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Investigation of Preservice Science Teachers' Attitudes Towards Nanotechnology According to Various Variables

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ABSTRACT

This study aims to examine the attitudes of preservice science teachers towards nanotechnology according to various variables such as gender, class level, and academic achievement. The cross-sectional survey method was employed in the study. The sample of the study consists of 199 preservice science teachers (170 females, 29 males). The used data collection tool is the Attitude Scale Towards Nanotechnology consisting of three sub-components (positive, negative, and utility). Descriptive statistics including mean and standard deviation scores were used in the descriptive analysis of the data, while Independent Samples t-test and ANOVA were used in the inferential analysis. According to the results, it was observed that the attitudes of preservice science teachers towards nanotechnology were at a "high" level. When the attitudes of preservice science teachers towards nanotechnology were examined according to the gender variable, it was determined that male preservice science teachers had a higher average attitude score than female preservice science teachers. When the attitudes were examined based on the class level variable, it was observed that the preservice science teachers in the 3rd year of education had the highest average attitude score, while those in the 2nd year had the lowest average attitude score. Regarding the academic achievement level variable, it was observed that the preservice science teachers with high academic achievement had a higher average attitude score than those with low academic achievement.

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INTRODUCTION

Nanoscience and nanotechnology (NST) are considered to be at the forefront of modern research and are acknowledged as the revolution of the 21st century (Sebastian & Gimenez, 2016). While the terms nanoscience and nanotechnology are often used interchangeably on the World Wide Web, there are distinct differences between these concepts (Ng, 2009). Nanoscience involves the manipulation of materials at the atomic and molecular scales, bringing together the fields of biology, physics, and materials science (Bayda et al., 2020). On the other hand, nanotechnology encompasses a set of technologies that enable the manipulation, control, and design of matter on the nanoscale to develop new products or applications or enhance the capabilities of existing products and applications (Baalousha et al., 2014).

The interdisciplinary nature of nanotechnology, encompassing various disciplines such as physics, chemistry, biology, pharmacy, and materials science, is a distinctive feature of the innovations in this field (Manjunatha et al., 2016; Singh, 2017). According to some, nanotechnology, which represents a new era in social transformation, has started to be used in many products and production steps with its various properties such as conductivity, hardness, softness and durability (Güzeloğlu, 2015 & Murty, 2013). Research and innovations in this field are leading breakthroughs in areas such as nanomaterials and manufacturing, medicine and healthcare services, nanoelectronics, information technology, national security, energy, biotechnology, aerospace and space, the food sector, cosmetic products, textiles, and agriculture (Bhushan 2015; Erkoç 2012; Singh 2017; The Royal Society & The Royal Academy of Engineering, 2004; Yakar, 2018). Nanotechnology is considered one of the most important technologies of today, thanks to its ability to impart significantly different new properties to materials among the developed technologies (Güzeloğlu, 2015).

The emerging technologies involve an understanding and research on how the fundamental ideas of nanotechnology can be taught (İpek et al., 2020). Despite scientists having conducted research at the nanoscale for many years, the development of new tools and techniques has led to interdisciplinary advancements defining this field (Jones et al., 2013). These developments, which enable us to understand the world at the nanoscale, hold significant potential to engage and excite scientists, educators, students, and the public (Newberry, 2012). Possessing specific knowledge, skills, and abilities in nanotechnology is synonymous with having nanotechnology itself. The realization of this depends on how well individuals have been educated in this field and how effectively they can utilize their skills (Ekli, 2010). In this regard, nanotechnology represents both a need and an opportunity for the transformation of our education system (Roco & Bainbridge, 2005). Consequently, schools, universities, and science centers providing education in the field of nanoscience and nanotechnology have begun to develop and test new courses and curricula with different approaches (Jones et al., 2015).

Advancements and innovations in science are rapidly progressing. In this context, it is important for research in science education to keep pace with these developments to shape effective educational practices (Jones et al., 2013). Nanotechnology, being a multidisciplinary field, is actively used in science education. Science education serves as an effective tool for students to enthusiastically learn about emerging technologies such as nanotechnology (Ekli & Şahin, 2010). Introducing students to some interesting concepts related to nanotechnology is important to capture their interest and attention (Lan, 2012). By integrating nanoscale phenomena into science education initially, adapting the education to technology, science, social sciences, and humanities is believed to be possible (Roco & Bainbridge, 2005). Considering that the science curriculum aims to develop individuals as scientifically literate (Republic of Türkiye Ministry of National Education, 2018), there is a connection between nanotechnology and science education (Şenel-Zor, 2017). As a new technology, incorporating nanotechnology into formal education where students can learn about new advanced technology will be an incentive for transformation (Ghattas, 2015). To harness the benefits of nanotechnology, it is necessary to educate individuals with the required expertise and transfer the knowledge base to future generations (Ekli & Şahin, 2010). Teacher training should be a significant goal to successfully implement nanotechnology education (İpek et al., 2020).

