Education Quarterly Reviews

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The Knowledge and Awareness Levels of Gifted Children on Nanotechnology

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Abstract
The purpose of the study is to determine the knowledge and awareness of gifted children receiving education in the Science and Art Center on nanotechnology. The descriptive survey model was used in the study. The purposeful sampling method was chosen and a total of 160 students receiving education in two Science and Art Centers located in the city of Antalya in the 2018-2019 academic year were included in the study. The students consisted of 5th, 6th, 7th, and 8th-grade students. The study tested whether the nanotechnology knowledge levels of gifted students differ according to the variables of students 'gender, grade level, knowledge source, parents' education level, and occupation. According to the findings, while the students' knowledge and awareness of nanotechnology did not create a significant difference in terms of the gender variable, it was determined that as the grade level increased, the knowledge and awareness level also increased. Also, it was determined that as the parents' education level increased, the students' knowledge on nanotechnology increased and that the knowledge and awareness of students whose parents are engineers or doctors were higher compared to the other students.

Keywords: Gifted Students, Nanotechnology, Awareness, Knowledge

1. Introduction

In the 21st century, the speedy development in science and technology guides the global economy and increases international competition. One of the developments is experienced in the area of nanotechnology. This technology is rapidly developing and spreading and almost all countries are making big investments in these areas. The nano represents research areas in science and technology. Nanoscience expresses the structure science which ranges between 1-100 nanometers (NNI, 2001) and is the study area that aims at designing and producing new nanostructures or adding new and extraordinary characteristics to existing structures as a result of designing and organizing objects in the nanometer scale and their physical, chemical and biological properties in various ways (Enil and Köseoğlu, 2016). Nanotechnology can be applied to numerous areas such as information technology, biotechnology, and cognitive science because it is the skill of processing materials on the smallest scale possible (Nikalje, 2015). The effect of nanotechnology gives direction to the industrial and state policies of

competing countries in the present time. As this technology known as nanomanufacturing in the production industry entered the market, the first generation "passive nanostructures" have emerged in 2001 (for instance, in nanoparticles, coating). Since most living beings operate at the nanoscale level, there is a need for many naturally emerging nanomaterials (Doyle, 2006). In 2005, the new nanomanufacturing wave emerged called the second generation "active nanostructures" (for instance, in medicine, transistors). The 3-D nanosystems and system systems" defined as third-generation (for instance, heterogenous nano components) have continued until 2010. Today, it is expected for the wave named "molecular nanosystems" which will be defined as the fourth generation to have more place in our lives as of 2020 (Kumar and Scarola, 2006; Roco, 2008; Yurik, 2011). In the 21st century, nanotechnologists have started using nanomaterials naturally formed or produced in numerous areas (Zhang & Feng 2006). Since nanomaterials are more advantageous compared to macromolecules and have wider surface areas /volume rates and advanced characteristics, they have been used in the health area, for instance, to produce images of areas with cancer tumors. Nanocomposite polymers increase certain improvements such as endurance, antimicrobial properties, and resistance to harsh weather conditions (Doyle, 2006). Due to this property, they are used frequently in the food packaging industry. The use of nanotechnology in this area provides the opportunity to increase the shelf-life of food products (Mei, McClements, Wu & Decker, 1998). Also, nanotechnology is often used in Technologies that are biology-based in the area of agriculture. Nanotechnology has been used to manipulate plants' genetic materials to increase variety which is resistant to diseases and can ripe faster (Lagaron, Cabedo, Cava, Feijoo, Gavara, & Gimenez, 2005). This technology can be applied in all areas of human life from health to agriculture and security. Lastly, nanotechnology will change the regenerative medicine sector, medicine researches, and stem cell researches (Nikalje 2015).

1.1. Importance of the Integration of Nanotechnology to Curricula

A method of increasing the participation of students studying nanotechnology is to integrate nanoscience into educational curricula. However, there are some barriers against the efficient integration of nanotechnology into K-12 curricula. The primary barrier is the representation of nanometer length scale and conceptualization. Researches show that students, even at the post-graduate and doctorate level in the area of chemistry have difficulty in visualizing and understanding objects and processes on the nanoscale (Hutchinson, Bodner & Bryan, 2011). Another difficulty is that nanotechnological concepts and processes cannot be easily understood until students are introduced to concepts of atoms, molecules, and chemical interactions. The studies carried out in this area make different teaching methods necessary for students o each level. Before students learn the subject of nanotechnology, their teachers should gain experience in teaching the concept in this area or at least reach a level of preparedness. However, nanotechnology applications are only a part of university education at the engineering or physics, chemistry graduate level. Sufficient places to these areas are not given place to teacher candidates who are to educate students in this area (Kulinowski, 2006). Nanotechnology cannot be and should not be taught as another subject due to its interdisciplinary nature in science lessons. Learning nanoscience requires integration with all the aspects of the science it embodies (Tessman, 2009).

