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The Effect of the Context of Science, Pseudoscience Demarcation on the Science Perceptions of Secondary School Students: The Case of Iridology*

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Abstract

The current study investigating the effect of a process planned in the context of science and pseudoscience demarcation on the development of science perception of secondary school students was designed upon an iridology case. In the process of the research, iridology was first presented to the students, sample applications were made and discussed in the class in general sense. Following that, the case was taken in detail with the small groups formed in the class and ended with the reports of group discussions. The data sources of the research of which participants were 21 secondary school students was comprised of "The Form for Science, Pseudoscience Demarcation" (FSPD) and group discussion reports and the data obtained was analysed qualitatively. The results of the study revealed that beliefs about science can be elicited and substantially developed in the context of demarcation of science from pseudoscience. It was found that participants had continued to accept empirical inquiry as a criterion of being scientific whereas reduced their emphasis on authority's point of views. After intervention some of them had also mentioned consistency and acceptance by community of science as new criteria for being scientific.

Keywords

Nature of science
Pseudoscience
Perception of Science
Iridology

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Introduction

The perceptions with regard to science and the nature of science comprise one of the popular research fields of science education and the arguments concerning the necessity of their teaching could be classified under five different headings: (i) utilitarian, (ii) democratic, (iii) cultural, (iv) moral and (v) science learning (Driver, Leach, Millar and Scott, 1996). Democratic and Cultural ones, in particular, are of importance in terms of daily life experiences as they are social and allowing individuals to take healthy decisions in some scientific issues and being appraised as a part of modern culture, respectively. However, it is known that the desired results have not been obtained despite a

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series of attempts to improve the perceptions and beliefs of students over science and its nature including recent educational reform movements (MEB, 2005; MEHRD, 2007), in particular, some significant misconceptions in the dimension of the nature of science still exist (Wei, Li and Chen, 2013; Bartos and Lederman, 2014; Tala and Vesterinen, 2015). When we touch to the source of the issue, two basic things come to the fore; (i) the confusion into the nature of science and (ii) the lack of research based sources which could be used by teachers in teaching the nature of science (Lederman and Lederman, 2004). As a matter of fact, the former one, the confusion, results from the fact that the science of which nature have been tried to define is a concept considered in different ways in all-purpose and different philosophical schools. It is also a natural result of the discussion bearing science historians, sociologists, psychologists, philosophers inside.

However, since such a discussion is limited for practical concerns and certain educational levels, it is most likely to come to a compromise. To illustrate, there has been a reference to the perception of a common nature of science basing upon the process up to 12th grade in secondary education on which a many researchers agree (Lederman, Abd-El-Khalick, Bell and Schwartz, 2002; Osborne, Collins, Ratcliffe, Millar and Duschl, 2003; Lederman and Lederman, 2004;). Therefore, in teaching the nature of science, it is possible to cope with the theoretical confusion mentioned about through such a common perception.

On the other hand, the second issue mentioned above, the competency of the research accumulation proposing models and practices to guide teachers, is still being discussed. Actually, even though some approaches to teaching the nature of science in the related literature have been discussed intensively, it is not likely to say that the models and examples of practices dealing directly with teachers have been given at the same intensity. In this sense, it is of crucial importance to develop effective models and examples of practices depending on the current approaches to teaching the nature of science, offering them to teachers to use. So, the first step in such a process must be the analyses of the current approaches mentioned. When we have a look at the studies focusing directly on the purpose of developing the beliefs of the nature of science, it is possible to see that mainly implicit and explicit or reflective approaches come to the fore (Lederman, 2007) and additionally, there is an emphasis on the historical approach from time to time (Gess-Newsome, 2002).

In the former one, the implicit approach, it was pointed out that individuals could improve their beliefs in the nature of science by providing them with a participation in scientific activities (Lawson, 1982). In other words, it is assumed that individuals implicitly develop a series of beliefs regarded with nature of scientific knowledge while actively engaging practices in which they used scientific process skills. However, it was seen that by this approach which was also the basis of many teaching programs especially since 1970's, the perceptions of individuals about nature of science could not be effectively developed (Meichtry, 1992). The research conducted by Abell, Martini and George (2001) with pre-service science teachers in which the phases of moon were observed shoud be viewed in this manner.

Such a result made explicit or reflective approach, the second one mentioned above, come to the fore more. What is focused in this approach is that the beliefs of individuals in the nature of science is made a subject of education in a planned and direct way, they think about their beliefs, interrogate them and make inference on them (Abd-El-Khalick, 1998). It was recorded that as explicit/reflective activities in teaching the nature of science give an opportunity to students to be aware of their earlier perceptions and evaluate them, they yield more positive results compared to non-reflective ones (Bell, Matkins and Gansneder, 2011; Rudge, Cassidy, Fulford and Howe, 2014). Besides that, it was suggested that such kind of activities must be extended from non-contextual to contextual at the high level, in order to make students do not regard their own learning as a simple application of "science at school" in the activities (Clough, 2006). As a matter of fact, it is likely seen that many students keep their current misconceptions with regard to the nature of science to a certain extent after the explicit/reflective teaching of nature of science. For instance, the studies carried out by Akerson, Abd-El-Khalick and Lederman (2000), Deniz and Adıbelli (2014) could be considered in this sense. The researchers stated that a strong background lies behind the misconceptions of students with regard to the nature of science and its processes and a positive improvement cannot be obtained without focusing on this background. Such a solution could only be achieved in the contexts making a sense for students, in other words in the contexts where perceptions can easily be discussed.

Contextuality come to the fore in the historical teaching approach which has a basis of the principle where the ideas of individuals over the nature of science could be developed through the investigation of historical development of science and taking it as a subject in teaching science. As an example, it was pointed out that individuals could perceive the development of scientific theories with the activities that are prepared in their historical context (Köseoğlu, Tümay and Budak, 2008). On the other hand, it was found that this approach dealing with the idea of integrating the history of science with the courses of science with its one side has yielded effective results in terms of perceiving the change in the scientific knowledge, but that it has lacked in making the desired effect on such dimensions as evaluating the paradigm changes and theories (Solomon, Duveen, Scot and McCarthy, 1992). For that reason, it seems unlikely to talk about an approach yielding successful results with no limitations. However, the studies carried out have given some significant clues with regard to the fact that more effective outcomes could be obtained with explicit/reflective approach (in the case of creating significant contexts) in teaching the nature of science compared to other approaches mentioned here (Carey, Evans, Honda, Jay and Unger, 1989; Akerson, Abd-El-Khalick and Lederman, 2000; Akerson ve Hanuscin, 2007; Khishfe and Lederman, 2007).

