

023

Azninda_2021_J._Phys._Conf._S
er._1747_012019.pdf
by

Submission date: 18-Jul-2021 12:33PM (UTC+0700)

Submission ID: 1620907062

File name: 023 Azninda_2021_J._Phys._Conf._Ser._1747_012019.pdf (819.87K)

Word count: 4623

Character count: 24595

PAPER • **5** OPEN ACCESS

Teachers' Views about Nature of Science (NOS) Using Reconceptualised Family Resemblance Approach to Nature of Science (RFN) Questionnaire

7
To cite this article: H Azninda *et al* 2021 *J. Phys.: Conf. Ser.* **1747** 012019

View the [article online](#) for updates and enhancements.



240th ECS Meeting ORLANDO, FL

Orange County Convention Center Oct 10-14, 2021

Abstract submission deadline extended: April 23rd

SUBMIT NOW

Teachers' Views about Nature of Science (NOS) Using Reconceptualised Family Resemblance Approach to Nature of Science (RFN) Questionnaire

H Azninda, Raharjo and T Sunarti

Postgraduate of Science Education Program, Universitas Negeri Surabaya, INDONESIA.

Email: haifa.19011@mhs.unesa.ac.id

Abstract. This study aimed to identify teachers view about Nature of Science (NOS). One of the most recent framework that focused on educational adaptation of NOS is called Reconceptualised Family Resemblance Approach to Nature of Science (RFN). Based on RFN, NOS is categorized by its aims and values, scientific inquiry, methods, knowledge and social-institutional aspect of science. Teacher plays big role in learning process to teach NOS both in implicitly or explicitly. However, only few of research that have been revealed teacher's view about NOS using RFN. A qualitative research method was considered in order to identify teacher's responses based on categories of RFN. This study also used 70 items "RFN-Questionnaire" that was adapted from Kaya et al (2019). Total 15 science teachers and 10 non-science teachers such as social and language teachers was participated in written questionnaire and interview processes. The result show that non-science teachers have different view about NOS in each category compared to science-teacher based on interview. Though a quantitative data analyse, using Mann-Whitney based on score from RFN-Q, suggest that there is no significant differences between non-science teacher and science teacher's overall score. This study concluded that teachers in both science and non-science majors have different view about NOS because of learning experience and processes they have received.

1. Introduction

Nature of Science (NOS) has been a curriculum goal for decades. Research that have done especially in the field of science education used "consensus view" about NOS and been applied in several curriculum analyses by some author i.e. [1-4]. Philosophers, historians, and scientists of the sociology of science agree that there is no specific definition that can explain NOS. Some general views on NOS, among them as described by Norman Lederman, agree that not all characteristics in NOS can be taught in learning activities. Teachers are advised to teach acceptable characteristics of NOS in the standards of science, philosophy, history, sociology of science, and science education literature [5].

Kaya et al. [6] stated that NOS can be explained both holistically and contextually using the Family Resemblance Approach (FRA). The definitions of NOS using FRA is previously mentioned by Irzik and Nola [7], namely Science as a cognitive-epistemic system includes the process of investigation,

4 goals and values, methodological methods and rules, and scientific knowledge, while science as a social-institutional system includes activities, professional, scientific ethos, social certification and dissemination of scientific knowledge, and social values. These categories have their respective relationships, however, each of these categories also has its own characteristics that differentiate it from other categories.

In general, FRA has 5 categories that characterize NOS, the first namely Aim and Value. Aim and value in science are described as a collection of the objectives of the product of scientific activity expected when studying science [6-7]. For example, the purpose of studying science is one of which is to be able to predict a natural phenomenon, explain the consistency of this phenomenon and make simplifications so that it can be easily accepted by many people. The second characteristic, namely, Science Inquiry which involves Scientific Practice and Scientific Methods which is described as a way or step in finding scientific knowledge, for example by making observations, collecting data, formulating hypotheses, conducting experiments, analyzing to making conclusions [6-7]. The third characteristic is about Scientific Knowledge which is described as the consistency of scientific knowledge, whether knowledge can change over time, or is it permanent. The fourth characteristic is about the Socio-Institutional Aspect of Science. This aspect includes whether or not the influence of political policy in science, the ability of a scientist to disseminate research results to many people, and the influence of finance in the scientific process. This socio-institutional aspect also analyzes the application of NOS in education as an institution that underlies learning and application of NOS to make it more familiar and clear [7].