When the literature is reviewed, many academic studies can frequently be seen which underline the importance of starting nanoscience education at early ages to increase nanoscience literacy (Laherto, 2012). Also, it can be seen that various projects have been initiated which aim at including nanotechnology in primary and middle-school curricula in different countries (Sweenay & Seal, 2008). Kumar (2007) underlined the lack of nano knowledge in science teacher candidates and nano perception in society in his study. He applied a survey of 10 items to 100 teacher candidates which evaluated different aspects of nanoscience and nanotechnology such as etymology and physical scale. The results show that the teachers of the future do not have sufficient 21st-century knowledge to be able to teach contemporary science in their lessons (Kumar, 2007). The researcher suggested increasing the knowledge of science teachers in this area by in-service training. Floyd-Smith et al. (2009) and Jones, Broadwell, Falvo, Minogue, and Oppewal (2005) presented examples as to how nanotechnology can be taught in the primary, middle and high-school levels. Floyd-Smith et al. (2009) have implemented a social help activity on nano cloths and some nano subjects related to the basic principles of nanotechnology. After the application, it was determined that the conceptual understanding of middle and high-school students has

increased by 20-52%. In another study in this area in which Jones et al. (2005) presented how nano cloth could be discovered at primary school level and naturally integrated into the current science curriculum with 5th-grade students, the researchers carried out an activity which tested nano processed cloth claimed to push stains and water. Since the subject of clothing made of nanotechnological cloths is related to the lives of the students, it was concluded as a result of the study that it had a positive effect on their interest in science and understanding of concepts.

Kumar and Scarola (2006) underlined that education on nanotechnology being more widespread in the level following middle-school education is not right and that educators have to teach nanotechnology subjects with insufficient resources. The researchers stated that this needs to be corrected because students make their academic decisions at the middle-school level and their attitude and perception develops at this level (Simpson et al., 1994); if there is a lack of curricula that support the application of nanotechnology in K-12 classes (Kumar and Maslin-Ostrowski, 2008), the students will probably not be interested in the subject of nanotechnology or careers related to it.

Nanotechnology has the potential to change the world and redefine our lifestyle. Nanotechnology will inevitably be a part of a majority of 21st-century occupations. It has been estimated that to sustain the nano industry until 2015, 2 million strong workforces would be required (Roco and Bainbridge, 2001), but unfortunately sufficient human resources could not be created. Therefore, it is necessary that K-12 classes rapidly integrate nanotechnology into the current curricula (Bowles, 2008; Floyd-Smith et al., 2009; Kumar and Kerr, 2008; Kumar, Lapp, Marinaccio and Scarola, 2008). This education can start at an early age. Kumar and Kerr (2008) argue that primary school level students can discover nano sub-screens: it is a subject related to the lives of primary school children and this is meaningful and purposeful participation. As for high-school-level chemistry classes, the importance of giving place to more complex nanotechnology subjects such as nano fuel cells.

As a result, countries needed a fluent workforce in the current economy and technologies which guide the global economy to protect their competitive power. Superpowers such as the USA or China need to comply with the workforce demands of the society and if necessary, to train science teachers on nanotechnology and integrate nanotechnology into the current science curricula to secure their future. In our country, Nanotechnology is among the prioritized subjects in TUBITAK's (Scientific and Technological Research Council of Turkey) Vision 2023 program. As it is stated in this program, although our nanotechnology studies have entered a period of reconstruction with EU's 6th Framework Program, nanoscience and nanotechnology are taught only in a few lessons and in a very limited manner in secondary education. In the middle and primary school levels, there are no nanoscience and nanotechnology education programs (Aslan and Şenel, 2015).

The purpose of this study is to determine the knowledge level of middle-school students receiving education in BILSEM on nanotechnology. In today's world, nanotechnology has strategic importance, besides the students receiving education in BILSEM being an important source for the future of our country. Therefore, since today's students will be the future's potential nanotechnology producers and consumers with their knowledge levels on the concept of nanotechnology, the obtained findings will shed light on the efficiency of the National science curriculum in the global world.