A determination in this way will be an answer to what approach could be based in the solution of the lack of model practices mentioned above. In order to develop the beliefs in a multidimensional way, it is essential to make the teaching of the nature of science an explicit subject in the program, carry out discussions over this subject and create meaningful contexts to provide the real interrogations of individuals. However, here stands a question to be answered, which is how to create a context to be meaningful for individuals. The answer of this question could be given over the issue of demarcation of science from pseudoscience referring directly to many concepts based on the nature of science. Because even though pseudoscience is not directly considered as a subject on the agenda in teaching science (Martin, 1994; Turgut, 2011), it reveals itself clearly in the form of a series of common beliefs in large parts of a community and forms a rich context for teaching the nature of science in its current position.

In such a context that is built upon pseudoscience, with critical evaluations in science classes, it is likely that students could make both scientific terminology (included in pseudoscientific assertions) and criteria of being scientific and also science as a form of knowing a subject of investigation more attentively. Since pseudoscientific assertions are offered to the whole society in an extraordinary and striking way over media in particular and it can attract a lot of people. Some research results showing that the rate of believing in pseudoscientific assertions is high in many communities also reveals some significant signs with regard to the potential interest and richness of this context (Liu, 2009).

Besides that, it is necessary to be aware of the fact that it is not so easy to make a distinction between science and pseudoscience which can be defined as a whole of a series of systematic propositions, applications and attitudes having an assertion of being scientific but not in reality while dealing with such a context (Martin, 1994; Preece and Baxter, 2000); because no series of clear and unchallenged demarcation criteria that could be applied to all cases have not been given yet (Turgut, 2011). However, it is necessary to know that one can act over some criteria offered by some philosophical movements and thinkers (logical positivism, fallibilism, progressive research programs, scientific revolutions etc.) (Turgut, 2009; Turgut, 2011) and it is likely to make current popular fields/assertions a subject of discussion with these criteria. Such a point of view will facilitate to overcome the reservations in order to carry the issue of the demarcation of science and pseudoscience into the content of science teaching.

In addition, it is likely to say that some researches formulated a series of practical criteria that could be worked at lower levels of educational stages in the analysis of series of pseudoscientific assertions and their supporters' behaviours which especially served over popular media. As an example, Martin (1994) underlined some "visible features" make assertions seem like scientific and "implicit features" revealing that they are not scientific in fact while evaluating pseudoscience and offered clear criteria for the issue of demarcation. The researcher revised the visible features of pseudoscience as; (i) its propositions are supported with a technical language referring to extraordinary and influential theories, (ii) the practitioners respond the criticised points with complex arguments by pointing out that these theories are supported firmly with proofs and (iii) the practitioners have organizations/journals and use authoritative texts. He indicated that all these things have made a great contribution to the pseudoscientific assertions in order to be appeared like scientific. Martin (1994) listed secret features of pseudoscience as follows; (i) their propositions are mostly untestable, (ii) critical tests are prevented and a negative proof is tried to be left out, (iii) their practitioners are isolated from science community and they never attempt to make a critical dialogue and (iv) pseudoscientist is dogmatic and has no tolerance for other theories. These determinations are of importance as it can be given a significant mission in the pseudoscience discussions that will be carried out particularly in science classes together with the criteria proposed by philosophical schools of thought mentioned above.

In the related literature, there are few researches included the issue of science, pseudoscience demarcation as an interesting context in teaching the nature of science by taking similar demarcation criteria into account together with the criteria put forward by philosophical schools of thought. In some researches carried out in this sense, it was determined that it was possible both to reveal the beliefs of the nature of science that has been made a subject of investigation and to be able to know approvals forming the background of these beliefs (Turgut, Akçay and İrez, 2010), and to develop these beliefs in question (Turgut, 2011). Thus, it was also found that, within the context of the issue of demarcation, some initiatives could be taken to solve some significant problems with regard to popular assessment instruments developed to question the beliefs about the nature of science. Because these assessment instruments are criticized as they just focus on declarative knowledge rather than contextual one, they are designed for researches more than in-class applications and as they cannot form an authentic context (Allchin, 2011). The idea that only the competency of students to be able to express some components of the nature of science could be assessed with such kind of tools can be added to these criticisms; whereas some information proposals should be offered to students in some contexts (for instance, popular pseudoscientific fields) that are meaningful for them as well and their perceptions with regard to science should be questioned in a more healthy way by providing them with an analysis of these proposals.

However, it is evident that the related researches containing similar processes as mentioned above (Lilienfeld, 2004; Losh and Nzekwe, 2011) were carried out with university students mostly and there is a need for the evaluation of the context of pseudoscience for the students at lower stages. Whether similar results could be reached in learning environments designed for the students studying in the primary and secondary stages should also be questioned; because as it is proceeded through the higher grades, transforming the perceptions of students becomes harder, therefore, it is recommended that teaching the nature of science should be started in earlier ages (Kang, Scharmann and Noh, 2004).

Under the light of these facts, it was aimed to create a meaningful context by the issue of demarcation of science and pseudoscience within the explicit/reflective teaching approach and to improve the science perceptions of the secondary school students in this context. The issue of demarcation is particularly preferred since it was though that in such a context the views of individuals with regard to science could be explicitly determined and questioned in a more reliable way and hence an opportunity of improvement could be caught. In this way, it was aimed to develop a sample teaching practice based upon research which teachers could easily carry to their classes in order to teach the nature of science and to investigate the effect of so called intervention on the perceptions about science. Therefore, the problem of the research could be expressed in two stages as follows; (i) "Can the perceptions of secondary school students about science be revealed in a reliable way with the explicit/reflective teaching practices that are designed in the context of science and pseudoscience demarcation?", (ii) "Can the perceptions of secondary school students about science be improved within this so called context?".