Researchers emphasized the potential benefits of learning and understanding NOS for students. Driver et. Al. [8] claim that understanding NOS helps students to raise awareness about socio-scientific problems, understand the scientific process, understand the norms of the scientific community, and value science as one of the main elements of society and culture. In this direction, one of the most important goals of science education is to study not only the content of science, but also the nature of science [8]. By learning science that also teaches the nature of science can make someone who has understood science will have an awareness of the important and essential components of science itself [9].

Several studies suggest using explicit and reflective learning methods to teach NOS [10-11]. Explicit learning means providing learning tools that have been prepared in advance, so that NOS can be taught in a comprehensive and planned manner. Meanwhile, reflective learning refers to giving students the opportunity to become aware of the aspects of NOS they use during learning [12]. This explicit and effective method is in accordance with two learning theories, namely the constructive theory and the theory of changing concepts.

4 The process of scientific investigation and the developmental nature of knowledge acquisition in science describes the nature of science. Scientific literacy plays an important role in various fields, including mathematics, science and technology, aspects of human relations, also the nature of science. Understanding the Nature of science and the ability of inquiry, from designing experiments, collecting and analyzing data, to drawing conclusions from analyzing that data, is an important part of scientific literacy [13].

Teachers' views of NOS affect how teachers perceive their teaching methods, and can influence students' perceptions. Teachers' responses about NOS have become part of their own teaching materials, so that the NOS that students have can indirectly be influenced by the views of the teachers who teach them. This causes the teacher's view of NOS and the importance of NOS hold key aspect for teachers, because teachers have the responsibility to teach NOS so that students can understand the meaning of NOS at the correct level [14].

However, knowing how important teacher's role is, the study about teacher's view about NOS using RFN is yet rarely done. In line with the points mentioned above, this study invited teachers to determine their perceptions and views of NOS, provide effective teaching strategies to improve their understanding of NOS, and develop graduates who can be scientifically literate in the future.

2. Method

This study involved 15 teachers teaching Science education (Physics, Biology and Science Education) and 10 teachers teaching non-science fields. To assess teachers' views on Nature of Science, this study adopted a 5-likert scale instrument (RFN questionnaire) developed by Kana et al, (2019). The RFN questionnaire consists of 70 items reflecting 5 categories of RFN in which 'Social-Institutional Aspects' category consists of several sub-categories ('Political Power Structure', 'Social Value', 'Educational Application') [9]. The data are both quantitative and qualitative. The quantitative component comes from Mann-Whitney of the mean results of the RFN questionnaire overall scores from both of group, to determine if there is a significant difference between the means of two groups. The questions of RFN-Q that has been designed using the RFN category (Table 1). The qualitative component was based on the results of interviews with respondents regarding their views on each FRA category which is tabulated based on the frequency of answers given by respondents.

Given the domain-specific emphasis on NOS that has been placed in teacher education sessions, several questions implicitly include references to this theme. In the questionnaire, the teachers were given 5 options which were 'strongly agree', 'agree', 'not sure', 'disagree' and 'strongly disagree' and they were asked to choose one of these options to determine their view of each statement.