For this purpose, the study also tested whether the nanotechnology knowledge levels of gifted students differ according to the variables of students 'gender, grade level, knowledge source, parents' education level, and occupation.

2 . Method

2.1. Research Design

In this study, a descriptive survey was used. A survey model is a research approach that aims at describing a past situation or a situation that still exists as it is. These are studies in which the vies, attitudes, and skills of the participants related to a subject or event are determined. These types of researches, in general, make it possible

to find answers to questions such as "at which level, at which stage, when" and determine the characteristics of large masses (Creswell, 2012).

2.2. Sample

The criterion sampling method was chosen among the purposeful sampling methods for the problems for which answers are sought within the scope of the study. Purposeful sampling methods focus on rich events and phenomena which can shed light on a problem. This sampling method is different from the probabilistic sampling method in terms of obtaining deeper knowledge (Patton,2014). In line with the purpose of the study, which was carried out in the light of this information, this sampling method was preferred since it was only focused on the views of gifted children on the subject area. In this context, the study was carried out with 160 students receiving education in two Science and Art Centers in the 2018-2019 academic year in the city of Antalya. 76 of these students were female and 84 were male. The students consisted of 5th, 6th, 7th, and 8th-grade students. 48 of these students were 5th, 34 of 6th, 32 of 7th, and 46 of 8th-grade students.
The descriptive analyses related to the frequency and percentage distribution of the students' socio-demographic characteristics in the study are given in Table 1.

Table 1: Findings on the Socio-Demographic Characteristics of the Students

Variables	Frequency	Percentage (%)
Gender		
Female	76	47.5
Male	84	52.5
Grade Level		
5th grade	48	30
6th grade	34	21.25
7th grade	32	20
8th grade	46	28.75
Mother's Education Level		
Primary school	6	3.8
Middle-school	34	21.3
High-school	36	22.5
University	84	52.5
Father's Education Level		
Primary school	6	3.75
Middle-school	6	3.75
High-school	48	30
University	100	62.5
Mother's occupation		
Teacher	32	20
Doctor	8	5
Engineer	6	3.8
Workman	14	8.8
Civil servant	30	18.8
Free-lance (trade)	14	8.8
Other	56	35

Continuation of Table 1: Findings on the Socio-Demographic Characteristics of the Students

Father's occupation		
Teacher	20	12.5
Doctor	12	7.5
Engineer	10	6.3
Workman	24	15
Civil servant	34	21.3
Free-lance (trade)	34	21.3
Other	26	16.3

When Table 1 is analyzed, it can be seen that the students' mothers' education level is a university with a maximum of 84 individuals (52.5%) and fathers' education level is a university with 56 individuals (70%). When the mothers' and fathers' occupations are analyzed, it can be seen that the category others is the highest in mothers' occupation with 56 individuals (35%) and the category of a civil servant and free-lance (trade) is the highest in fathers' occupation with 34 individuals (21.3%).

2.3. Data Collection Tools

In the study, the personal information form and Nanotechnology Questions Form were used.

In the personal information form, there are questions about the students' gender, mother's education level, father's education level, mother's occupation, father's occupation, and whether the student has heard about the concept of nanotechnology before or not. To measure the students' knowledge of nanotechnology, a question form consisting of 11 questions was used. The question form was prepared by Alpat, Uyulgan, Şeker, Altaş, and Gezer (2017) through the analysis of the studies in the literature on nanotechnology. The first 5 of the nanotechnology questions related to the subject were determined as the attention-grabbing questions for the students. The remaining 5 questions were formed as Knowledge Test on Nanotechnology. The gains of the 6 questions about the Academic Success test know the concept of nanotechnology, being able to explain the purposes of applying nanotechnology, being able to form the connection between nanotechnology and the branches of science it is related to, being able to associate the subject of nanotechnology with Daily life, being able to explain the pros and cons of nanotechnology and being able to create/present different ideas about the development of nanotechnology.

2.4. Analysis of the Data

In the analysis of the questions related to the knowledge test on nanotechnology, scoring was done by categorizing the answers as full comprehension, partial comprehension, and no comprehension. If the students give full answers to a question, that question is evaluated in the full comprehension category and receives 2 points. If the student gives a partial answer, then it is evaluated in the partial comprehension category and receives 1 point. If the student gives an unrelated answer or leaves it blank, it is evaluated in the no comprehension category and receives 0 points.