Method

In the current study that was planned to reveal and improve the perceptions of the secondary school students about science through the activities that were prepared in the context of science and pseudoscience demarcation, qualitative methodology (Strauss and Corbin, 1998) was used. The study could be defined in the scope of action research in which the issue of demarcation was designed as a context in order to increase the quality of teaching the nature of science and evaluated in terms of its efficacy by the teacher practitioner (Mills, 2003; Bogdan and Biklen, 2007). The participants of the study, the teaching practice carried out and the process of analysis with data sources were given below as headings.

Participants

The participants of the study were 21 eighth grade students (17 girls and 4 boys) attending to a state school in the city of Sakarya in the first semester of 2012-2013 academic year. In the selection of the group, the fact that although the perceptions about science start to improve in early years, there is no adequate research accumulation with the students at this stage in this sense was the main reason. The students participating in the research was chosen from the two eighth grade classes in the school where the researcher works in line with the criteria of availability and having the qualifications that would provide carrying the process on a reliable merit.

Course Context

In the current study aiming at revealing and developing the perceptions about science of the participants, the teaching practice was constructed upon the rich context of the issue of demarcation of science and pseudoscience. However, it was necessary to make a limitation in this context and derive a manageable content by taking into consideration the characteristics (grade and etc.) of participants. Because, many disciplines and assertions of knowledge have been encountered in this context with regard to different parts of life such as astrology concerning celestial bodies and stones used for healing in terms of health. For that reason, the researchers first examined some pseudoscientific fields and disciplines for their contents and terminologies in line with the units and acquirements of the 2005 Science and Technology Teaching Program in order to obtain the suitable cases. As a result of the evaluation made, it was determined that the contents, assertions and terminologies of iridology, bending spoon, levitation, reflexology and healing stones are considered as suitable cases for the participants and teaching practices were planned for each case that would last three to four class hours. However, in order to present the process broadly and the data in detail, this study was limited only to the case of iridology.

In the first stage of the process, the related case (iridology) was introduced multi-dimensionally with the presentation by the correspondent researcher teacher without tagging it as science or pseudoscience. After the presentation, the case was opened for discussion and it was aimed both to determine the perceptions of the students about being scientific and reassess them by questioning in the process of discussion. For that reason, the discussions were developed depending on criteria of being scientific and then students attempted to evaluate whether the case was scientific or not. This first process of discussion that was carried out with the whole group in the class was followed by small group discussions. The teacher researcher carrying out the teaching practice initiated small group discussions with a series of guiding questions that would allow to examine the case in depth. An individual was chosen as a note-taking person in this small groups with three to four, and he recorded the discussions. Later, these initial small groups were separated (with a technique similar to jigsaw) and the discussions were carried on in new small groups. After ending the discussions carried on with the new small groups, the students turned back to their initial small groups and they made their decision upon the case in question, recording it in the final group reports. The process was briefed in Figure 1.

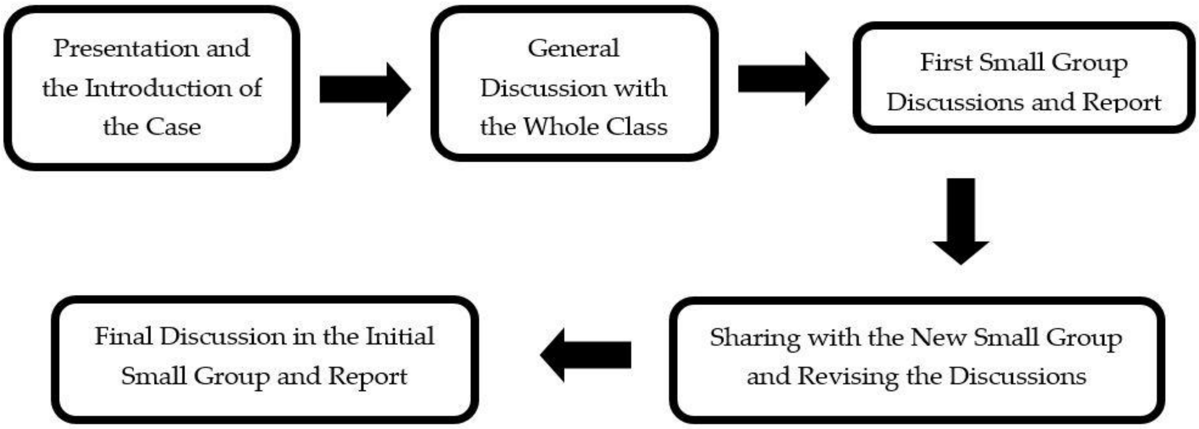

Figure 1. The Process

The teaching practice prepared in this sense for the case of iridology was briefed as an example below:

The teacher explains that he will talk about an alternative way in the diagnosis of diseases and writes "IRIDOLOGY" in capital letters on the board. Then, he introduces iridology and its assertions in general with the presentation he prepared. The neural system and sense organs which iridologists use in their assertions (Appendix 1) are referred (students learned this subject before) in this presentation. Students are given basic knowledge about the structure of eye and they ways followed in the diagnosis and treatment of the diseases related to eye are shown. The presentation goes on with the historical development and assertions of iridology. In this way whether the assumptions regarding iridology are complied with current scientific theories and the method it follows are opened to discussion. In addition, examples of iridology studies is given and how medical groups assess these studies is revised.

Following that, the class is divided into groups of three or four. Iridology is discussed in detail in these groups in such sub-headings as whether it is scientific, what is the basis of its assertions, how the data is collected, whether there occurs a significant income in the sector, how it is considered in medical groups etc. Meantime, a sample iridology study is presented to class. The iris picture in this study (right and left) is shown and then the history of the patient is told to the students. The spots on the iris are marked and a map of iris used by iridologists is opened. The marked spots on the iris are examined with the help of this map and the related areas in the map for these spots are determined. The disease defined by the map according to these determined areas of spots and the assertions of iridology are discussed with the students. The same process is repeated with another case in the groups. In addition, the materials used in the diagnosis of iris are introduced in the groups and students are informed about their prices, as to whether there are any programs in the universities, and whether it is possible to get a certificate or a diploma from the public departments for iridology. After completing the first discussion in their initial groups in the light of what is presented to them, the students prepare a common report and examine iridology in terms of being scientific or not.