Table 1. Distribution of question items based on RFN categories

Category	Example	Question Items	Item Numbers	
			Positive	Negative
<i>Aim and Values</i>	Diversity of solving scientists' problems collectively implies impartial results (positive items)	7	2, 20, 40, 51, 69	46, 56
<i>Scientific Inquiry</i>	The power of an experiment comes from testing scientific hypotheses time and time again by scientists.	13	4, 5, 15, 19, 23, 33, 38, 57, 61, 63	26, 52, 64
<i>Scientific Method</i>	There is a universal (general) scientific method that is used by all scientists around the world (negative items)	9	11, 22, 24, 28	8, 25, 37, 49, 60
<i>Scientific Knowledge</i>	Theories and laws are forms of scientific knowledge, but learning models are not forms of scientific knowledge (negative items).	9	10, 30, 44, 50, 54	3, 16, 43, 66
<i>Institutional-Socio Aspect</i>	Scientists must respect the environment (positive items).	16	7, 9, 14, 32, 34, 41, 45, 48, 53, 58, 67, 70	13, 18, 36, 39
<i>Educational Application</i>	Science teaching must state that the law is certain and cannot be changed.	16	1, 6, 12, 17, 21, 27, 29, 31, 42, 55, 59, 62, 65	35, 47, 68

3. Results and Discussion

3.1. RFN-Questionnaire

The quantitative data in this study were obtained from the mean scores obtained by the two groups of teachers, namely the science teacher group and the non-science teacher group. The mean of the two groups was then tested using the Mann-Whitney Independent test, to determine whether there were significant differences between the two groups.

Table 2. Teachers RFN-Q Overall Scores

Major	Department	Number	Total Number	Questionnaire Score	Average Score
Science	Physics	9	15	250, 290, 248, 272, 248, 256, 244, 278, 272	258,7
	Biology	1		235	
	Science Edu.	5		266, 260, 274, 261, 226	
Non-science	Indonesian	4	10	254, 264, 258, 282	269,6
	Social	2		272, 265	
	Islamic Edu.	4		288, 283, 258, 272	

Based on Table 2., it can be seen that the mean score of the non-science teacher group is higher than the science teacher group. Furthermore, to determine whether there is any difference between the two mean RFN-Q scores the data was tested using the Mann-Whitney test.

Table 3. Independent-Samples of Overall 'RFN-Q' Score Mann-Whitney U Test Summary

Test Statistic	Standard Error	Standardized Test Statistic	Asymptotic Sig.(2-sided test)	Exact Sig.(2-sided test)
102.000	17.986	1.501	.133	.144

*p>0.05

Based on Table 3., which the statistical values are higher than significant value, indicates that there is no significant difference between the mean score of the science teachers and non-science teachers. The RFN-Q scores are then grouped by major teachers, and analysed based on the NOS category according to the FRA in Table 1.

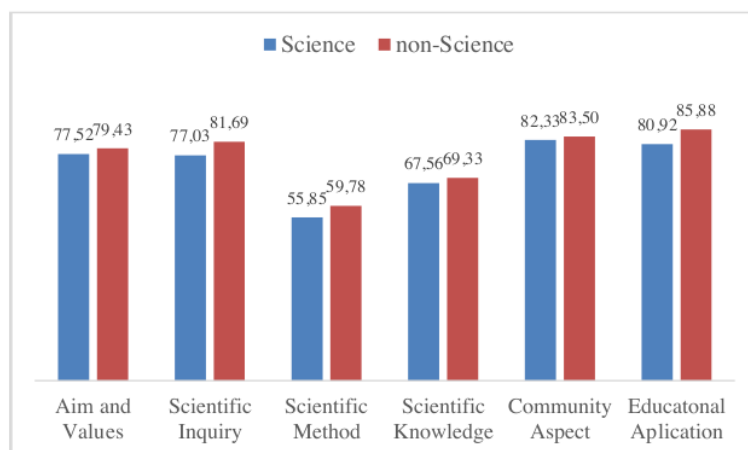


Figure 1. Comparison of Scores between Group of Science Teachers and Non-science Teachers based on FRA's NOS category

Based on Figure 1, it can be seen that the category with the lowest mean score is the scientific method and educational application with the highest mean score. Furthermore, to qualitatively determine the teacher's views on NOS, interviews were conducted.