SPSS was used in the analysis of the data. First, the t-test for independent samples and ANOVA tests were applied in cases where the distribution of the research data was normally distributed, while the Kruskal Wallis tests were applied when they did not show normal distribution. In cases where a significant difference is determined, the cohen d effect size value was calculated with the formula $Z\sqrt{N}$. It is expressed as small if the effect size value is less than 0.2, medium if it is between 0.2 and 0.8, and large if it is higher than 0.8 (Cohen, 1988).

3.Results

The analysis of the knowledge test on nanotechnology scores in terms of the students' gender was done through the independent samples t-test. The finding related to the test is given in Table 2.

Table 2: Findings on the Knowledge Test on Nanotechnology Scores in terms of the Gender Variable

Gender	N	X	SD	t	p
Female	76	4.00	2.27	1.027	.308
Male	84	3.50	2.07		

When Table 2 was analyzed, a significant difference between the gender variable and the knowledge test on nanotechnology scores as a result of the analyses in which the change in the knowledge test scores in terms of the students' gender was analyzed (t=1.027, p>.05). Although there was no significant change, it was seen that the female students' knowledge test on nanotechnology scores was higher than the male students' scores.

The analysis of the students' knowledge test on nanotechnology scores in terms of the grade variable was done through ANOVA. ANOVA findings of the knowledge test on nanotechnology scores in terms of the grade variable are given in Table 3.

Table 3**:** ANOVA findings on the Knowledge Test on Nanotechnology Scores in terms of the Grade Variable

Grade	N	X	SS	F	p	Significant Difference
5th grade	48	2.85	2.03	14.653	.000	5th grade – 8th grade 6th grade – 7th grade 6th grade – 8th grade
6th grade	34	2.65	1.04			
7th grade	32	4.45	2.23			
8th grade	46	5.05	2.25			

When Table 3 was analyzed, a significant difference was found between the knowledge test on nanotechnology scores according to the grade variable as a result of the analyses in which the students' knowledge test on nanotechnology scores were analyzed according to the grade variable [$F_{(156)}$=14.653, p<.05]. As a result of the Tukey multiple comparisons test done to determine between which groups the significant difference resulted from, it was determined that this difference results between 5th-8th grades, 6th-7th grades, and 6th-8th grades. When the effect sizes were calculated, it was found to be medium in size. It can be said that the differences are medium in size.

Kruskal-Wallis findings of the knowledge test on nanotechnology scores according to the students' mothers' education level and occupation are given in Table 4.

Table 4: Kruskal-Wallis findings of the knowledge test on nanotechnology scores according to the students' mothers' education level and occupation

Mother's education level						
	N	Mean Rank	sd	X^2	p	Significant difference
Primary school	6	68.50	3	23.138	.011	Middle-school-university
Middle-school	34	64.38				
High-school	36	61.39				High-school-university
University	84	98.62				

Continuation of Table 4: Kruskal-Wallis findings of the knowledge test on nanotechnology scores according to the students' mothers' education level and occupation

Mothers' occupation						
Teacher	32	96.16	6	34.246	.008	Teacher-other
Doctor	8	110.63				Engineer-workman
Engineer	6	131.33				Engineer-other
Workman	14	98.00				Engineer- Civil
Civil servant	30	90.83				servant
Free-lance (trade)	14	70.64				Workman-other
Other	56	56.00				Doctor-other
						Civil servant-other

When Table 4 was analyzed, a significant difference was observed between the knowledge test scores in terms of the mothers' education level according to the Kruskal-Wallis test done to see whether there was a difference between the knowledge test scores in terms of the mothers' education level $[X^2_{(3)}=23.138, p<.05]$. As a result of the Mann-Whitney U test done to determine between which groups this significant difference resulted from, it was found that the difference was between middle-school-university and high-school-university groups. When the effect sizes were calculated, it was found to be medium in size. It can be said that the differences are medium in size. As a result of the analyses in which the knowledge test scores were analyzed in terms of the mothers' occupation, a significant difference was determined $[X^2_{(6)}=34.246, p<.05]$. As a result of the Mann-Whitney U test done to determine between which groups this significant difference resulted from, it was found that the difference was between teacher-other, engineer-other, engineer-workman, Engineer- civil servant, doctor-other, workman-other, and civil servant-other occupation groups. When the effect sizes were calculated, engineer-other, engineer-workman, Engineer- civil servant, doctor-other group differences were large. The other differences were found medium in size.

Kruskal-Wallis findings of the knowledge test on nanotechnology scores according to the students' mothers' education level and occupation are given in Table 5.