After this stage, new groups are formed with again three or four participants with students from different initial groups. Students try to deepen the discussions they made in the initial groups under the same headings with their new group friends. In this way, they are informed about the discussions made in other groups. After the completion of new group discussions, students turn back to their initial groups and share their new ideas, if any. Later on, the groups end the study by writing their final reports.

Data Sources and Analysis

The basic data source of the research was made up of "The Form for Science, Pseudoscience Demarcation" (FSPD) which was developed by the researchers which comprised of open-ended questions. The FSPD was developed according to the criteria determined by Anderson (1990) as (i) determining the problem, (ii) writing the items, (iii) taking the expert view and (iv) carrying out the pilot study. Designed totally contextually and made up of a text regarding the case and two open-ended questions, FSPD (See Appendix 1 for the Iridology Form) was applied to each participant individually twice before and after the case with an interval of a week. The other data source of the research was group discussion reports prepared by the participants. In these reports, there were the ideas of the participants recorded by the note-taking attendant with regard to scientific method/s, being scientific in general and the status of the current case for being scientific or not. The groups prepared two separate reports for each case, one before jigsaw process and one after it.

Both data sources were analysed qualitatively. The data obtained by pre and post FSPD was revised as a whole in order to determine the potential concepts/patterns repeated for the purpose of creating a valid system of coding. In this sense, the participant forms were renamed representatively (for example, P1, P2) and the form of each student was read separately (as a whole in its own), and all the conceptual structures determined were coded in short. This firstly formed list of codes was revised, similar and cyclical codes were unified and a more meaningful list of codes representing the data was obtained (Gay, Mills and Airasian, 2006; Bogdan and Biklen, 2007). Then, the codes in this new list were sorted and grouped into more abstract constructs which constituted categories (Strauss and Corbin 1998; Maxwell 2005; Creswell 2005). In order to increase the validity of the results obtained in the related process, participants were both interviewed face to face over the answers they written and the group discussion reports were included in the analysis process similarly and comparatively if required. In addition to all these, the same analysis process was repeated by an independent researcher and a compliance was found between the lists of codes formed at the rate of 94%. After the evaluation of the differences between the codes and negotiation, the forms were revised again. The analysis process ended when it is concluded that the codes represented the data obtained and their frequencies were determined.

One of the categories reached in the process of analysis and the codes given under this category were given in Table 1.

Table 1. Sample Category and Codes

Category	Codes
Empirical Investigation	Trial/Testing Observation Data/Evidence

How the codes given in Table 1 derived with the analysis of the participants' answers given to questions of FSPD was briefed below.

Sample Code: Trial/Testing

Participant's Answer: *"I would make a test with a person who is ill and one who is not…".*

Sample Code: Data/Evidence

Participant's Answer: *"Being scientific depends on researches and data…".*

Results

As the problem of the current study including a teaching practice designed upon iridology was made up of whether perceptions of science in such a context could be reliably determined and then developed, it was decided that the presentation of the results should be started with the codes representing participants' perceptions. Therefore, the distribution of the codes achieved with the analysis of the answers given to the questions in pre and post FSPD and the categories which they grouped under were given comparatively in Table 2 below.

Table 2. The Comparison of Pre and Post Perceptions about Being Scientific

Categories	Codes	Pre-Intervention		Post- Intervention	
		f	%	f	%
Empirical Investigation	Trial/Testing	6	24	9	36
	Observation	2	8	3	12
	Data/Evidence	5	20	2	8
Utility/Benefit	Prevalence	-	-	3	12
	Social Utility	2	8	1	4
Authority View	Literature Review	8	32	3	12
	Expert View	2	8	1	4
Consistency	Consistency of Iridologists	-	-	2	8
	Consistency in Assertions	-	-	1	4

It was found that the perceptions of the participants about being scientific both before and after the teaching practice could be given especially in three categories, and that empirical investigation and authority view in these categories are of great significance. In addition to them, although a new category called consistency was appeared after the teaching practice, it had no such significance as others. When it comes to all these categories and the codes under them, it is likely to say that participants were able to exhibit their perceptions with regard to science in various dimensions when they aimed at demarcating science and pseudoscience in the process planned. Therefore, it is possible to assert that the issue of demarcation of science and pseudoscience formed a meaningful context for participants for revealing their perceptions regarding science. This determination revealed that the efficacy of the designed teaching practice could also be questioned with regard to developing the perceptions of the participants about science and the results obtained before and after the process as given above in Table 2 were examined separately in detail and evaluated comparatively.

Perceptions about Being Scientific Before Teaching Practice

As for the results obtained with the analysis of the answers given to FSPD before the teaching practice, given in Table 2 above, it was found that the participants pointing out that they would take "empirical investigation" into consideration while evaluating the status of the iris analysis for being scientific and made some reference to concepts such as "trial/testing (24%)", "data/evidence (20%)", and "observation (8%)". The discussion with regard to these concepts can be seen explicitly in the sample answer of a participant given below:

> *"I would make a test with a person who is ill and another one who is not. I would examine the eyes of both and decide that it was scientific if there is a spot on the eye of the one who is ill and there isn't any on the eye of the one who is not ill (P4)"*

In such kind of expressions, it was found that the participants made an emphasis only on simple observation and testing processes while talking about experimenting, therefore they exhibited the indications that they had some misconceptions with regard to scientific experimentation. Similar arguments were also encountered in the expressions of some students thinking that iridology is a pseudoscientific discipline:

"… I think it must be investigated and some data must be collected, a trial must be done and it must be proven… I think the method of iris analysis is not scientific. Being scientific depends on research and data. This one is something that we see directly and say it as an assumption… (P2)".

Pointing out that some evaluations could be made with regard to being scientific for a discipline with similar expressions generally based on the idea of making researches, observations and trials/experiments, depending assertions on concrete data, students tried to question iridology with these criteria and exhibited consistent behaviours in their own right.