The ultimate goal in the professional development of teachers is to impact students' learning. Therefore, it is crucial to examine what teachers actually do with the new knowledge in nanotechnology concerning what students learn (Jones et al., 2013). This is because, in today's world, it is widely accepted that real power comes not from physical strength but from intellectual strength. The first step to embracing the era of nanotechnology is to educate future teachers in this field (Ekli & Şahin, 2010). Training for educators is essential to advance nanotechnology education. Educators encourage excitement and creativity by providing technical content. To cultivate a skilled workforce in the growing field of nanotechnology, it is necessary to attract and educate students. Therefore, providing education with suitable and sufficient educators becomes imperative (Winkelmann & Bhushan, 2017). Additionally, teachers should know every aspect (applications, potential risks arising from applications, benefits, importance, etc.) of nanotechnology. This is because information acquired about one dimension of nanotechnology can influence people's attitudes toward nanotechnology (Ekli & Şahin, 2010).

Attitudes have been a fundamental topic in social psychology for many years due to their influence on both our social perceptions and behaviors (Kağıtçıbaşı & Cemalcılar, 2014). Attitude is a way of evaluating things we like and dislike, feel close to or detest, and our relationship with our surroundings (Zimbardo & Leippe, 1991). It is believed to guide individuals in adapting to their surroundings, facilitate their adjustment, and also have an impact on directing their behaviors (Tufan & Güdek, 2008). In recent years, discussions about interactions between science and society increasingly emphasize the importance of public acceptance and response to emerging technologies (Burri & Bellucci, 2008). Determining the public's attitude toward nanotechnology and identifying the sources of this attitude are crucial for both shaping nanotechnology policies and the global development of nanotechnology (Zhang et al., 2015). The future position of nanotechnology will be determined by society's attitude toward it (Roco & Bainbridge, 2001). Therefore, measuring attitudes toward nanotechnology is considered crucial to fully harness its potential (Şenel-Zor & Kan, 2021). In the field of education, traditional thinking is the direct influence of knowledge on the learner's attitude and the conversion of this attitude into behavior (Chien-Yun et al., 2012). Therefore, it is important, especially for science teachers and preservice science teachers, to determine their attitudes toward nanotechnology. In this respect, using appropriate tools to determine attitudes towards nanotechnology and providing the necessary support for the development of these attitudes after obtaining the results is important (Şenel-Zor & Kan, 2021).

Studies on attitudes toward nanotechnology in the literature have been reviewed. In this context, research has been conducted on the attitudes toward nanotechnology of the general public (Chen et al., 2013; Fischer et al., 2012; Lee et al., 2005; Macoubrie, 2006; Scheufele et al., 2008), social scientists (Khalid et al., 2016), middle school students (Ekli, 2010), high school students (Kim et al., 2011), undergraduate students (Nerlich et al., 2007), preservice teachers (Şenel-Zor et al., 2019; Şenel-Zor & Kan, 2018), science teachers (Kim & Hong, 2010), and students and teachers (Much et al., 2019). It has been observed that many studies conducted in recent years have focused on the attitudes toward nanotechnology. As a result of these studies, it is evident that there are positive attitudes toward nanotechnology (Ekli, 2010; Kim & Hong, 2010; Kim et al., 2011; Macoubrie, 2006; Şenel-Zor et al., 2019). While the majority of studies in the literature focus on the attitudes of the general public toward nanotechnology, research on the attitudes of students and preservice teachers toward nanotechnology is relatively limited.

Teachers' attitudes toward nanotechnology and the integration of related content, materials, and activities into science classrooms can significantly influence their behaviors in implementing these practices in science classrooms (Ghattas, 2015). Competencies such as teachers' knowledge level about emerging technologies will have an impact on students' attitudes. It is crucial for preservice science teachers to have a sufficient level of knowledge about nanotechnology and be able to integrate nanotechnology into science subjects to foster a positive attitude towards nanotechnology in students. Research on the attitudes of preservice science teachers toward nanotechnology and its implementation in school curricula, one of today's technologies, is limited. It is believed that this study will contribute to the literature by determining the attitudes of preservice science teachers toward nanotechnology, understanding nanotechnology comprehensively, determining its future role, and adapting to the nanotechnology era.

This research aims to determine the attitudes of preservice science teachers toward nanotechnology and to examine them based on variables such as gender, grade level, and academic achievement. The following research questions were addressed in line with the stated aim:

1. What are the attitudes of preservice science teachers (1st, 2nd, 3rd, and 4th grades) toward nanotechnology?
2. Is there a difference in the attitudes of preservice science teachers toward nanotechnology based on gender?
3. Is there a difference in the attitudes of preservice science teachers toward nanotechnology based on grade level?
4. Is there a difference in the attitudes of preservice science teachers toward nanotechnology based on academic achievement level?

