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An Investigation of Prospective Teachers' Views about the Nature of Science in Terms of Gender, Age and Department Variables

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Authors' contributions

This work was carried out in collaboration between both authors. Authors AIS and AS designed the study, wrote the protocol and supervised the work. Authors AIS and AS carried out all work and performed the statistical analysis. Author AIS wrote the first draft of the manuscript. Author AS managed the literature searches and edited the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study is to analyse prospective teachers' views about the nature of science. The study has also revealed the students' profiles in the sub-categories of the nature of science according to some variables (gender, age and department). The study is a descriptive survey research. Sample: It was conducted with 827 students who were enrolled in the formation program in the education faculties of two Public University in the 2014-2015 education year. The data were collected through the "Views about the Nature of Science" inventory which was developed by Mick, Nott and Jerry Wellington [26] and adopted into Turkish by Toz [33] as well as Personal Information Form. Results show that the participants demonstrated a positivist, realist, deductive, independent and contextual profile in terms of the sub-categories of the nature of science. The participants' views about the nature of science were found to differ according gender, age, and the departments they graduated from. In conclusion, the present study revealed parallel results with those

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conducted before in that prospective teachers showed a decrease in their positivist views when they were newly graduated from the university and the positivist belief became more precise with the increase in age. It is suggested to further investigate the reasons why prospective teachers demonstrate such a profile. Higher level thinking skills in the education programs should involve science as a powerful thinking method and prospective teachers should be provided with such a skill which can help people to understand, explain and control the universe. Therefore, education programs should include the necessary evaluations and improvements; and those programs should have such courses as “science history”, “the nature of science” and “science philosophy”.

Keywords: Formation program; prospective teachers; nature of science; science.

1. INTRODUCTION

Science is formed through the connection between the factual and conceptual world; it is a powerful thinking process which helps to understand, explain, and control the universe [1]. Science should be perceived neither simply as an effort to realize facts, nor as a body of knowledge to be explained holistically with scientific methods and memorized. Science is the ongoing process of conceptual development, an effort of interpreting data, and a process of discussing the interpretations again and again. Students can internalize this process only if they have the opportunity to experience it by themselves. Hence, in the education processes, students should be provided with activities that will make them think and act like scientists. Practices that increase students’ awareness about the differences distinguishing scientific information from other types of information and follow a powerful analysis and problem solving process rather than solely data collection are of great importance. Science is the life itself, it is a part of human [2-7].

According to positivist paradigm, science is a complete production which has been presented as a result of experiences and observations and expressed mathematically [8,9]. To understand science, we should review complete productions because we can understand only concrete productions. However, science is not a production but an activity, so it is not independent of us. It is an activity of scientists; and thus understanding science requires understanding beliefs and cultures of the people who produced it [10]. To summarise, while the first view indicates a positivist view which tries to explain the truth in an inductive way based on objective experiences and observations [11-14] the second view indicates a post-positivist view which defines science as a human activity [12,14,15]. Although it is questioned (in the articles by Karl Popper and Thomas Kuhn), it is a reality that the first view (positivism) is more widely accepted and has a wide effect [16]. This notion can be perceived by the tendency that people see science as a process independent of themselves.

The nature of science is a comprehensive concept which includes science philosophy, science history, and science sociology. The basic questions to be answered in the dimensions that form the nature of science are: what is the role of science, scientific process, society, scientists, and the way they work in improving and directing science? [17-19]. Therefore, it is important that education processes should be planned, applied, and evaluated at both theory and practice levels, in scientifically appropriate ways. In this regard, the questions “What kind of understanding do individuals develop regarding the nature of science with the education programs applied?” and “Do these programs raise individuals with desired qualities?” gain even more importance, especially if the point in question is teacher education.

With a decision taken in 1982, pre-service teacher training was transferred to the universities in cooperation with the Ministry of National Education. However, due to the developments and the policies since 1982, the role of education faculties in raising teachers has been subject to much debate. The discussions whether education should be accepted as science have surely a role about this issue. Many times, education was considered equal with teaching profession, and sometimes, due to its practice aspect, it is considered as an art which can be performed by anyone who encounters education. In fact, education is a science with its theoretical and practice aspects, just like other fields such as medicine, agriculture, and engineering [20]. Our view of science could be negatively affected by factors such as various practices in teacher education and some policies with decisions based on non-scientific data.