A great number of the students expressed before the teaching practice that it is necessary to take an "authority view" in order to decide whether any discipline is scientific or not. The concepts focused on under this category were "literature review (32%)" and "expert view (8%). A sample answer recalling so called concepts and the approaches exhibited by the students in the context of the related category was given below:

"I firstly research it on my own and then decide whether this assertion is scientific or not…(P7)".

It was seen in the face to face interview that the participant assuming researching as one of the prerequisites in the process of deciding whether a discipline is scientific or not, actually attributed a meaning to research as reading certain sources or asking others:

Researcher: How do you make a research?

P7: I search it on the Internet.

Researcher: Do you make it in other ways, as well?

P7: I ask it to the people around me and look it up in books.

Besides the participants putting a mission of authority to such kind of sources and expressing that they would take the knowledge they obtained from these sources into consideration, some others took certain titles as criteria for themselves directly:

"Iris analysis is scientific; as Dr. Frank Lee found this analysis with his own determination…(P8)".

Expressing that iris analysis method was found with the studies of a doctor, this participant considered the title of "doctor" as a source of authority and underlined that what the doctor told forms a significant basis for him in deciding whether iridology is scientific or not.

Before the teaching practice, the third category, coming out in line with the perceptions exhibited by the participants in terms of questioning whether iridology is scientific, became "utility/benefit" even if it was not as significant as the other two. Two participants had a pragmatist approach to the case in terms of its social benefit. A sample expression evoking the concept of the "social utility" by the related participants was given below:

"… I will decide that it is scientific if it has some good points… To me, iris analysis is scientific; as we can learn whether we have a deadly disease out of iris analysis… if we have, we will have a chance of early diagnosis.(P6)".

The participant acting upon the assertion that it would be possible to diagnose potential diseases as a result of iris analysis expressed that such a discipline had good sides, so it could be regarded scientific with the idea that it had a social utility. It is likely to brief this approach in a simple way that if it works it is scientific.

Perceptions about Being Scientific After Teaching Practice

The comparative results presented in Table 2 derived by the analysis of the answers to questions of FSPD after teaching practice along with the group discussion reports indicated that a great number of participants went on evaluating "empirical investigation" as a significant criterion for being scientific. They went on referring to the concepts of "trial/testing (36%)", "observation (12%) and "data/evidence (8%)". However, compared to pre-teaching practice, it was found that the dominance of testing increased but that data collection lost its earlier dominance. A sample answer containing an emphasis with regard to empirical investigation processes was given below:

> *"I decide by testing and searching… I think it is not scientific… Iridology has not been proven yet. You cannot diagnose without proof. (P4)"*

The participant putting an emphasis on the proving process in particular while deciding the status of the case in question for being scientific pointed out that the empirical evidence obtained in this way would be a significant criterion. The examination of the report prepared by the group of the related participant yielded that there exist similar expressions regarded with the same discussion:

> *"…In order to think that an event is scientific, we must have evidence. We can reach this evidence through experiments. In addition, we carry out scientific research and collect data. We decide whether it is scientific or not depending on this evidence. To us, iridology is not scientific as we conducted the same experiments with the maps they gave us, but we obtained different results. Also, they decide on a disease depending on the colour of eye, however, it is not a proven knowledge (Group2)".*

Participants went of keeping their idea of "proving is the indispensable must of being scientific", which they dominated heavily before the teaching practice. Additionally, they exhibited various expressions with regard to the fact that experiments are a significant stage in the process of proving and highlighted that different results likely to be obtained by particularly attributing the concept of repeatability would harm the validity of the assertions. All these arguments showed that the criterion coded as collection of data/evidence, which seemed to lose its dominance after the teaching practice was placed within the testing process by the participants, therefore it kept on existing in the perception of empirical investigation.

Even though it was not majority opinion as compared with the category of "empirical investigation", a part of the participants regarded the status of iris analysis for being scientific in terms of "utility/benefit" as in before teaching practice. However, an addition like gaining acceptance because of its prevalence was made to the criterion of social utility. The distribution of the category for these concepts was "prevalence (12%)" and "social utility (4%)". Sample answers containing the views regarding the related category was given below:

> *"… I will decide by seeing whether it is getting common or not… (P16)"*

> *"It is not scientific since it would be known in the world if it were and all the diseases would be diagnosed and cured very easily… (P10)"*

Participants making a reference to the criteria of utility therefore to prevalence made an emphasis on the importance of the universal consent in this sense. While questioning its status for being scientific, they highlighted that it did not have a widespread application throughout the world, thinking it as a negative side as it was applied only in a few countries. The participants marked their basic argument upon "if the assertions were real, some processes of diagnosis that would be considered as a revolution worldwide would be appeared and it would be so widespread". In this sense, they regarded social utility as a criterion of spreading spirally in different countries. Similar expressions were encountered in group reports:

> *"If it were a scientific study, it would spread to other countries, it would be a valid branch and specialization, and a profession with a special department at hospitals. (Group1)".*

> *"Iridology is not scientific to us; as there is no department as iridology in Turkey and at universities. (Group3)".*

After the teaching practice where the category of "utility/benefit" increased its significance, it was found that the category of "authority view" decreased its dominance (lowered to 16%). Carrying on making an emphasis to the authority figure after the teaching practice, the participants mostly highlighted making research from various sources in other words review in this category (12%).

"… I would decide whether it is scientific or not by collecting data… (P10)"

"… I would decide by making a research … (P16)"

In the face to face interviews, when the participants were asked to clarify what they meant by making research or collecting data (it was found that the answers were not again so clear even though the same request was made before the teaching practice), they highlighted mostly the internet as the source of knowledge and research domain:

Researcher: Which sources would you prefer to collect data?

P10: I would collect it from the Internet.

Researcher: Into what?

P10: I would make it into whether the studies by Dr. Lee carried were real.

In another interview made in the same content, when it was questioned how the process of research would be carried out, some answers having direct references to the data that was more qualitative and would be made a subject of research were reached compared to the ones before the teaching practice:

Researcher: How can you carry out the research and what ways do you use?

P16: I would make a search for the results of the experiments carried out before and I would do it on the department where Dr. Lee work or on the Internet.