METHOD

Research Design

In this study, the cross-sectional survey method, a quantitative research method, was employed as one of the quantitative research methods. Survey research is a research method that determines the opinions or characteristics such as interest, attitude, skill, and ability of participants related to an event or subject and allows research on larger samples compared to other types of research. Cross-sectional survey research describes a method in which variables are measured at a single point in time, the sample is large, and the research includes diverse groups (Büyüköztürk et al., 2018). In cross-sectional research, information is collected at one time from a pre-determined population (Fraenkel & Wallen, 2009). In this research, quantitative data were analyzed using the "Attitude Towards Nanotechnology Scale" (ATNS) to determine the existing attitudes of preservice science teachers towards nanotechnology.

Research Sample

The population of this study consists of preservice teachers studying in the Department of Science Teaching in Turkey. Since the population is located in a very large geography, easier access to preservice teachers and time were effective in determining the sample. In this study, convenience sampling, one of the non-random sampling methods, was used. Convenience sampling is the selection of a group of individuals who are suitable for a research (Fraenkel & Wallen, 2009). Accordingly, the sample of the study consisted of 3rd and 4th grade students who took the "Applications of Science in Technology" course, which is one of the courses of the Department of Science Teaching and includes topics such as semiconductor technologies and nanotechnology, and 1st and 2nd grade students who did not take this course. Thus, a total of 199 pre-service teachers (170 female, 29 male), including 57 pre-service teachers from the 4th grade, 71 pre-service teachers from the 3rd grade, 47 pre-service teachers from the 2nd grade, and 24 pre-service teachers from the 1st grade, were included in the data analysis process.

Research Instruments and Processes

The Nanotechnology Attitude Scale for Preservice Science Teachers was used in this study to collect data for the examination of preservice science teachers' attitudes toward nanotechnology based on various variables. The scale, developed by Şenel-Zor and Kan (2018, 2021) and subjected to validity and reliability analyses, consists of a total of 24 items prepared on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The highest possible score that can be obtained from the scale is 120, while the lowest is 24. An increasing score on the scale implies a higher attitude toward nanotechnology. The scale comprises three factors: the positive component (items 5, 14, 16, 17, 19, 20, 22, 23, 24), the utility component (items 1, 2, 4, 6, 8, 10, 12, 15, 18), and the negative component (items 3, 7, 9, 11, 13, 21). In their studies, Şenel-Zor and Kan (2018, 2021) conducted a reliability analysis to demonstrate the reliability of the scale. The Cronbach's alpha (Cr-α) reliability coefficient of the scale was found to be 0.926, while the reliability coefficients for each factor were determined as 0.889, 0.892, and 0.813, respectively. In the present study, the reliability analysis conducted on preservice science teachers yielded a Cronbach's alpha (Cr-α) reliability coefficient of 0.90 for the overall scale, and for each factor, the reliability coefficients were 0.859, 0.883, and 0.789, respectively.

Data Analysis

The data obtained using the ATNS were analyzed through descriptive and inferential statistical methods using the SPSS 21 program to determine the attitudes of the preservice science teachers towards nanotechnology. Descriptive analysis involved examining the mean (M) and standard deviation (SD) scores, while inferential analysis employed parametric tests such as Independent Samples t-test and One-Way Analysis of Variance (ANOVA) tests based on the fulfillment of assumptions.

The arithmetic means of the items were interpreted using the coefficient of variation. The coefficient of variation can be calculated by dividing the difference between the highest and lowest measurements by the number of groups determined by the researcher (Büyüköztürk et al., 2012). Since the scale used in the study is a 5-point Likert scale, the number of groups was set to 5. Accordingly, the coefficient of variation in this study was determined as $\alpha = (5-1)/5 = 0.80$. Based on this coefficient of variation, the grouping was interpreted as follows: average values between 1.00-1.80 were considered as "Strongly Disagree," values between 1.81-2.60 as "Disagree," values between 2.61-3.40 as "Undecided," values between 3.41-4.20 as "Agree," and values between 4.21-5.00 as "Strongly Agree."

Before conducting inferential analyses to determine whether the total scores obtained from the attitude scale and the scores obtained from the sub-dimensions of the scale differed by gender, grade level, and academic achievement level, it was examined whether the scores met the assumption of normal distribution. Skewness and kurtosis coefficients were examined to determine whether the scores met the assumption of normal distribution. To ensure a normal distribution of the scores, the accepted value for the skewness coefficient should be less than 3, and the kurtosis coefficient should be less than 10 (Kline, 2005). In the study, the skewness coefficients of the variables ranged from -2.137 to 0.345, and the kurtosis coefficients ranged from -0.051 to 7.983. In cases where the distributions were homogeneous, parametric tests, specifically independent t-tests and one-way analysis of variance (ANOVA), were utilized for analysis, and the results were interpreted based on a significance level of $p=0.05$.