Various studies conducted in recent years have dealt with the nature of science [21-31]. These studies usually focused on identifying the views of teachers and students about the nature of science. However, no studies were found to be conducted with prospective teachers who have not been appointed yet. Seeking answers to the question "What are the profiles of prospective teachers especially who attend a formation program because they were not employed in their own field of science regarding the nature of science?" is of great importance in terms of discussing the teacher quality in Turkey. Thus, results of the present study are important in discussing the paradigm transformations in teacher education in the world.

The purpose of this study is to investigate prospective teachers' profiles in relation to their views about the nature of science. In line with this general purpose, the study was guided by the following questions:

1) What is the frequency of the prospective teachers' nature of science scores?
2) What is the frequency of the nature of science scores according to variables such as gender, age, department, knowledge in the courses, and instruction of topics such as science and scientific thinking?
3) Are there any significant differences between gender and the nature of science scores?
4) Are there any significant differences between age and the nature of science scores?
5) Are there any significant differences between the departments and the nature of science scores?

2. METHODOLOGY

This study used a descriptive survey model. In this model the aim is to define the present situation, compare present situation with defined standards or state relationship between certain cases [32]. In this study with the use of this model prospective teachers' profiles in relation to their views about the nature of science has been described. A total 827 students who were enrolled in the formation programs in Çukurova University-Adana and Mustafa Kemal University-Hatay city located in Mediterranean region of Turkey in the 2014-2015 education year participated in this study. In each classroom, the purpose of the study was explained and students were ensured of the anonymity and confidentiality of their responses. Participation in this study was voluntary, although all students present on the date of the data collection participated. Students completed a demographic sheet and the "The Views of the Nature of Science Inventory" with no time limits. Of all the participants, 532 students (64.3%) were enrolled in the formation program at Çukurova University and 295 students (35.7%) at Mustafa Kemal University. It was found that the participants in the formation program from both universities graduated from 16 different departments and 64 different universities in Turkey. Of all the participants, 517 (62.5%) were female and 310 (37.5%) were male. As for their age groups, 377 were in the "19-24" age group, 246 were in the "25-29" age group, and 204 were in the "30 and over" age group. When the participants were asked whether they received any instruction on such topics as information, science, scientific thinking, and scientific research, 582 students (70.4%) replied "no" and 245 (29.6%) students replied "yes". Those who indicated "yes" also wrote which courses and topics they received.

2.1 Data Collection Tools

The data collection tools which were used in the study were a) "Views of the Nature of Science Inventory" which was developed by Mick Nott and Jerry Wellington [33] and adopted into Turkish by Toz [30] and b) "Personal Information Form".

2.1.1 The views of the nature of science inventory

The inventory was developed by Mick Nott and Jerry Wellington [33] with a view to identifying people's views regarding the nature of science as well as revealing their nature of science profiles. Toz [30] adapted the inventory into Turkish in scope of the master's thesis titled "Evaluation of the Views of Physics Teachers regarding the nature of Science in terms of Some Variables". Validity and reliability studies were performed by Toz. The inventory consisted of 24 items, and the participants' scores were calculated according to their responses that ranged from -5 to +5 (-5, -4: totally disagree, -3,-2: disagree, -1, 0, +1: I do not know, +2,+3: I agree, +4, +5: totally agree).

The inventory consisted of five sub-dimensions which were included among the nature of science views and demonstrated as the opposite poles of one line. Inductivism – Deductivism:

items 5, 11, 19, 23 5), (2) Relativism – Positivism: items 1, 3, 21, 12, 14, 16, 18, 20), (3) (Contextualism – Decontextualism: items 2, 3, 6, 8, 13, 16, 18), (4) (Process – Content: items 7, 9, 17, 24, 15), and (5), Instrumentalism – Realism: items 10, 21, 4, 12, 14).