Table 5: Kruskal-Wallis findings of the knowledge test on nanotechnology scores according to the students' mothers' education level and occupation

Father's Education Level						
	N	Mean rank	sd	X^2	p	Significant difference
Primary school	6	30.50	3	15.552	.053	-
Middle-school	6	55.33				
High-school	48	70.92				
University	100	88.20				
Father's Occupation						
Teacher	20	103.15	6	29.158	.028	Doctor-workman
Doctor	12	121.42				Doctor-civil
Engineer	10	82.60				servant
Workman	24	67.63				Doctor-other
Civil servant	34	80.00				Teacher-other
Free-lance (trade)	34	90.91				Civil servant-
Other	26	50.45				other
						Free-lance
						(trade)-other

When Table 5 was analyzed, a significant difference was not observed between the knowledge test scores in terms of the fathers' education level according to the Kruskal-Wallis test done to see whether there was a

difference between the knowledge test scores in terms of the fathers' education level [$X^2_{(3)}$=15.552, p>.05]. As a result of the analyses in which the knowledge test scores were analyzed in terms of the fathers' occupation, a significant difference was found [$X^2_{(6)}$=29.158, p<.05]. As a result of the Mann-Whitney U test done to determine between which groups this significant difference resulted from, it was found that the difference was between doctor-workman, doctor-civil servant, doctor-other, teacher-other, civil servant-other, and free-lance (trade)-other occupation groups. When the effect sizes were calculated, doctor-other difference was found large. Other differences (doctor-workman, doctor-civil servant, teacher-other, civil servant-other, and free-lance (trade)-other occupation) were found medium in size.

Findings related to the Kruskal-Wallis analysis done to determine whether the students' answers about where they heard the word nanotechnology before affected the knowledge test scores are given in Table 6.

Table 6: Kruskal-Wallis findings on knowledge test on nanotechnology scores

	N	Mean Rank	sd	X^2	p	Significant difference
Newspaper/magazine	42	84.00	4	13.220	.136	-
TV program	44	95.82				
Internet	30	80.53				
Textbook	12	67.17				
Other	32	63.19				

When Table 6 was analyzed, a significant difference between the knowledge test scores in terms of where the students' heard about the concept of nanotechnology as a result of the analyses in which the knowledge test scores of the students were analyzed in terms of where they heard about the concept of nanotechnology [$X^2_{(4)}$=6.990, p>.05]. The analysis of the students' answers to questions asked to attract the attention of the students to the subject of nanotechnology is given in Table 7.

Table 7: Findings on questions to attract attention

Question 1	Theme	f	%	Answer examples
	Possible	110	68.75	* As a reward of nanotechnology, printing on smaller objects can be possible.
	Not possible	40	25	* Although technology is developed, printing on such a thin object is not possible.
	Undecided	10	6.25	
Question 2	Theme	f	%	
	Closet	80	50	* This shape reminds me of a closet.
	Microorganism	20	12.5	* A black and white photograph of a fountain
	Microscope view	30	18.75	* Looks like a microorganism visual.
	A nanotechnological tool	10	6.25	* Visual of a nanotechnological tool
	An object	10	6.25	
	A fountain	10	6.25	
Question 3	Theme	f	%	
	Nanotechnology	40	50	* Produced through chemical tests.
	Through experiments and tests	16	20	* Produced as a result of nanotechnology.
	Through short pieces of thread	8	10	* Produced as a result of people's problems.
	About a problem	8	10	* Produced by joining very small pieces of thread.
	By covering with wax	8	10	

Continuation of Table 7**:** Findings on questions to attract attention

Question 4	Theme	f	%	
	By coating with a special fluid	24	25.53	* We can protect it by covering it on rainy and cold days.
	By covering them	32	34.04	* I would build a greenhouse and put a heater inside.
	By covering with silicone through nanotechnology	24	25.53	* I would use nanotechnological tools to build it and put a protective object inside.
	By covering with silicone	8	8.51	
	Through greenhouses	6	6.38	
Question 5	Theme	f	%	
	Dimension			
	Dimension in mm	24	24	* I think it must be 1mm, because when people can break down atoms, why shouldn't it be possible to create such a small statue? It is in Turkey.
	1 meter	8	8	
	Dimension in cm	22	22	* It is 1 meter and located on Earth.
	nanometer	14	14	
	At a level that can only be seen with a microscope	32	32	
	Where is it?			
	Outside of Earth	14	20	
	Inside a computer	8	11.43	
	Turkey	36	51,42	
	Other Countries	12	17.14	

When Table 7 was analyzed, it was seen that the gifted children answered the first question, "Is it possible to print a cartoon strip on a strand of hair?" as possible at a high rate (68.75%). In the 2nd question, the students resembled the visual to a closet (f=80). It was determined that a low number of students answered as a nanotechnological tool (6.25%). In the 3rd question, it was determined that a high number of students answered inventions such as non-crease pants are possible through nanotechnology (30%). When the students' answers were analyzed about how a statue can be protected in the 4th question, it was seen that the rate of the students who answered through nanotechnology was 12.25%. In the 5th question, it was seen that only 14 of the students answered as nanometer about the dimensions of the statue.