Ethic

Ethical principles (Miles & Huberman, 1994) were taken into consideration throughout the study. A consent form was presented to the preservice science teachers, assuring them that their participation was voluntary and that they could freely terminate their participation at any point in the study.

FINDINGS

In this section, the data obtained through the ATNS for Preservice Science Teachers were analyzed to examine preservice science teachers' attitudes toward nanotechnology concerning variables such as gender, grade level, and academic achievement level. The findings resulting from the analysis of these data are presented below.

Findings Regarding the Attitudes of Preservice Science Teachers Towards Nanotechnology

According to the results of the descriptive statistics obtained from the ATNS applied to determine the attitudes of preservice teachers towards nanotechnology, it is seen that preservice teachers have an average attitude score of (M=3.78) in the whole scale.

As the scores obtained from ATNS increase, preservice science teachers' scores related to nanotechnology also increase. The scores obtained from this scale range from 24 to 120. This range is divided into three equal parts, where individuals scoring between 24-55 are categorized as having a "low" level of attitude, those scoring between 56-87 are categorized as having a "moderate" level, and those scoring between 88-120 are categorized as having a "high" level of attitude. The attitude levels of preservice science teachers participating in the research based on the total scores they obtained related to nanotechnology are presented in Table 1.

Table 1. *Distribution level of total attitude scores of preservice science teachers participating in the research*

Attitude Level	*N*	%
Low (24-55)	1	0.50
Medium (56-87)	74	37.19
High (88-120)	124	62.31
Total	199	100

According to Table 1, it is observed that 62.31% (N=124) of preservice science teachers have a "high" level of attitude towards nanotechnology. It is determined that 37.19% of preservice science teachers (N=74) show a "medium" level of attitude, and 0.50% (N=1) exhibit a "low" level of attitude.

Findings on Preservice Science Teachers' Attitudes Towards Nanotechnology Based on Gender Variable

Descriptive statistics results on the attitude levels towards nanotechnology based on the gender of preservice science teachers are presented in Table 2.

Table 2. *Descriptive statistics results on the mean scores of preservice science teachers' attitude towards nanotechnology, obtained from the sub-dimensions of ATNS, according to gender*

Factor	Gender	*N*	*M*	*SD*
Positive	Female	170	29.67	5.81
	Male	29	32.31	5.83
Benefit	Female	170	37.41	4.93
	Male	29	37.79	5.70
Negative	Female	170	24.21	3.54
	Male	29	24.59	4.79
Total	Female	170	90.23	10.77
	Male	29	93.51	11.12

As seen in Table 2, the average scores obtained by female preservice science teachers in the positive sub-dimension (M=29.67), benefit sub-dimension (M=37.41), and negative sub-dimension (M=24.21) of ATNS are lower than the scores obtained by male preservice science teachers in the positive sub-dimension (M=32.31), benefit sub-dimension (M=37.79), and negative sub-dimension (M=24.59) of the scale. Additionally, when the total attitude scores are examined, it is observed that the average scores of female preservice science teachers (M=90.23) are lower than the average scores of male preservice science teachers (M=93.51).

A parametric independent t-test was conducted to determine whether there is a significant difference in the attitudes towards nanotechnology, as measured by the ATNS, among science preservice science teachers based on the gender variable. The obtained results are presented in Table 3.

Table 3. *T-test results for the relationship between the sub-dimensions of ATNS and total attitude scores of preservice science teachers based on gender*

Factor	Gender	*N*	*M*	*SD*	*df*	*t*	*p*
Positive	Female	170	29.67	5.81	197	-2.256	.025
	Male	29	32.31	5.83			
Benefit	Female	170	37.41	4.93	197	-.382	.703
	Male	29	37.79	5.70			
Negative	Female	170	24.21	3.54	197	-.498	.619
	Male	29	24.59	4.79			
Total	Female	170	91.21	11.63	197	-1.510	.133
	Male	29	94.76	12.02			

According to Table 3, there is a significant difference in the average attitude scores of preservice science teachers based on gender in favor of male preservice science teachers (M=32.31; SD=5.83) compared to female preservice science teachers (M=29.67; SD=5.81) in the positive sub-dimension of ATNS [t(197)=-2.256, p <0.05]. However, there is no significant difference between female preservice science teachers (M=37.41; SD=4.93) and preservice science teachers (M=37.79; SD=5.70) in the benefit sub-dimension of ATNS [t(197)=-0.382, p>0.05]. Likewise, there is no significant difference between female preservice science teachers (M=24.21; SD=3.54) and male preservice science teachers (M=24.59; SD=4.79) in the negative sub-dimension of ATNS [t(197)=-0.498, p>0.05]. Additionally, there is no significant difference in the average total attitude scores between female preservice science teachers (M=91.21; SD=11.63) and male preservice science teachers (M=94.76; SD=12.02) [t(197)=-1.510, p>0.05] based on the scores obtained from ATNS.