Each dimension corresponds to some certain items in the inventory (the items are written next to the dimension names in parenthesis). Some items seem to be shared by different sub-dimensions. In the adaptation study, Toz [33] found the reliability co-efficient as 0.684 while the present study has found it .6707. In this regard, the data collection tool is reliable enough to be used as a questionnaire form. There is a relationship between low reliability co-efficiency and the number of items. However, if the items have the content that can measure the desired qualities, the inventory can be used even if the reliability co-efficient is as low as .49 [34].

2.2 Analysis

The data collection tools used in the study was administered by the researchers in the summer semester of the 2014-2015 education year to the students who were enrolled in the formation program in Çukurova University and Mustafa Kemal University. The data were collected by administering the questionnaires in group sessions, after obtaining the necessary permissions. The students were given the practice forms and asked to fill in the inventory. After the prior information studies, the participants filled in the inventory in approximately 15 minutes. The researchers were present in the groups during the time the participants filled in the inventory and they provided explanations when necessary.

The data collected from the study were analysed using SPSS 17.0 package programming. Personal information about the participants was demonstrated with frequency and percentages. As to the data about the nature of science, they were coded based on the information provided by Toz [30] in the data analysis section. Then, the data were presented in tables with the percentage, mean scores and balanced view frequencies. Moreover, t-test and one-way variance analysis were performed with a view to identifying whether the students' views on the nature of science differentiated according to gender, age, and department variables.

3. RESULTS

This section demonstrates findings in relation to the data obtained from classroom teaching department students through "Views of the Nature of Science inventory" in accordance with the sub-aims of the study.

An analysis of Table 1 and Fig. 1 together shows that students who received formation (90.7%) had positivist views and the mean scores in this dimension was found $\overline{X}$ =18.27. Although it was very little in the relativism-positivism dimension (N_0 =62 % N_0: 7.5), balanced view was also identified. A similar case was found in favour of Realism in the Instrumentalism-Realism sub-dimension (Realism: 86.2%, $\overline{X}$ =12.15, N_0: 6.8%), and in favour of Content in the Process-Content sub-dimension (Content: 91.1%, =11.68, N_0:4.7%). As for the Inductivism-Deductivism sub-dimension, 73% of the participants had deductivism view. On the other hand, mean scores were found $\overline{X}$ =8.91 and balanced views were N_0:17.4%. In the Contextualism-Decontextualism sub-dimension, Decontextualism was 60.8% and Contextualism was 12.0%, and the highest balanced view value was found in this sub-dimension (%N_0 27.1).

Table 2 demonstrates the participants' sub-dimension mean scores in the nature of science according to gender, age, departments, and instruction of topics such as information, science and scientific thinking.

As seen in Table 2, the highest mean scores in all the variables (gender, age, department, and instruction of topics) were in favour of positivism in the RL-PZ sub- dimension. The lowest score in all variables was found in the IN-DE sub-dimension. This finding suggests that the participants' strongest stance was in their positivist profiles while the most moderate one was in their deductivism profiles.

In the gender variable, female students' mean scores were found to be higher than the scores of male students in the sub-dimensions of Inductivism-Deductivism and Process-Content while the male students outscored female students in all the other dimensions. According to the age variable, mean scores of those in the 25-29 age group were higher in the Relativism-Positivism and Process-Content sub-dimensions than the mean scores of the ones in other age

groups. The mean scores of the participants in the 30 and over age group were higher than the mean scores in other age groups in the sub-dimensions of Inductivism-Deductivism, Contextualism-Decontextualism, and Instrumentalism-Realism.

According to the analysis of the departments the participants graduated from, mean scores of the students who graduated from social fields (Turkish Philology, History, Geography, etc.) were higher than the mean scores of those who graduated from science fields (Physics, Chemistry, Biology, Mathematics, etc.) in the sub-dimensions of Relativism-Positivism, Process-Content and Instrumentalism-Realism. Mean scores of those who graduated from science fields (physics, chemistry, biology, mathematics, etc.) were higher in the Inductivism-Deductivism, and Contextualism-Decontextualism sub-dimensions.

Mean scores of the participants who indicated that topics such as "information, science, scientific thinking" were instructed were found to be lower than the scores of those who said these topics were not instructed only in the Contextualism-Decontextualism sub-dimensions.