The answer of this participant who was thought to mean obtaining the data, the results of related experiments and discussions essential for being able to decide whether an assertion is scientific with the concept of research through various ways was found significant as it represented the knowledge of what to search where beyond making a random search on the Internet.

Beyond all these codes and categories that were derived from the answers given by the participants before and after the teaching practice with different frequencies, a new category that was encountered after the practice had also appeared. In this category that was called "consistency", it was found that a group of participants, relatively a small one (12%), made a reference to the consistency among "iridologists" (8%) and among "assertions expressed" (4%) while questioning the status of iridology. So called references could be seen in the sample answers given below:

"I would decide depending on the consistency between the disease of the person and the report obtained after the clinical examination (P13)"

"If Dr. Lee had the same idea/assertion as other iridologists, I would think that it is scientific, if not, I would think that it is not scientific (P15)"

Upon the evaluation of the answers, it was found that participants highlighted the arguments that all the iridologists are required to conclude in the same way in the same case and the diagnosis they made through iridology must be consistent with the ones made through modern medicine. Pointing out that it would be inconsistent to produce assertions of different diagnosis in only one case, the participants expressed such an inconsistency as a failure to be scientific. Similar arguments were encountered in the reports of group discussions:

"… Iridology is not scientific. Iridologists use 19 different maps while making a diagnosis. If it were scientific, there would only be one map, every iridologists would reach the same result… (Group5)".

In their discussions, the participants put an importance on the variety of the maps iridologists use in particular and gave some clues about the fact that the variety of these diagnoses were perceived beyond possible differences likely to occur during the evaluation of the data. According them, the differences occur because of the maps used and hence the problem is methodological. Participants in their group reports indicated that they found out also some inconsistencies among assertions of iridology as a discipline:

> *"… While we are examining the case, the iriscope showed the spots we saw on the projector device in different places… Then, iridologist finds more diseases than the patient complains about, in addition, more diseases come out in the report after the examination… (Group 1)".*

In their expressions similar to these, the participants pointed out that the results they obtained during the activities were different from those of the iridologists and also implied the contradiction between the results of iridologists with the results obtained with the devices they used. It was found that the expectations of the participants thinking that iridology should be applicable in all cases with regard to the need to clarify the assertions decisively with their current position were not met, so they marked the discipline as pseudoscientific.

Discussion, Conclusion and Suggestions

Even though the nature of science has been uttered as a significant teaching objective from the early 1900s onward, it started to be made a subject of systematic research from 1960s and the perceptions of students, teaching programs, the perceptions of teachers, developing their perceptions and the relative efficacies of various teaching practices were focused respectively (Lederman, 2006). In the first stage of this research, that is likely to express a two-stage study that might be placed under the heading of the efficacy of teaching practices, whether the science perceptions of the students could be revealed reliably in an explicit/reflective process which designed in the context of demarcation of science and pseudoscience were put on the agenda.

This case could be answered over the codes and themes with regard to science and its nature formed with the analysis of the student answers obtained both before and after the teaching practice. As given clearly in the results part of the study, the students expressed their perceptions regarding science in nine different codes under four different categories together within the designed teaching context. What's more, they had to express their perceptions with certain warrants within such a context, therefore they were led to think over the assertions they put forward. This is a crucial point and shown clearly in the sample answers presented. For that reason, it is likely to say that the science perceptions of the students could be expressed in a more detailed and reliable content in this way besides the questionnaires/forms made up of such questions as "What is science for you? Could you define it?" having no sample case to carry out a discussion and having no meaningful context. It is likely to say that this result should be viewed as a significant step of solution for the problem of determining the beliefs of the nature of science in a reliable manner since it is a crucial handicap for classical assessment instruments that focused on declarative knowledge rather than conceptual, designed for researches rather than in-class use and did not form a context (Allchin, 2011).

In the second stage of the problem of the research, whether the science perceptions of the secondary school students could be developed with the help of an explicit/reflective teaching practice designed in the context of demarcation of science and pseudoscience was the focus. In order to answer this question, it is necessary to make a comparative evaluation over the results with regard to the science perceptions presented separately before and after the teaching practice. The students participating the study pointed out that they would emphasize mostly criteria of empirical investigation and authority view in order to decide on the status of the assertions for being scientific when they encountered with any case before the teaching practice. Besides that, it was observed that some participants brought forward the social utility criterion as well. However, it is not so likely to say that a positive profile could be drawn with regard to the perceptions (of being scientific) of the students with these themes some of which could be used as a criterion in demarcation of science and pseudoscience. As a matter of fact, the participants performed inadequate conceptually in these themes, since they defined empirical investigation as a simple trial/testing process and science as an accumulation of factual knowledge depending just on evidence. Besides that, the results of the research derived after the teaching practice showed that the participants developed their perceptions about demarcation of science and pseudoscience and being scientific in the process at least in certain categories. The participants went of making reference to empirical investigation but they left the tendency to decide without questioning by just making research from certain sources in particular and by accepting the views of outer authorities to a great extent. In addition, such new themes as consistency between the practitioners and assertions and prevalence with a basis of having acceptance by scientific community were seen to be appeared which could be regarded as an indication of development despite the frequencies of these themes were low.

The empirical investigation and authority figure of the research coming to the forefront as criteria of being scientific particularly before the teaching practice therefore comprising a significant component of the perception of science have been a subject of many other researches carried out in other cultural environments (Alfonso and Gilberd, 2010), which could make it ordinary in their appearance in the form of dominant concepts. On the other hand, new themes emerging after the teaching practice and the fact that authority figure lost its significance showed that individuals could find an opportunity to make reflections over their beliefs in such a context and transform them. The results that were obtained as a result of a short term practice created an opinion that the context of demarcation of science and pseudoscience could be used in an effective way in developing the perceptions of the secondary school students about being scientific. So it could be asserted that it would be possible to develop the beliefs of individuals more with long term practices including other various cases in such a context. Indeed, it is known to us that in order to be effective, teaching practices regarded with science and its nature must be constructed in the contexts that would give an opportunity to students to be in epistemic dialogues, since in such contexts some ideas that are embedded in with regard to science and its nature that cannot be easily formulized could be discussed (Bartholomew, Osborne and Ratcliffe, 2004). In this way, such kind of necessities as “the significance of the context” and “being open to the reflective idea” that are ignored in many researches (Schwartz, Lederman and Crawford, 2004) where the beliefs of individuals with regard to science are aimed to develop through the participation into the studies of scientists and similar activities in this way but the desired result cannot be obtained.