Findings Regarding the Attitude Towards Nanotechnology Among Preservice Science Teachers Based on the Grade Level Variable

Descriptive statistical results of preservice science teachers' attitude levels towards nanotechnology according to grade levels are provided in Table 4.

Table 4. *Descriptive statistical results of the average scores obtained by preservice science teachers in the sub-dimensions and total attitude scores of ATNS according to the grade level variable test*

Factor	Grade Level	*N*	*M*	*SD*
Positive	1st Grade	24	29.41	5.65
	2nd Grade	47	28.51	6.13
	3rd Grade	71	31.70	5.25
	4th Grade	57	29.56	6.12
Benefit	1st Grade	24	38.17	4.32
	2nd Grade	47	36.74	4.41
	3rd Grade	71	37.51	6.45
	4th Grade	57	37.70	3.66
Negative	1st Grade	24	23.46	4.02
	2nd Grade	47	24.28	2.71
	3rd Grade	71	24.45	4.60
	4th Grade	57	24.37	3.14
Total	1st Grade	24	90.63	9.79
	2nd Grade	47	89.02	9.17
	3rd Grade	71	92.20	12.71
	4th Grade	57	90.30	10.05

As seen in Table 4, the average scores obtained by preservice science teachers from ATNS vary. When the sub-dimensions of the attitude scale are examined, in the positive sub-dimension, preservice science teachers in the 3rd grade (M=31.70) have the highest average score, while those in the 2nd grade (M=28.51) have the lowest average score. In the benefit sub-dimension, preservice science teachers in the 1st grade (M=38.17) have the highest average score, while those in the 2nd grade (M=36.74) have the lowest average score. In the negative sub-dimension, preservice science teachers in the 3rd grade (M=24.45) have the highest average score, while those in the 1st grade (M=23.46) have the lowest average score. When the average of the total scores obtained from the attitude scale is examined, preservice science teachers in the 3rd grade (M=92.20) have the highest average score, while those in the 2nd grade (M=89.02) have the lowest average score.

A one-way analysis of variance (ANOVA), a parametric test, was conducted to determine whether there is a significant difference in the average scores obtained by preservice science teachers in the sub-dimensions and total attitude scores of ATNS based on the grade level variable. The results obtained are presented in Table 5.

Table 5. *One-way analysis of variance (ANOVA) test results for the average scores obtained by preservice science teachers in the sub-dimensions and total attitude scores of ATNS according to the grade level variable*

Factor	Source of Variation	Sum of Squares	Mean Squares	*df*	*F*	*p*	η^2	Mean Difference
Positive	Between Groups	328.875	109.625	3	3.3	.022	.048	2-3
	Within Groups	6492.402	33.294	195				
	Total	6821.276		198				
Benefit	Between Groups	39.522	13.174	3	.516	.672	.008	
	Within Groups	4979.946	25.538	195				
	Total	5019.467		198				
Negative	Between Groups	18.681	6.227	3	.442	.723	.007	
	Within Groups	2746.203	14.083	195				
	Total	2764.884		198				
Total	Between Groups	300.900	100.300	3	.849	.469	.013	
	Within Groups	23035.773	118.132	195				
	Total	23336.673		198				

According to Table 5, there is a significant difference in the average attitude scores obtained by preservice science teachers in the positive sub-dimension of ATNS based on the grade level variable (F=3.293; p<0.05). To determine which groups exhibit significant differences, post hoc test comparisons using Tukey results indicate that preservice science teachers in the 3rd grade (M=31.70; SD=5.25) have a significantly higher attitude towards nanotechnology compared to those in the 2nd grade (M=28.51; SD=6.13). There is no significant difference in the average attitude scores obtained by preservice science teachers in the benefit sub-dimension of ATNS based on the grade level variable (F=0.516; p>0.05). There is no significant difference in the average attitude scores obtained by preservice science teachers in the negative sub-dimension of ATNS based on the grade level variable (F=0.442; p>0.05). Additionally, there is no significant difference in the average attitude scores obtained by preservice science teachers based on the grade level variable in terms of the total attitude scores from ATNS (F=0.849; p>0.05).