3.2. Interview about NOS

The results of interviews with science and non-science teachers share a common view of the goals and benefits of science. The responses most frequently expressed by teachers about the goals and benefits of science are shown in Table 4.

Table 4. Codes for Teacher Views' about Aims and Values of Science

Code	Explanation of Code	Science N=15		Non-Science N=10	
		#	%	#	%
Explain phenomenas	Explain natural phenomena, for example the occurrence of rainbows, the use of bacteria in yeast for food	11	73	2	20
Facilitating human work.	Making digital technology and machines that can facilitate human work.	2	13	5	50
Understanding the relationship between humans and nature	Science studies the energy potential of various natural resources.	2	13	1	10

Based on Table 4, the majority of respondents, both the science and on-science teacher groups, stated that the purpose and benefits of science is to explain the surrounding phenomena. It can be seen a big difference, where the non-science teacher group mentioned the benefits of science associated with human needs. This result is in accordance with previous research [2] [5] [15] which states that non-scientific groups have more control over several aspects of humanity which are learned through philosophy, history and religious teachings.

Table 5. Codes for Teacher Views' about Scientific Inquiry of Science

Code	Explanation of Code	Science N=15		Non-Science N=10	
		#	%	#	%
Experiment	Conducting experiments to prove a theory / law.	12	80	2	20
Laboratory Activity	Conducting experiments in the laboratory to test a hypothesis	2	13	6	60
Testing laws or theories	Test a theory by direct experimentation	1	6	1	10

Based on Table 5, the teachers of all the teachers who were interviewed, none of them mentioned the possibility of testing the hypothesis without doing practice, although there are several theories or laws that cannot be directly experimented with. For example, Kepler's Law and Newton's Law of Gravity which involve objects with massive mass. For the non-science teacher group, more than one respondent stated that they studied science the last time when they were at the elementary school level. B09 stated "I last studied science 20 years ago, when I was in elementary school (respondent is 34 years old). Because after that I was enrolled in a religious school and currently teaches Islamic religious education. What I know is that currently scientific practice is carried out in laboratories with certain standards. The goal is to improve motoric skills"

Most teachers' understanding of NOS has remained the same over time. As teachers' understanding of NOS begins to develop, teachers may be able to relate these changes to the experiences they have received while implementing inquiry-based learning. Because it takes a long time, it is necessary to

realize the need to show new regulations as accelerators (catalysts) so that curriculum and resolution can be better to facilitate learning [16].

Table 6. Codes for Teacher Views' about Scientific Methods of Science

Code	Explanation of Code	Science N=15		Non-Science N=10	
		#	%	#	%
Systematic steps	The sequence for testing a hypothesis starts from observing, conducting experiments, collecting data, analyzing and making conclusions	10	67	3	30
Do experiment	Conduct experiments to prove a theory / law.	1	6	3	30
Systematic ways	Method is a way to find / prove something that is done in a certain order.	1	6	3	30

Based on Table 6., there are keywords that are the same as Scientific Inquiry, namely Do Experiment. When explaining the definition of a systematic step, the science group teacher then explained that the scientific method is part of the practice of science. Meanwhile, the non-science teacher stated that the method was a way to find / prove knowledge. These results prove that the characteristics of science are related to one another, but also have their own characteristics. The difference between the method and the practice of science is that the practice of science can ignore the systematic step, if the goal of the practice does not involve experimental variables. Practice is also part of the method, besides the method of observation or measurement. To be more specific, scientific method is a collection of different methods or techniques used to test a hypothesis. A hypothesis is a provisional assumption that is put forward against a phenomenon that is being observed [17]. These phenomena are generally empirical - that is, they are gathered through observation and / or experimentation. There is often a misunderstanding between theory and hypothesis. A theory is the product of a previously tested hypothesis, which means that proven intent can explain an observed phenomenon. A hypothesis needs to be proven or refuted through investigation [18].