Table 1. Frequency of classroom teaching department students' scores according to sub-dimensions

	Sub-dimensions	N	%	$\overline{X}$	N_0	$\%N_0$
1	Relativism	15	1.8	-9.15	62	7.5
	Positivism	750	90.7	18.27		
2	Inductivism	79	9.6	-5.11	144	17.4
	Deductivism	604	73.0	8.91		
3	Contextualism	99	12.0	-7.30	224	27.1
	Decontextualism	504	60.9	13.34		
4	Process	35	4.2	-5.40	39	4.7
	Contextualism	753	91.1	11.68		
5	Instrumentalism	58	7.1	-5.93	56	6.8
	Realism	713	86.2	12.15		

$\overline{X}$: Mean score; N_0: The number of prospective teachers who had balanced view (0 point) in the sub-dimension
$\%N_0$: The percentage of prospective teachers who had balanced view (0 point) in the sub-dimension

Table 2. The participants' nature of science mean scores according to gender, age, departments, and instruction of topics such as information, science and scientific thinking

Variables	Intervening variables	RL-PZ (-40/+40) $\overline{X}$	IN-DE (-20/+20) $\overline{X}$	CO-DE (-40/+40) $\overline{X}$	PR-CO (-25/+25) $\overline{X}$	INS-RE (-25/+25) $\overline{X}$
General mean score		16.47	6.13	7.43	10.41	10.05
Gender	Female	16.36	6.16	6.69	10.43	10.04
	Male	16.66	6.09	8.66	10.39	10.07
Age	19-24	15.56	5.83	6.34	10.07	9.77
	25-29	17.42	6.34	7.83	10.85	10.20
	30 and over	17.02	6.45	8.94	10.53	10.38
Department	Social Fields	16.51	5.65	7.36	10.49	10,07
	Science Fields	16.45	6.46	7.47	10.36	10.04
Instruction of topics	Yes	16.62	6.29	7.32	10.79	10.14
	No	16.12	5.77	7.69	9.52	9.84

RL-PZ: Relativism-Positivism sub-dimension PR-CO: Process-Content sub-dimension
IN-DE: Inductivism-Deductivism sub-dimension; INS-RE: Instrumentalism-Realism sub-dimension
CO-DE: Contextualism-Decontextualism sub-dimension $\overline{X}$: Mean Score