Findings Regarding the Attitude Towards Nanotechnology Among Preservice Science Teachers Based on the Variable of Academic Achievement Level

The descriptive statistical results regarding the attitude levels towards nanotechnology based on the academic achievement levels of preservice science teachers are provided in Table 6.

Table 6. *Descriptive statistical results of the average scores obtained by preservice science teachers in the sub-dimensions and total attitude scores of ATNS according to the variable of academic achievement level*

Factor	Achievement Level	*N*	*M*	*SD*
Positive	High	98	30.32	5.79
	Low	101	29.81	5.97
Benefit	High	98	38.10	4.41
	Low	101	36.84	5.52
Negative	High	98	24.89	3.62
	Low	101	23.66	3.76
Total	High	98	91.73	10.94
	Low	101	89.72	10.72

As seen in Table 6, preservice science teachers with high academic achievement levels have higher average scores in the positive sub-dimension (M=30.32), benefit sub-dimension (M=38.10), and negative sub-dimension (M=24.89) of ATNS compared to preservice science teachers with low academic achievement levels, who obtained average scores of (M=29.81), (M=36.84), and (M=23.66) in the positive, benefit, and negative sub-dimensions, respectively. Additionally, when total scores are examined, it is observed that preservice science teachers with high academic achievement levels have higher average scores (M=91.73) compared to the average scores of preservice science teachers with low academic achievement levels (M=89.72).

Parametric tests, specifically independent samples t-tests, were conducted to determine whether there is a significant difference in the average scores obtained by preservice science teachers in the sub-dimensions and total attitude scores of ATNS based on the variable academic achievement level. The obtained results are presented in Table 7.

Table 7. *Independent samples t-Test results for the sub-dimensions of ATNS and the total attitude score according to the variable of academic achievement level of preservice science teachers*

Factor	Achievement Level	*N*	*M*	*SD*	*df*	*t*	*p*
Positive	High	98	30.32	5.79	197	-.605	.546
	Low	101	29.81	5.97			
Benefit	High	98	38.10	4.41	197	-1.775	.077
	Low	101	36.84	5.52			
Negative	High	98	24.89	3.62	197	-2.337	.020
	Low	101	23.66	3.76			
Total	High	98	91.73	10.94	197	-1.309	.192
	Low	101	89.72	10.72			

According to Table 7, there is a significant difference in the average attitude scores of preservice science teachers in the negative sub-dimension of ATNS based on the variable academic achievement level. Preservice science teachers with high academic achievement levels (M=24.89; SD=3.62) have significantly higher average attitude scores than those with low academic achievement levels (M=23.66; SD=3.76) [t(197)=-2.337, p<0.05]. In contrast, there is no significant difference in the average attitude scores obtained by preservice science teachers in the positive sub-dimension of ATNS based on the variable academic achievement level. Preservice science teachers with high academic achievement levels (M=30.32; SD=5.79) and those with low academic achievement levels (M=29.81; SD=5.97) have similar average attitude scores [t(197)=-0.605, p>0.05]. Similarly, there is no significant difference in the average attitude scores obtained by preservice science teachers in the benefit sub-dimension of ATNS based on the variable academic achievement level. Preservice science teachers with high academic achievement levels (M=38.10; SD=4.41) and those with low academic achievement levels (M=36.84; SD=5.52) have similar average attitude scores [t(197)=-1.775, p>0.05]. Additionally, there is no significant difference in the total attitude scores obtained from ATNS based on the variable of academic achievement level. Preservice science teachers with high academic achievement levels (M=91.73; SD=10.94) and those with low academic achievement levels (M=89.72; SD=10.72) have similar total attitude scores [t(197)=-1.309, p>0.05].

DISCUSSION AND CONCLUSION

Discussion and Conclusion on the Attitude Towards Nanotechnology Among Preservice Science Teachers

The average attitude scores of preservice science teachers towards nanotechnology in all dimensions were found to be M=3.78 using the ATNS. Furthermore, the majority of sci preservice science teachers exhibit attitudes towards nanotechnology at the level of 'Agree/Strongly Agree.' This result aligns with similar findings in the literature (Khalid et al., 2016; Kim & Hong, 2010; Kim et al., 2011; Macoubrie, 2006; Şenel-Zor et al., 2019). When examining the literature, attitudes towards nanotechnology have been associated with perceptions of nano concepts, knowledge, exposure, and the perception of benefits and risks of nanotechnology. Ghattas (2015) emphasized that the attitudes of science teachers towards the implementation of nanotechnology in science classrooms are influenced by various factors such as lack of knowledge, self-confidence, social influences, school and student type, personal perspective, and time and resource constraints. The literature suggests that science teachers have a positive attitude and diverse perspectives on the benefits and risks of nanotechnology (Kim & Hong, 2010), there is a positive relationship between students' knowledge levels and their attitudes toward nanotechnology (Ekli, 2010; Kim, 2011), there is a positive relationship between academic career and attitudes towards nanotechnology (Khalid et al., 2016), and attitudes towards nanotechnology are associated with trust in scientists (Lee et al., 2005).

