category has the highest arithmetic mean ($\bar{x}$= 4.55), while the 22nd item belonging to the 'Method' category has the lowest arithmetic mean ($\bar{x}$ = 2.13). The arithmetic averages of the categories vary according to grade levels. In the Aims and Values category, the arithmetic average of 3rd grade preservice teacher is 3.41, while 4th grade students' mean is 3.51. In the Scientific Practices category, the arithmetic average of 3rd grade preservice teacher is 3.92, while the arithmetic average of 4th grade students is 3.83. In the Method category, the arithmetic average of 3rd grade preservice teacher is 3.06, while the arithmetic average of 4th grade students is 2.90. In the Scientific Knowledge category, the arithmetic average of 3rd grade preservice teacher is 3.56, while the arithmetic average of 4th grade students is 3.60. In the Social Institutional Aspects category, the arithmetic average of 3rd grade preservice teacher is 3.75, while the arithmetic average of 4th grade students is 3.68. In the last category, Educational Applications, the arithmetic average of the 3rd grade preservice teacher is 3.95, while the arithmetic average of the 4th grade students is 3.88. When the arithmetic averages are examined, the category in which preservice teacher have the highest arithmetic average in both grade levels is the 'Educational Applications' category. The category with the lowest arithmetic mean is the 'Method' category at both grade levels.

Conclusion and Discussion

The fact that prospective science teachers at the specified grade levels exhibit attitudes towards the reconceptualized family resemblance approach to the nature of science that are above average and positive indicates their positive disposition towards teaching science as well. Muğaloğlu (2006) emphasized that as the scientific skills and positive attitudes of prospective teachers towards teaching science improve their perspectives on the nature of science also become more favorable. Prospective science teachers' participation in laboratory courses has been effective in shaping their positive attitudes towards the approach.

In Bilen's study in 2003, it was noted that prospective teachers who engaged in laboratory studies developed a positive attitude towards the scientific process by working like scientists in identifying existing problems, formulating methods for problem-oriented research, and drawing conclusions akin to scientists. Laboratory studies are associated with the scientific practices category of the family resemblance approach. Moreover, the lack of statistically significant difference between the grade levels of prospective science teachers suggests that there is no variation in the course content supporting the reconceptualized family resemblance approach to the nature of science between third-year and fourth-year students. This could imply that teaching does not progress qualitatively and cumulatively as students advance in their studies. Although Okan and Kaya (2023) emphasized that the family resemblance approach can be taught at all grade levels, they underscored the necessity for a cumulative progression in this teaching.

Another reason for the absence of statistically significant differences in the attitudes of prospective science teachers towards the family resemblance approach at different grade levels could be the lack of practical application in classroom instruction. Deficiencies in practical applications may include insufficient classroom discussions, unequal emphasis on each criterion of family resemblance, a lack of collaborative learning, and prospective teachers not taking an active role in the process. These aspects are associated with the Scientific Practices category of the family resemblance approach.

In reviewing the literature, Kaya and Erduran's (2019) study demonstrated that implementing workshops and practical applications in teaching the family resemblance approach led to significant improvement, as evaluated before and after the application. This indicates that practical applications yield more successful results in teaching family resemblance. Similarly, Cullinane and Erduran's (2022) study, which included practical applications, showed an increase in prospective teachers' knowledge levels regarding the family resemblance approach to the nature of science after the application. These studies underscore the effectiveness of practical applications in teaching the family resemblance approach, aligned with the Scientific Practices category. To effectively teach the family resemblance approach to the nature of science, criteria for both the nature of science and the family resemblance approach should be directly introduced to prospective teachers, ensuring their familiarity with the criteria and concepts.

Furthermore, given the lack of statistically significant differences in the attitudes of prospective teachers at different grade levels within this study, differentiation in course content should be considered for both grade levels. Additionally, increasing the use of laboratories in teaching the nature of science based on this approach and encouraging prospective teachers to actively engage in research processes akin to scientists through various activities suitable for the nature of science are crucial steps.

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