As related literature reviewed, it can be stated that an adequate accumulation of research into demarcation of science and pseudoscience and pseudoscientific beliefs has not been formed yet and in particular such kind of research have not been encountered at such levels as secondary education. The ones in the literature are known to be designed mostly over the determination and evaluation of the so called believes. Of the studies carried out in this sense, Nickell (1992) investigated the paranormal beliefs of high school students, Preece and Baxter (2000) examined the beliefs of secondary school and high school students over astrology, healing stones, Pena and Paco (2004) studied into the acceptance levels of pseudoscientific assertions of last year undergraduate students, Lundström (2007) examined the pseudoscientific beliefs of high school students. As one can see, in such kind of studies there was no significant ground of discussion with regard to demarcation of science and pseudoscience beyond the determination of beliefs and a process was not developed in order to provide an awareness concerning the questioning of pseudoscientific beliefs and demarcation criteria. In fact, it is likely create a significant accumulation in teaching the nature of science through research that would carry the context of demarcation of science and pseudoscience including practices aiming at improving the perceptions with regard to science into the learning environments. Because, components regarding motivation and worldviews comprise a significant role at the point of developing perceptions over science and its nature (Abd-ElKhalick and Akerson, 2004) and these components would be shaped as a facilitator to internalize the importance and necessity of the nature of science by some daily life practices over pseudoscientific claims that are closely related to cultural elements. It is possible to see such kind of efforts in practices designed for upper levels, such as for candidate teachers and university students (Alfonso and Gilbert, 2010: Turgut, Akçay and İrez, 2010; Tsai, Lin, Shih and Wu, 2015) however, it is crucial that some initiatives should be taken in the lower levels where perceptions with regard to science starts to shape. As an example within this scope, some in-class activities and teaching interventions similar to iridology focusing on the issue of demarcation of science and pseudoscience that would attract the attention of students could be included in suitable units and subjects in the Science Teaching Program. As such kind of activities would also contribute the students' level of academic knowledge (Çetinkaya, Turgut, Duru and Ercan, 2015), it would be regarded positively by teachers. Therefore, the current research, which is one of the first studies in Turkish literature and offering a model implementation for teachers at the level of secondary education is of importance to related area.

References

Abd-El-Khalick, F. (1998). *The influence of history of science courses on students' conceptions of the nature of science* (Unpublished doctoral dissertation). Oregon State University, Oregon.

Abd-El-Khalick, F., & Akerson, V. L. (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education*, *88*, 785-810.

Abell, S., Martini, M., & George, M. (2001). That's what scientists have to do: Preservice elementary teachers' conceptions of the nature of science during a moon investigation. *International Journal of Science Education, 23*(11), 1095-1109.

Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching*, *37*(4), 295-317.

Akerson, V., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: results of a 3-year professional development program. *Journal of Research in Science Teaching*, *44*(5), 653-680.

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education, 95*, 518-542.

Alfonso, A. S., & Gilbert, J. K. (2010) Pseudo-science: A meaningful context for assessing nature of science. *International Journal of Science Education*, *32*(3), 329-348.

Anderson, G. (1990). *Fundamentals of educational research*. Bristol: The Falmer Press.

Bartholomew, H., Osborne, J., & Ratcliffe, M. (2004). Teaching students ''ideas-about-science'': Five dimensions of effective practice. *Science Education*, *88*, 655-682.

Bartos, S. A., & Lederman, N. G. (2014). Teachers' knowledge structures for nature of science and scientific inquiry: Conceptions and classroom practice. *Journal of Research in Science Teaching*, *51*, 1150–1184.

Bell, R. L., Matkins, J. J., & Gansneder, B. M. (2011), Impacts of contextual and explicit instruction on preservice elementary teachers' understandings of the nature of science. *Journal of Research in Science Teaching*, *48*, 414-436.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods*. Boston: Allyn and Bacon.

Carey, S., Evans, R., Honda, M., Jay, E., & Unger, C. (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. *International Journal of Science Education, 11*(5), 514-529.

Clough, M. (2006). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. *Science Education, 15*, 463-494.

Creswell, J. W. (2005). *Educational research: Planning, conducting and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education, Inc.

Çetinkaya, E., Turgut, H., Duru, M. K., & Ercan, S. (2015). Bilimsel okuryazarlıkta ilk adım: Akademik bilgi düzeylerinin bilim, sözde-bilim ayrımı bağlamında geliştirilmesi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 24,* 446 - 476. doi:10.14582/DUZGEF.546

Deniz, H., & Adibelli, E. (2014). Exploring how second grade elementary teachers translate their nature of science views into classroom practice after a graduate level natüre of science course. *Research in Science Education.* Advance online publication. doi:10.1007/s11165-014-9447-5

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young peoples' images of science*. Buckingham, UK: Open University Press.

Gay, L. R., Mills, G. E., & Airasian, R. (2006). *Educational research: Competencies for analysis and applications* (8th ed). Upper Saddle River, NJ: Pearson/Merrill/Prentice Hall.

Gess-Newsome, J. (2002). The use and impact of explicit instruction about the nature of science and science inquiry in an elementary science methods course. *Science & Education*, *11*(5), 55-67.

Kang, S., Scharmann, L., & Noh, T. (2004). Examining students' views on the nature of science: Results from Korean 6th, 8th, and 10th graders. *Science Education, 89*(2), 314-334.

Khishfe, R., & Lederman, N. G. (2007). Relationship between instructional context and views of nature of science. *International Journal of Science Education, 29*(8), 939-961.

Köseoğlu, F., Tümay, H., & Budak, E. (2008). Bilimin doğası hakkında paradigma değişimleri ve öğretimi ile ilgili yeni anlayışlar. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 28*(2), 221-237.