When examining the studies in the literature, it is observed that the attitude toward nanotechnology is associated with sensations. These sensations are most commonly obtained from various media sources such as TV, radio, and the Internet (Ekli, 2010; Kim & Hong, 2010; Kim et al., 2011). However, it has been found that students trust their teachers and nanotechnology researchers the most (Kim et al., 2011).

In ATNS, it is observed that the majority of preservice science teachers encounter nanotechnology through TV, news, or advertisements, and their attitudes toward nanotechnology are at a high level. There are studies related to the coverage of nanoscience and nanotechnology in national newspapers published in Turkey (Çalık et al., 2021; Kamanlıoğlu & Güzeloğlu, 2010; Şenocak, 2017). These studies found an increase in the number of nanotechnology-related news over the years, with the content of the news mostly focusing on scientific discoveries and commercial applications of nanotechnology. The content of the news also showed a positive approach. In this context, the increasing numbers of nanoscience and nanotechnology-related news in newspapers in our country over the years may be associated with preservice science teachers encountering nanoscience and nanotechnology more frequently, leading to an increase in their attitudes towards nanotechnology.

The average scores obtained by preservice science teachers in the benefit sub-dimension of ATNS, which includes the benefits of nanotechnology for daily life and society (M=4.16), were found to be higher than the overall average scores from the scale (M=3.78). It is concluded that there is a relationship between attitudes toward nanotechnology and attempting to perceive the benefits and risks of nanotechnology (Chen et al., 2013; Ekli, 2010; Fischer et al., 2012; Kim & Hong, 2010; Kim et al., 2011; Nerlich et al., 2007). Considering that encountering nanotechnology mostly occurs through media such as TV, news, or advertisements, the extent to which the media addresses the benefits and risks of nanotechnology becomes significant. The focus of preservice science teachers in the current study on the beneficial aspects of nanotechnology may be associated with encountering the benefits of nanotechnology more frequently in the media, while exposure to its risks is relatively rare.

Discussion and Conclusion on the Attitude Towards Nanotechnology Based on the Gender Variable of Preservice Science Teachers

When examining the attitudes towards nanotechnology based on the gender variable of preservice science teachers, it is observed that although male preservice science teachers have higher average scores from ATNS compared to female preservice science teachers, there is no significant difference between gender and attitudes towards nanotechnology in the negative and benefit sub-dimensions of the scale and in total attitude scores. However, a significant difference is found in favor of male preservice science teachers in the ATNS positive sub-dimension. When similar studies in the literature are examined, Senocak (2014) concluded that there was a significant difference between familiarity with nanotechnology and gender in favor of males. Similarly, Ekli (2010) found a significant difference in favor of males between the basic knowledge and views of elementary school second level students towards nanotechnology according to gender, while a significant difference was found in favor of male students in students' attitudes towards technology. On the other hand, Şenel-Zor et al. (2019) aimed to examine the attitudes of preservice physics, chemistry, biology and science teachers towards nanotechnology according to various variables and found that there was no significant difference between the average attitude scores of preservice teachers according to gender.

When examining attitudes towards nanotechnology based on gender, it was determined that male preservice science teachers have higher attitudes towards nanotechnology compared to female preservice science teachers. Chang et al., (2009), in their studies examining students' attitudes towards technology, attributed differences in attitudes towards technology and gender to psychological and identity factors, social factors, curriculum, pedagogy and school factors, and career factors. In this context, differences in attitudes towards technology based on gender can arise due to variations in the knowledge levels that male and female students have about technology, as well as the greater interest that males show in new technological topics compared to females (Fang et al., 2007). In the study by Ekli (2010), it was found that male students exhibit an interest in technology in their daily lives, find technology more appealing and interesting, and express a desire to pursue careers in this field. On the other hand, it was observed that female students do not have a strong inclination towards pursuing careers in the field of technology. In this study, the higher attitudes of male preservice science teachers towards nanotechnology may be associated with greater interest and inclination towards nanotechnology, which is one of today's technologies, among male preservice science teachers.