4. Conclusion and Discussion

As a result of the analyses in which the knowledge of the students on nanotechnology in terms of their gender was analyzed, a significant difference was not found between their knowledge of nanotechnology in terms of gender. However, it was seen that the female students' average scores were higher compared to the male students. Alpat et al. (2017) determined in their study that there is no significant difference between knowledge on nanotechnology and female and male students. İpek et al. (2020) concluded in their study that there is a difference between the knowledge of males and females on nanotechnology, but that awareness of the males was higher compared to the females.

Another finding obtained as a result of the study was that knowledge of the students on nanotechnology in terms of gender created a significant difference. It was observed that as grade level increased, the students' knowledge of nanotechnology also increased. This finding is parallel to the study of Floyd-Smith et al. (2009). Atabaş (2012) in his study underlined that the cognitive development levels of students should be taken into consideration during the process of including nanotechnology in the curriculum and the difficulties in teaching the concept of nanotechnology to the students before the abstract thinking stage. A majority of concepts related

to nanotechnology being abstract and the lack of knowledge of young age group children on physics and chemistry are the greatest barriers to lack of knowledge. However, in Sagun-Gököz and Akaygün's (2013) study, the researchers expressed that the workshop activity on nanotechnology training was found informative, effective, and fun by the students.

In some studies, it was concluded that the education level and occupation of the parents are influential in terms of the introduction of the concept of nanotechnology to the students' or TV, newspapers, and magazines at home are effective on the students' knowledge on nanotechnology (Atabaş, 2012). In our study, it was determined that the education level of the parents has a significant effect on the knowledge of the students on nanotechnology as well. It was determined that the knowledge level of students whose mother-father are engineers, teachers, and doctors are higher compared with other occupations. Also, a majority of the students stated that they heard about the concept of nanotechnology on TV. In support of this finding, in Ekli (2010)'s study, it was determined that the students have positive views on nanotechnology, they do not hear much about nanotechnology, and that they mostly hear about nanotechnology and have pre-knowledge from TV programs. Similarly, in Enil and Köseoğlu's study (2016), it was concluded that teacher candidates mostly acquire information about nanotechnology from radio and Tv programs. In most studies, it has been observed that awareness of nanotechnology has not been created and individuals have insufficient knowledge about it (Elmarzugi et al.,2014; Enil and Köseoğlu, 2016; Şenocak, 2014). It may be beneficial to have visual and written media support or to use social media which has become popular in recent times to create awareness in individuals and increase their general knowledge level on nanotechnology. Knobel, Murriello, Bengtsson, Cascon, and Zysler (2010) emphasize the connection between the concepts related to science students learn in school and science in society. In his study which aimed at determining the understanding of international primary, middle school, and high-school students of nanotechnology and nanoscience, the researcher reported that about 60% of the students mentioned nanotechnology or nanoscience terminology and only 18% of these students expressed that they have heard these terms in school, while 31% expressed that they heard these terms outside of school.

According to the findings of this study, nanotechnology's being a current technology necessitates it to be included in curricula. Also, students finding this subject interesting and informative support the idea that the subject should be taught in an integrated manner with science curricula in primary and middle school and with physics and chemistry curricula in secondary education. However, studies report that nanotechnology and nanoscience concepts should be integrated with concepts unique to a specific subject and scientific events and that this will allow nanotechnology to be taught with an interdisciplinary approach (Ak, 2009; Daly, Hutchinson and Bryan, 2007; Stevens, Sutherland, Schank and Krajcik, 2007).

In a conclusion, the human resources need in the area of nanotechnology will increase in the future and today's students will have a workforce in these areas. Nanoscience and nanotechnology education should be developed not only in middle schools and high schools but at all levels of society by targeting the human resources at each level. Teaching an area of science and technology in formal and informal learning environments at a level required by our age will have significant contributions to the education of targeted human resources.