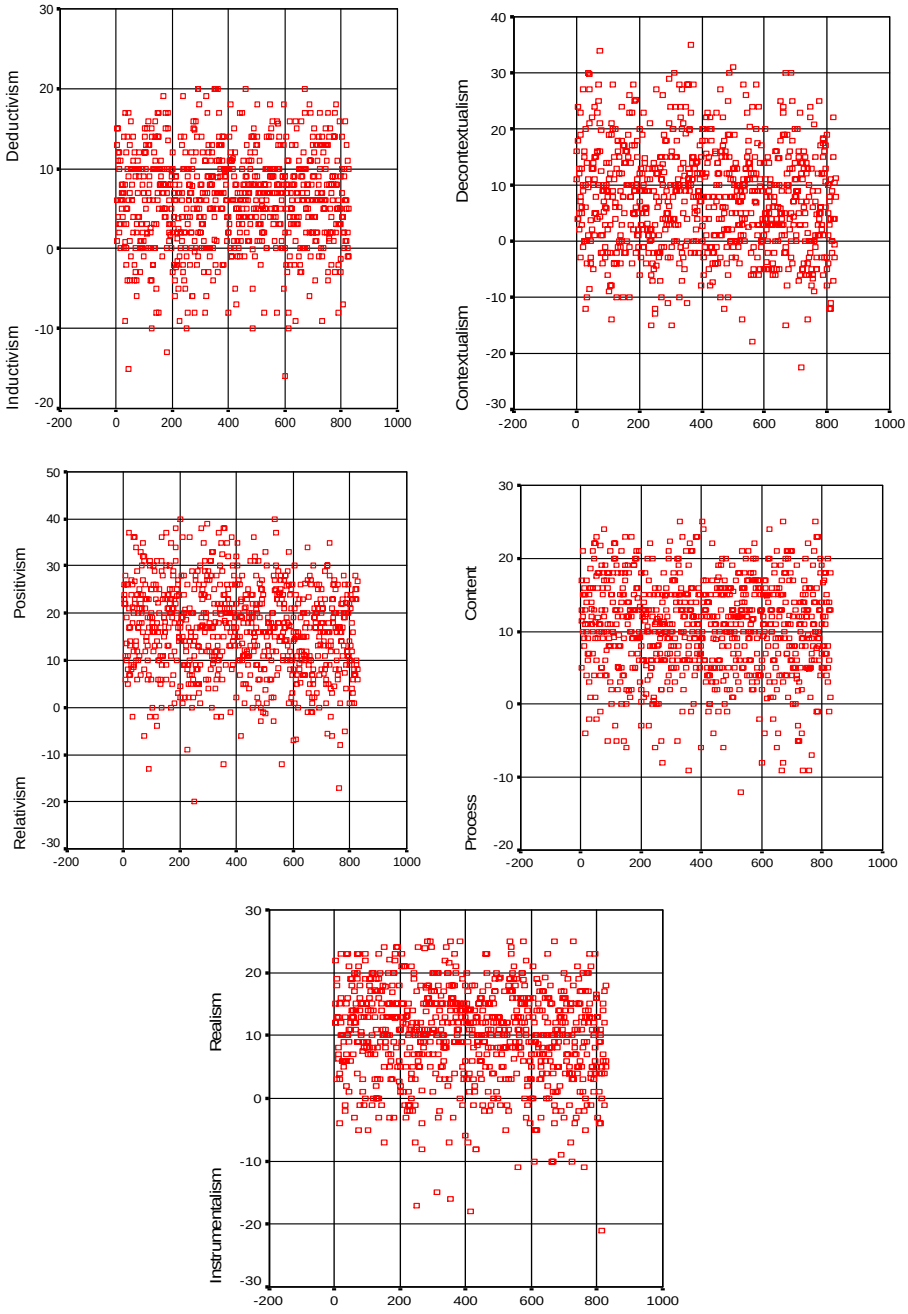

Fig. 1. Scatter Diagram according to the participants' Nature of Science Scores

3.1 An Evaluation of the Scores Obtained from the "Views of the Nature of Science Inventory" According to Variables such as Gender, Age and Departments

The difference according to gender was in favour of Decontextualism view in the Contextualism-Decontextualism sub-dimension. An analysis of the mean scores of both female and male students in the Contextualism-Decontextualism sub-dimension shows that the mean scores of the female students were lower than those of male students. Acoording to Independent groups t-test which was performed with a view to identifying the significance of the difference,

Table 3. Comparison of the scores obtained from the nature of science inventory according to the Departments, U-test results

	Departments	N	Mean rank	Sum of ranks	U	p
Relativism-Positivism	Science fields	493	413.72	203964.50	-.041	.967
	Social fields	334	414.41	138413.50		
Inductivism-Deductivism	Science fields	493	428.99	211494.50	-2.196	.028
	Social fields	334	391.87	130883.50		
Contextualism - Decontextualism	Science fields	493	416.87	205517.50	-.420	.674
	Social fields	334	409.76	136860.50		
Process – Content	Science fields	493	413.59	203897.50	-.061	.952
	Social fields	334	414.61	138480.50		
Instrumentalism – Realism	Science fields	493	410.47	202362.50	-.517	.605
	Social fields	334	419.21	140015.50		

there was a significant difference in favour of the male students in the Contextualism-Decontextualism sub-dimension scores [t(825)=-2.956, p<05)].

Whether the nature of science sub-scale mean scores had significant differences according to age groups variable was identified using one-way variance analysis. Analysis results indicated a significant difference according to age variable in the Relativism-Positivism and Contextualism-Decontextualism sub-dimensions. LSD results, one of the multiple comparison tests, were analysed with a view to identifying the groups where significant difference occurred (in favour of which groups). LSD test results showed that there was a significant difference in favour of the 25-29 age group between the 19-24 and 25-29 age groups in terms of the Relativism-Positivism sub-scale mean scores [F(2,824)= 3.325, p<.05]; there was a significant difference in favour of the 30 and over age group between the 19-24 and 30 and over age groups in terms of the Contextualism-Decontextualism sub-scale mean scores [F(2,824)= 5.428, p<.05].