Discussion and Conclusion on the Attitude Towards Nanotechnology Based on the Grade Level Variable of Preservice Science Teachers

When examining the attitudes of preservice science teachers towards nanotechnology according to the grade level variable, it was observed that preservice science teachers in the 3rd grade had the highest average scores on the ATNS, while those in the 2nd grade had the lowest average scores. Additionally, there was no significant difference in the attitudes towards nanotechnology between grade levels in terms of ATNS negative and benefit sub-dimensions, as well as total attitude scores. However, it was found that in the ATNS positive sub-dimension, preservice science teachers in the 3rd grade had a higher attitude towards nanotechnology compared to those in the 2nd grade. This difference may be attributed to the elective courses that preservice science teachers prefer at their respective grade levels. The fact that topics such as semiconductor technologies, nanotechnology and different physical sensors are covered in the "Applications of Science in Technology" course, which is one of the field education elective courses taught in the 3rd grade of the Science Teacher Education Department, may be associated with the fact that the 3rd grade pre-service teachers have higher attitudes towards nanotechnology. This could explain why 3rd-grade preservice science teachers have a higher attitude towards nanotechnology. The results suggest a potential influence of the content of elective courses on the attitudes of preservice science teachers toward nanotechnology.

Discussion and Conclusion Regarding Preservice Science Teachers' Attitudes Towards Nanotechnology Based on Academic Achievement Level

When examining the attitudes of preservice science teachers towards nanotechnology based on the variable of academic achievement level, it is observed that preservice science teachers with high academic achievement have higher total scores on ATNS than those with low academic achievement. Additionally, there is no significant difference in the positive and benefit sub-dimensions, as well as total attitude scores of ATNS based on academic achievement level. However, a significant difference in favor of preservice science teachers with high academic achievement is found in the negative sub-dimension of ATNS.

Similar to the literature, academic achievement in the field of science has been shown to influence the development of preservice science teachers' attitudes toward nanotechnology (Kim et al., 2011; Şenel-Zor et al., 2019), the positive opinions of students towards nanotechnology (Ekli, 2010), and the positive development of students' cognitive awareness (Emrahoğlu & Öztürk, 2010). The literature suggests that increasing awareness of nanotechnology has a positive impact on the development of positive attitudes toward nanotechnology. Ahmed et al., (2015) found that the level of awareness of nanotechnology significantly increases with the increase in educational duration, and a higher level of awareness and higher education level has a positive effect on participants' attitudes towards nanotechnology. Furthermore, Şenel-Zor (2017) demonstrated in her study that activity-based nanoscience and nanotechnology education led to a positive increase in preservice science teachers' awareness of nanotechnology. In this context, there seems to be a connection between high academic achievement and the development of positive attitudes towards nanotechnology, as well as high awareness and opinions regarding nanotechnology.

As a result of the conducted study, it is observed that preservice science teachers have a high level of attitude towards nanotechnology. Considering that attitude towards nanotechnology is thought to be associated with the level of knowledge and sensation, it is seen that incorporating nanotechnology into school curricula from primary school onwards and giving more prominence to nanotechnology in media sources can enhance individuals' attitudes towards nanotechnology. Taking into account that the use of various technological materials increases positive attitudes towards technology (Ekli, 2010), it is also believed that early exposure to technology and a tendency towards technology positively influence the attitude towards nanotechnology.

RECOMMENDATIONS

In line with the findings of this study, recommendations are presented for researchers aiming to explore a similar topic and for educators in this field, highlighting the groups that could potentially be affected by the results and benefit from them.

In this study, only the attitudes of preservice science teachers towards nanotechnology were examined based on variables such as gender, grade level, and academic achievement level. In future studies in this field, the attitudes of preservice science teachers from other fields towards nanotechnology can be investigated, and a comparison can be made between the attitudes of preservice science teachers in science fields and those in various other fields.

Furthermore, while there are studies examining the attitudes of students and preservice teachers towards nanotechnology in our country, there is a lack of research specifically investigating the attitudes of teachers. The attitudes of teachers towards nanotechnology could be explored and compared based on variables such as subject area, educational background, age, gender, and the type of institution they work in (public or private).

It is believed that the attitudes of future science teachers who will train the next generation of nanotechnology experts will improve as their perceptions of the benefits and risks of nanotechnology are enhanced. At this point, media, as one of the sources of nanotechnology perception, can provide more coverage not only on the benefits but also on the risks of nanotechnology.

There is an interaction between the level of knowledge in the field of nanotechnology and attitudes toward nanotechnology. To enhance positive attitudes towards nanotechnology, knowledge gaps in the field of nanotechnology should be addressed, and national and international planning can be implemented to increase knowledge levels.

Since the benefits and risks of nanotechnological applications will be perceived more consciously with the increase in the level of knowledge towards nanotechnology, it can be thought that the attitude towards nanotechnology can reach a higher level. In this direction, it can be thought that increasing the knowledge level of preservice science teachers by including nanotechnology in science curricula may lead to an increase in attitudes towards nanotechnology. The studies aiming to identify the sources of attitudes towards nanotechnology in the literature are limited. A qualitative study is recommended to be conducted to identify the sources of attitudes towards nanotechnology for researchers working in this field.

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