Table 7. Codes for Teacher Views' about Scientific Knowledge of Science

Code	Explanation of Code	Science N=15		Non-Science N=10	
		#	%	#	%
Science changes over time.	Changes in a science are caused by the times and human intellectual abilities	8	53	6	60
Impact of upgrading technology	Technological developments affect the method	4	27	2	20
Change in theories is due to complete the previous one	A theory cannot change, but it can be completed, like the atomic theory.	3	20	1	10

Respondent A05 said "It is possible to change, because of the development of the era, the human mind, knowledge and technology, the human mind and technology will also develop, what is now being found is simple, maybe one day it will be explained in more detail"

These responds inform that respondent agree that science is not made to be an absolute and inviolable guide, instead science is found to be a guide in predicting possibilities, which these possibilities can be used as hypotheses to be used as an experiment, so that science continues to develop. The development of science itself can be done by learning new methods and mastering variety of

technologies. The combination of method and technology can contribute to detailing previous theories or make a theories more contextual.

Some laws / theories that have been able to survive and have been proven by many experiments have little chance of changing. However, this law / theory can be based on evidence in the form of data and new perspectives. The occurrence of changes in science that sometimes feels very precise is corrected by the high curiosity of various scientists, so that scientists compete to find the most appropriate explanation through hypothesis testing. This is part of a normal and healthy scientific process [19].

Table 8. Codes for Teacher Views' about Socio-Institutional Aspect of Science

Code	Explanation of Code	Science N=15		Non-Science N=10	
		#	%	#	%
Regulation throughout research	Regulations made by stakeholders can influence the way scientists work in developing their research.	2	13	5	50
Social needs	The need to socialize so that the knowledge gained can be disseminated directly by minimizing errors.	5	33	4	40
Can't explain impact of political issue	Do not understand the role of political power or do not follow political developments.	8	53	1	10
(Educational Application) School is the first place	Student learn science which is taught by teacher at school. School has very important roles	8	53	8	80

Table 8. is the Institutional-Socio Aspect which includes the Educational Application category. Interviewer B04 said that *“Political power can influence the world of education. Because there are limitations that are made, with the power that someone has, he will be able to limit the scientific activities carried out by a scientist.”*

And mostly, teacher from science department said that they have no idea about the power of politics hold. But they can explain the impact of social aspects well. Respondent A11 said *“Influential, political power. I don't know because I don't know politics. But I will explain according to my knowledge, the political partnership is very influential on the economy and other aspects, but I personally cannot give an example.”*

Although they cannot explain well the influence of political power on a science, science teacher groups realize the nature of humans as social beings who need help in solving problems, especially in the field of science. However, respondents could not mention the most important socialization activities in science, namely how a scientist can discuss, argue and also present the results of his research in front of many people. Scientists participate in social life as citizens who can encounter scientific problems that are not their expertise. This is a disadvantage of the narrow science that a scientist studies during his formal education. As with scientists, narrow science education causes teachers to be unprepared for public issues related to science [20].

For the Educational Application we did intentionally mention what school role about NOS. Respondent mostly agreed that school is the basic and foundation about how both student and teacher perceive about what is science actually mean. Thus, teacher might some complexity while teaching NOS explicitly and directly, because student who have a lot of curiosity will construct their own knowledge by asking and discussing it on class. Teacher must be ready and have all planed in their courses. [5] [7]

recommend to use Scientific Inquiry model to teach NOS implicitly and make it clear in closure statement or conclusion of course.

Even though a curriculum that is based on a scientific approach has been implemented in every subject, there are still no systematic changes involving the history, philosophy and sociology of science, especially in science lessons. Teachers only teach science content so that both teachers and students do not have the opportunity to deepen their views on science. The need for training that trains teachers to understand public perceptions of science, which makes use of the history, philosophy, and sociology of science and specifically addresses teachers' NOS views [21].

This study involved 25 respondents whose sample size was small for use in a qualitative method. Although the Mann-Whitney test can be used as a statistical hypothesis test, further analysis of the impact is needed to reduce the risk of error. In this analysis, the quantitative analysis in the form of the RFN-Q score is complemented by the analysis obtained from the interviews, describing the consistency of each teacher's views on NOS. Since RFN is a new approach to explain NOS in world education, this finding can be said to be a preliminary study of teachers' views on NOS. Subsequent research involved needing more samples to a quantitative test [6].