5. Suggestions

- Giving more place to new technologies such as nanotechnology in curricula may increase students' knowledge on this subject.
- Awareness activities such as short and long-term workshops, summer schools, exhibitions, promotions, museum exhibitions, multimedia activities can be organized for students in line with their age levels.
- Due to the interdisciplinary characteristic of nanotechnology, this subject can be given a place in other lessons and textbooks besides science lessons in middle schools, and students' awareness and knowledge levels can be developed.
- In schools which gifted students receive education, workshops can be organized on nanotechnology and students' awareness and interest can be increased.

References

Ak, N. (2009). *Nanoteknoloji eğitiminin lise düzeyine uyarlanması.* Yüksek Lisans Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara

Alpat, S. K., Uyulgan, M. A., Şeker, S., Altaş, H. Ş., & Gezer, E. (2017). Effect of cooperative learning on academic achievement and opinions of the 10th grade students' in the topic of nanotechnology at secondary level. *Journal of the Faculty of Education, 18*(1), 27-57.

Aslan, O. ve Şenel, T. (2015). Fen alanları öğretmen adaylarının nanobilim ve nanoteknoloji farkındalık düzeylerinin çeşitli değişkenlere göre incelenmesi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 24*, 363-389.

Atabaş, Ü. (2012). *İlköğretim öğrencilerini nanoteknoloji ve biyoteknoloji konularında eğitmeye ve bilgilendirmeye yönelik bir çalışma.* Yüksek Lisans Tezi, Fatih Üniversitesi Mühendislik ve Fen Bilimleri Enstitüsü, İstanbul.

Bowles, K. (2008). *Teaching nanotechnology in the K-12 science classroom. In A. E. Sweeney & S. Seal (Eds.),* Nanoscale science and engineering education (pp. 37– 47). Stevenson Ranch, CA: American Scientific Publishers.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences (2nd ed.).* Hillsdale, NJ: L. Erlbaum Associates

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (4rd ed.).* Upper Saddle River, NJ: Prentice Hall

Daly, S., Hutchinson, K., & Bryan, L. (2007). Incorporating nanoscale science and engineering concepts into middle and high school curricula. *Proceedings of the American Society for Engineering Education.12*(1).

Doyle, E. M. (2006). Veterinary drug residues in processed meats potential health risk. *A Review of the Scientific Literature,* 2 - 7.

Ekli, E. (2010). *İlköğretim ikinci kademe öğrencilerinin nanoteknoloji hakkındaki temel bilgi ve görüşleri ile teknolojiye yönelik tutumlarının bazı değişkenler açısından araştırılması.* Yüksek Lisans Tezi, Muğla Üniversitesi Fen Bilimleri Enstitüsü, Muğla.

Elmarzugi, N. A., Keleb, E. I., Mohamed, A. T., Benyones, H. M., Bendala, N. M., Mehemed, A. I. ve Eid, A. M. (2014*).* Awareness of Libyan students and academic staff members of nanotechnology. *Journal of Applied Pharmaceutical Science, 4*(06), 110-114.

Enil, G. ve Köseoğlu, Y. (2016). Fen bilimleri (fizik, kimya ve biyoloji) öğretmen adaylarının nanoteknoloji farkındalık düzeyleri, ilgileri ve tutumlarının araştırılması. *International Journal of Social Sciences and Education Research, 2*(1), 61-77.

Floyd-Smith, T., Baah, D., Bean, K., Hollinger, A., Vickers, D., & York, J. (2009). Principles of nanotechnology for middle and high school students, *Journal of Materials Education, 31*(3-4), 167–174.

Hutchinson, K., Bodner, G. M., & Bryan, L. (2011). Middle-and high-school students' interest in nanoscale science and engineering topics and phenomena. *Journal of Pre-College Engineering Education Research (J-PEER)*, *1*(1), 4.

İpek, Z., Atik, A. D., Tan, S., & Erkoç, F. (2020). Awareness, exposure, and knowledge levels of science teachers about nanoscience and nanotechnology. *Issues in Educational Research, 30*(1), 134-155.

Jones, M. G., Broadwall, B., Falvo, M., Minogue, J., & Oppewal, T. (2005). It's a small world after all. *Science and Children, 43*(2), 44–46.

Knobel, M., Murriello, S. E., Bengtsson, A., Cascón, A., & Zysler, R. (2010). The perception of nanoscience and nanotechnology by children and teenagers. *Journal of Materials Education, 32*(1-2), 29-38.