Lawson, A. E. (1982). The nature of advanced reasoning and science instruction. *Journal of Research in Science Teaching*, *19*(9), 743-760.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*, 497-521.

Lederman, N. G., & Lederman, J. S. (2004). Revising instruction to teach nature of science. *The Science Teacher, 71*(9), 36-39.

Lederman, N. G. (2006). Research on nature of science: Reflections on the past, anticipations of the future. *Asia-Pasific Forum on Science Learning and Teaching, 7*(1), 1-11.

Lederman, N. G. (2007). Nature of science: Past, present and future. In S. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831-880). Mahwah, New Jersey: Lawrence Erlbaum Publishers.

Lilienfeld, S. O. (2004). Teaching psychology students to distinguish science from pseudoscience: Pitfalls and rewards. In B. K. Saville (Ed.), *Essays from excellence in teaching* (pp. 26-32). Society for the Teaching of Psychology.

Liu, X. (2009). Beyond science literacy: Science and the public. *International Journal of Environmental & Science Education, 4*(3), 301-311.

Losh, C. S., & Nzekwe, B. (2011). Creatures in the classroom: Preservice teacher beliefs about fantastic beasts, magic, extraterrestrials, evolution and creationism. *Science & Education, 20*, 473-489.

Lundström, M. (2007, August). Students Beliefs In Pseudoscience. Proceedings of the *European Science Education Research Association Conference (ESERA)*. Malmö: Sweden

Martin, M. (1994). Pseudoscience, the paranormal, and science education. *Science & Education*, *3*, 357-371.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Milli Eğitim Bakanlığı (MEB). (2005). *İlköğretim Fen ve Teknoloji Dersi (6., 7. ve 8. Sınıflar) Öğretim Programı*. Ankara: Milli Eğitim Bakanlığı.

Ministry of Education and Human Resources Development (MEHRD). (2007). *The revised 7th Korea national curriculum standards in 2007*. Seoul: MEHRD.

Meichtry, Y. J. (1992). Influencing student understanding of the nature of science: Data from a case of curriculum development. *Journal of Research in Science Teaching*, *29*(4), 389-407.

Mills, G. E. (2003). *Action research: A guide for the teacher researcher*. Upper Saddle River, NJ: Pearson Education, Inc.

Nickell, D. S. (1992). *The pseudoscientific beliefs of high school students* (Unpublished doctoral dissertation). Indiana University School of Education, Bloomington.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about- science" should be taught in school? A Delphi study of the expert community. *Journal of Research in Science Teaching, 40*, 692-720.

Pena, A., & Paco, O. (2004) Attitudes and views of medical students toward science and pseudoscience. *Medical Education Online. 9(4),* 1-7. doi:10.3402/meo.v9i.4347

Preece, P. F., & Baxter, J. H. (2000). Scepticism and gullibility: The superstitious and pseudoscientific beliefs of secondary school students. *International Journal of Science Education*, *22*(11), 1147-1156.

Rudge, D. W., Cassidy, D. P., Fulford, J. M., & Howe, E. M. (2014). Changes observed in views of the nature of science during a historically based unit. *Science & Education*, *23*(9), 1879-1909.

Schwartz, R., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, *88*(4), 610-645.

Solomon, J., Duveen, J., Scot, L., & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in the classroom. *Journal of Research in Science Teaching*, *29*(4), 409-421.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publications Inc.

Tala, S., & Vesterinen, V. (2015). Nature of science contextualized: Studying nature of science with scientists. *Science & Education*. *24*(4), 435-457.

Tsai, C. Y., Lin, C. Y., Shih, W. L., & Wu, P. L. (2015). The effect of online argumentation upon students' pseudoscientific beliefs. *Computers & Education*, *80*, 187-197.

Turgut, H.(2009). Fen ve teknoloji öğretmen adaylarının bilimsel sözde-bilimsel ayrımına yönelik algıları. *Eğitim ve Bilim*, *34*(154), 50-68.

Turgut, H., Akçay, H., & İrez, S. (2010). Bilim sözde-bilim ayrımı tartışmasının öğretmen adaylarının bilimin doğası inanışlarına etkisi. *Kuram ve Uygulamada Eğitim Bilimleri/Educational Sciences: Theory & Practice*, *10*(4), 2621-2663.

Turgut, H. (2011). The context of demarcation in nature of science teaching: The case of astrology. *Science & Education*, *20*(5-6), 491-515.

Wei, B., Li, Y., & Chen, B. (2013), Representations of nature of science in selected histories of science in the integrated science textbooks in China. *School Science and Mathematics*, *113*, 170-179.

Appendix 1. FSPD – Iridology Form

Dear Students,

The extraction taken from a newspaper and questions below were prepared to learn your views for the scientific research. Please read the news carefully and answer the questions sincerely.

A New Development in the Field of Health

A group of researchers pointed out that some spots and lines appear on certain parts of iris, which is the colourful part of eye, when people become ill. These researchers suggest that it is possible to learn about the genetics and hidden potential diseases of people by examining the spots on iris. Talking to the press, Dr. Frank Lee explained that iris is a region where nerve endings are seen intensively and the chemical changes in the body are transmitted to iris through the neural system. According to Dr. Frank Lee, the diseases related to every organ leaves a mark in different parts of iris. Indicating that they have been searching which part of iris has information about which organ, Dr. Lee added that they are about to finalize their study and they will have had a map of iris in the end. Reiterating that it would be possible to have an early diagnosis of some deadly diseases by making an eye scanning regularly in recent years, Dr. Lee completed his speech saying that "The saying of 'Eyes are the Mirror of Heart' will be changed into 'Eyes are the Mirror of Body" from now on.

A part of news published in a national daily newspaper was given above. Dr. Frank Lee presented his studies to a committee examining scientific data, wishing them to question the status of the method of "iris analysis" for being scientific with a desire to apply it at hospitals and to establish departments in universities in order to train "iris analysis" experts.

Suppose that you are a member of this committee. Accordingly;

1. Following which methods, could you decide whether this assertion is scientific or not?

2. Do you think the method of "iris analysis" mentioned is scientific? Why? Discuss it with the reasons.