Based on the explanation above, different views on NOS can occur due to differences in the background of knowledge that has been studied by each group of teachers [22]. The non-science teacher group, including those from the department of religion, literature and social affairs, have studied human traits as social beings, history, philosophy, humanity more deeply than the science teacher group [23]. Particularly in the scientific methods category, non-science teachers are surprisingly able to name sequences of scientific methods consisting of observing, collecting data, formulating hypotheses, conducting experiments, analyzing to making conclusions. This happens because of the influence of changes in the curriculum in Indonesia, from Curriculum Based Unit (KTSP) to Curriculum 2013 which uses a scientific approach in every subject. This result is in line with research findings [6] [15] [24] which stated that the non-science group has a better perception than the science group in several categories, especially in the institutional-socio aspect category.

5 Conclusion

This study aimed to identify teachers view about Nature of Science (NOS) using RFN-Q. This study is underlined on the practical and empirical implication of the FRA to NOS and contribute limited amount of literature on NOS in education context. Based on data analyse, there was no statistically significant difference between the mean RFN-Q score of the science teacher group and the non-science teacher group, though the mean score non-science group was higher. The qualitative results obtained from the interviews indicated that there were different views on each of the NOS categories, although they had different views, the two groups of teachers were able to explain their views about NOS well in the Aims and Values categories. Despite getting high scores in the Socio-Institutional Aspect category, teachers have not been able to provide good explanations and examples, especially on political issues. This differences of view make a gap between qualitative and quantitative is possible. Curricula and regulation need to develop courses that trains teachers to understand public perceptions of science, which makes use of the history, philosophy, and sociology of science and specifically aims to address teachers' NOS views. Learning using a scientific literacy approach or scientific inquiry also need to be developed to understand and introduce NOS widely in the world of education.

References

- [1] Deng F, Chen D.-T, Tsai C.-C, and Tsai, C S 2011 *J. of Sci Edu* **95** 961
- [2] Erduran S, Dagher Z 2014 *Reconceptualizing the nature of science for science education: Scientific knowledge, practices and other family categories* (Dordrecht: Springer)
- [3] Rudolph J L 2000 *J. of Cur Stu.* **32** 403
- [4] van Eijck M, Hsu P.-L, and Roth W.-M 2009 *J. of Sci Edu* **93** 611

- [5] Lederman N G, Abd-El-Khalick F, Bell R L, Schwartz R E S 2002 *J. of Res in Sci Teach* **39** 497
- [6] Kaya E, Erduran S, Aksoz B, Akgun S 2019 *Int. J. of Sci & Educ* **41** 21
- [7] Irzik G, Nola R 2014 New directions for nature of science research. In *M. Matthews (Ed.), International handbook of research in history, philosophy and science teaching* (Dordrecht: Springer) p 999
- [8] Driver R, Leach J, Millar R, Scott P 1996 *Young people's images of science* (Buckingham: Open University Press)
- [9] Osborne J, Collins S, Ratcliffe M, Millar R, Duschl R 2003 *J. of Research in Sci Teaching* **40** 692
- [10] Akerson V L, Abd-El-Khalick F, and Lederman N G 2000 *J. of Res in Sci Teach* **37** 295
- [11] Williams C, Rudge D 2016 *J. of Sci & Edu* **25** 407
- [12] Abd-El-Khalick F, Lederman N G 2000 *Intl J. of Sci Edu* **22** 665
- [13] McDonald, J and Dominguez, L 2005 *J. of Col Sci Teach*, **35** 18
- [14] Mihaladz G, Doğan A 2014 Science Teachers' Views about NOS and the Place of NOS in Science Teaching *Procedia - Social and Behavioral Sciences* **116** 3476
- [15] Parker L, Krockover G, Lasher-Trapp S, Eichinger D 2008 Ideas about the nature of science held by undergraduate atmospheric science students. *Bulletin of the American Meteorological Society* **89** 1681
- [16] David M Moss 2001 *Int. J. Sci Educ* **23** 771
- [17] Gasparyan AY, Ayvazyan L, Mukanova U, Yessirkepov M, Kitas GD 2019 *J. Korean Med Sci* **34** 1
- [18] M. Castillo The Scientific Method: A Need for Something Better? 2013 *AJNR Am J Neuroradiol* **34** 1669
- [19] Allchin D 2011 *Sci & Educ* **95** 518
- [20] Ryder, Jim, John Leach, and Rosalind Driver 1999 *J. Res Sci Teach* **36** p 201
- [21] Flick L B, Lederman N G (ed.) 2004 Scientific Inquiry and Nature of Science. *Sci & Tech Education Library* chap 18 p 389-425 (Dordrecht: Springer)
- [22] Akgun S, Kaya E 2020 *Sci & Edu* **29** 299
- [23] Irzik, Gürol, Nola, Robert 2010 *Sci & Educ* **20** 591
- [24] Liu S Y and Tsai C C 2008 *Int. J. of Sci & Educ* **30** 1055