Mann Whitney U-test was performed with a view to finding out whether there was a significant difference between the mean scores of the departments and the views regarding the nature of science (Table 3).

As you see in the Table 3 that only Inductivism-Deductivism sub-dimension indicated a significant difference between the departments and the views about the nature of science [U=-2.196, p<0.05]. There were no significant differences according to the departments in terms of the other sub-dimensions.

4. DISCUSSION AND CONCLUSION

It was found that the participants had positivist views (90.7%) and although it was slight, they demonstrated balanced view in the Relativism-Positivism dimensions (N_0 =62%N_0: 7.5). On the other hand, the participants' views were 86.2% for realism, 91.1% for content, 73% for deductivism, and 60.8% for decontextualism. Positivist view claims that the universe can be defined in a realistic way, everything exists in nature secretly, and they can be revealed with experiments and observations [35].

It also claims that people can know external reality with sense organs and this information is objective information which is purified from subjective values. Positivist view also indicates that nature resembles a machine. Exploring the rules of nature is the job of science; and science performs this mission through various measurements and can express it mathematically. Science reveals scientific principles such as law and theory in an inductive way. If one mentions about the rules of nature, it cannot be examined without context and a phenomenon may not yield similar results when it is evaluated in terms of the relationships between cause and effect. In other words, that you have come up with the same result in one thousand observations does not guarantee that you will have the same result in the one thousand first observation [36]. Similarly, Karl Popper [36] emphasizes that science is a human activity and a scientist cannot mention a science which is independent of his own understandings and beliefs.

Hence, science is an activity of testing hypothesis that people developed by creating a

bond between the factual and conceptual world to understand the universe, and drawing conclusions. Therefore, science is not a result of inductive implications. It is created by the scientist as a response to people's efforts to explain the truth. The finding that the participants of the present study have positivist view could be explained by the use of the problem solving skills in the present education system and the insufficient research and review strategies [37]. This result also indicates that the participants see themselves as individuals who have to learn scientific principles and transfer them to their students in the future rather than as scientist who produce information. This understanding could have been resulted from a strict hierarchical education structure [38].

The difference in terms of gender was found to be in favour of Decontextualism and of male students in the Contextualism-Decontextualism sub-dimension. Mean scores of the female students were found to be lower than those of males. This finding can be interpreted as females' having more balanced views in the Contextualism-Decontextualism sub-dimension than males. This finding was parallel with other studies in the literature [22,23,25,27] but it was not parallel with some others [30,39].

According to age variable, there was a significant difference in favour of the 25-29 age group between the 19-24 and 25-29 age groups in terms of the Relativism-Positivism sub-scale mean scores; and there was a significant difference in favour of the 30 and over age group between the 19-24 and 30 and over age groups in terms of the Contextualism-Decontextualism sub-scale mean scores. The increase in the mean scores with the increase in age can be considered that the students turned back to a hierarchical structure and adopted the view that science was not affected by the social and cultural values.

The present study has found that prospective teachers have positivist belief about science. In this regard, prospective teachers do not accept information which has not been tested with experiences and observations and cannot be explained mathematically as scientific information. They also do not view scientific information as information which should be evaluated in cultural reality. Views of prospective teachers who have the mission of raising future generations regarding scientific information gains even more importance as they are going to educate scientists and generations which will produce information in the future.

Higher level thinking skills in the education programs should involve science as a powerful thinking method and prospective teachers should be provided with such a skill which can help people to understand, explain and control the universe. Therefore, education programs should include the necessary evaluations and improvements; and those programs should have such courses as "science history", "the nature of science" and "science philosophy".

In this period when teacher education models are discussed in Turkey, we need to focus on the quality, not the quantity of the teachers we raise. Teachers' quality is important in designating the students' and thus that of society's quality. Studies to be conducted in the future can further investigate this issue with various data collection techniques which enable in-depth data collection. The reasons why positivist view is so popular can be investigated. The present study has reflected the views of prospective teachers who graduated from 16 departments and 64 different universities and were enrolled in the formation programs in two universities. Hence, with this aspect, the results can shed light to the issue of thinking about teacher education quality.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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