Kulinowski, K. M. (2006). *Incorporating nanotechnology into K-12 education. M.C. Roco, W. S. Bainbridge, (Ed.)*, Nanotechnology: Societal Implications - Individual Perspectives, (ss. 322-327), Berlin, Heidelberg: Springer

Kumar, D. D. (2007). The nanoscale science in technology and teaching. *Australian Journal of Education and Chemistry, 68*, (20-22).

Kumar, D. D., & Kerr, R. (2008). *K-12 science education in nanotechnology: Examples using computer-based laboratory instrumentation. In A. E. Sweeney & S. Seal (Eds.),* Nanoscale science and engineering education (pp. 49–56). Stevenson Ranch, CA: American Scientific Publishers.

Kumar, D. D., Lapp, S. I., Marinaccio, P., & Scarola, K. (2008). Science literacy strategies anchored in nanotechnology. *School Science Review, 89*(329), 63–73.

Kumar, D. D., & Maslin-Ostrowski, P. (2008). Policy considerations for nanoscience education. *Journal of Materials Education, 30*(5-6), 385–388.

Kumar, D. D., & Scarola, K. (2006). Nanotechnology and closed-captioned videos: Improving opportunities for teaching science to ESL students. Asia-Pacific Forum on Science Learning and Teaching, 7(2). Retrieved from http://www.ied.edu.hk/apfslt/v7_issue2Kumar/index.htm

Laherto, A. (2012). *NanoScience education for scientific literacy: Opportunities and challenges in secondary school and in out-of-school settings.* Doctoral dissertation, University of Helsinki, Finland.

Lagaron, J., Cabedo, L., Cava, D., Feijoo, J., Gavara, R., & Gimenez, E. (2005). Improving packaged food quality and safety. Part 2: *Nanocomposites. Food additives And Contaminants, 22*(10), 994-998. doi: 10.1080/02652030500239656

Mei, L., McClements, D., Wu, J., & Decker, E. (1998). Iron-catalyzed lipid oxidation in emulsion as affected by surfactant, pH and NaCl. *Food Chemistry, 61*(3), 307-312. doi: 10.1016/s0308-8146(97)00058-7.

National Nanotechnology Initiative. (2001). Nanotechnology and you. Retrieved from http://www.nano.gov/html/gacts/faqs.html.

Nikalje, A. (2015). Nanotechnology and its applications in medicine. Medicinal Chemistry, 5(2). doi: 10.4172/2161-0444.1000247.

Roco, M. (2008). Nanotechnology in the United States and the National Science Foundation [Electronic presentation]. Retrieved from http://www.nsf.gov/bfa/dias/policy/docs/irishnano.pdf.

Roco, M., & Bainbridge, W. (2001). *International strategy for nanotechnology research and development.* Retrieved from www.nsf.gov/crssprgm/nano/ connections/international/1jnr_int.doc.

Sagun-Gököz, B. ve Akaygün, S. (2013). Üniversiteden liseye uzanan köprü: Bir nanobilim atölye çalışması. *Boğaziçi Üniversitesi Eğitim Dergisi, 31*(2), 49-72.

Simpson, R. D., *Koballa, T. R., Oliver, J. S., & Crawley, F. E. (1994). Research on the affective dimension of science learning. In D. Gabel (Ed.),* Handbook of research on science teaching and learning (pp. 211–234). New York, NY: The National Science Teachers Association.

Sweeney, A. E. & Seal, S. (Eds.) (2008). *Nanoscale science and engineering education.* Stevenson Ranch, CA: American Scientific Publishers.

Şenocak, E. (2014). A survey on nanotechnology in the view of the Turkish public. *Science Technology & Society, 19*(1), 79–94.

Tessman, J. M. (2009). *Students' conceptions of nanoscience phenomena: The beginning of a nanoscience concept inventory.* Doctoral dissertation, Purdue University.

Yurick, K. A., (2001). *Effects of Problem Based Learning with Web-Anchored Instruction in Nanotechnology on the Science Conceptual Understanding, the Attitude Towards Science, and the Perception on Science in Society of Elementary Students*, . Doctoral dissertation, Florida Atlantic University, Florida.

Zhang, Z., & Feng, S. (2006). The drug encapsulation efficiency, in vitro drug release, cellular uptake and cytotoxicity of paclitaxel-loaded poly(lactide)–tocopheryl polyethylene glycol succinate nanoparticles. *Biomaterials, 27*(21), 4025-4033. doi: 10.1016/j.biomaterials.2006.03.006