ORIGINALITY REPORT

17%

SIMILARITY INDEX

13%

INTERNET SOURCES

15%

PUBLICATIONS

0%

STUDENT PAPERS

PRIMARY SOURCES

1	www.tandfonline.com Internet Source	3%
2	repositorio.unesp.br Internet Source	3%
3	Selin Akgun, Ebru Kaya. "How Do University Students Perceive the Nature of Science?", Science & Education, 2020 Publication	2%
4	link.springer.com Internet Source	2%
5	iopscience.iop.org Internet Source	1%
6	www.pure.ed.ac.uk Internet Source	1%
7	repository.usd.ac.id Internet Source	1%
8	"International Handbook of Research in History, Philosophy and Science Teaching",	<1%

Springer Science and Business Media LLC,
2014

Publication

9

www.ioste.org

Internet Source

<1 %

10

"Nature of Science in Science Instruction",
Springer Science and Business Media LLC,
2020

Publication

<1 %

11

mafiadoc.com

Internet Source

<1 %

12

Ebru Kaya, Sibel Erduran. "From FRA to RFN,
or How the Family Resemblance Approach
Can Be Transformed for Science Curriculum
Analysis on Nature of Science", Science &
Education, 2016

Publication

<1 %

13

scholarcommons.usf.edu

Internet Source

<1 %

14

www.fb4all.com

Internet Source

<1 %

15

Ebru Kaya, Sibel Erduran, Busra Aksoz, Selin
Akgun. "Reconceptualised family resemblance
approach to nature of science in pre-service
science teacher education", International
Journal of Science Education, 2018

Publication

<1 %

16	www.usask.ca Internet Source	<1 %
17	docobook.com Internet Source	<1 %
18	Bing Wei, Yaqing Wang. "The Presentation of Science Practice in Twenty Historical Cases", <i>Science & Education</i> , 2020 Publication	<1 %
19	<i>Encyclopedia of Science Education</i> , 2015. Publication	<1 %
20	Regina Kelly, Sibel Erduran. "Understanding aims and values of science: developments in the junior cycle specifications on nature of science and pre-service science teachers' views in Ireland", <i>Irish Educational Studies</i> , 2018 Publication	<1 %
21	Rosária Justi, Paula Cristina Cardoso Mendonça. "Discussion of the Controversy Concerning a Historical Event Among Pre-service Teachers", <i>Science & Education</i> , 2016 Publication	<1 %
22	journal.hsforum.com Internet Source	<1 %
23	keynote.conference-services.net Internet Source	<1 %

24

"Science Education", Springer Science and
Business Media LLC, 2017

Publication

<1 %

25

eprints.nottingham.ac.uk

Internet Source

<1 %

Exclude quotes On

Exclude matches Off

Exclude bibliography On