Educational Policy Analysis and Strategic Research, V 15, N 2, 2020

Informal Effect of The Biographical Film on The Views of Prospective Science Teachers on Nature of Science*

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Abstract

In this study, the effects of a documentary and a biographical film, which was watched in an informal environment, on the prospective science teachers' nature of science (NOS) views were examined. The study conducted according to the mixed research methodology. The data were obtained through the open-ended questionnaire prepared by considering the consensus aspects of the NOS. The participants were shown a documentary-style biographical film about a cross-section of the life of a famous scientist. The findings show that there are changes in the participants' views on some of the consensus aspects of the nature of science. Some of these were in the desired direction, but the retention was weak. Also, some of the changes are in an undesirable direction such as to create a science myth. According to the results, it can be thought that films adapted from the history of science can be used to teach the nature of science. Since films produced for different purposes such as art and entertainment may cause problems in teaching the nature of science, it can be suggested to use such films in a more structured learning environment.

Keywords: Nature of Science, History of Science, Prospective Science Teachers, Biographical Film

DOI: 10.29329/epasr.2020.251.6

*This study is a comprehensive version of the presentation "Influence of a Movie Adapted from the History of Science on Science Teacher Candidates' views About Science" in 14th IHPST Biennial Conference in 2017, Ankara, Turkey.

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Introduction

The nature of science brings together fields that study science, such as the history, sociology, and philosophy of science, and other fields that do not study science, such as psychology. In this way, the nature of science becomes the subject of an interdisciplinary effort to understand what science is, its function, how the scientific community is organized, and how science and society affect each other (McComas, Clough & Almozroa, 1998). Understanding the nature of science is necessary, not only for experts but for all those studying. Accordingly, science-literate individuals should have understanding and actions regarding some aspects of science and scientific knowledge (National Research Council [NRC], 2013; Ministry of Turkish National Education, 2006, 2018).

If the different definitions put forward regarding the content of the nature of science should be examined, emphasis can be seen on the fact that science is a human activity. For example, when the approach known as consensus view (Abd-El-Khalick, Bell, & Lederman, 1998), which is largely structured by Lederman (2007) and known as the most adopted approach in the literature, is examined; Among the elements of the nature of science, which scientists and philosophers of science have reached consensus and are capable of covering all sciences, are science influences from social and cultural values (social and cultural influence). In addition, although it is not generally accepted as consensus, the nature of a widespread science is that science is part of social and cultural traditions (McComas & Olson, 2000). On the other hand, Matthews (2012) emphasizes the philosophy of science and especially its history and proposes it as a context for the teaching process in discussing and questioning the general features of science in social, cultural and ethical dimensions.

Different methods and / or strategies are proposed for how the nature of science should be taught. According to the implicit strategy, the learner will learn the nature of science when he is involved in the process. According to some researchers, due to the lack of direct focus on the nature of science, it is considered limited in teaching NOS (Lederman, 1992; Abd-El-Khalick & Lederman, 2000a). Against this, it is the explicit-reflective strategy, which is a more developed version of a strategy previously referred to as a direct strategy in the literature. The difference of this strategy from the previous one is that it gives the learner the opportunity to think, evaluate and infer about the nature of science in the process and to move the elements of the nature of science (especially the elements defined by the consensus view) into the learning environment (Abd-El-Khalick & Lederman, 2000a; Akerson & Volrich, 2006). Finally, according to the historical strategy, in the teaching process of the nature of science, the life of the scientists and the conditions such as science adventures or the story of an invention are tried to be brought into the classroom environment and thus, the learners are given a scientist perspective. In this way, the nature of science is taught in the teaching process (Şeker & Welsh, 2006). From the point of view of the strategies/methods proposed for teaching the nature of

science, it is clear that the historical strategy will give faith to learners to make sense of a social phenomenon like a social scientist.

Matthews (2015), states that science subjects will become more concrete and understandable in a science teaching environment structured through examining the lives and studies of scientists. This is possible with the history of science. However, although the integration of HOS into the teaching process is difficult (Abd-El-Khalick & Lederman, 2000b), it is known that this approach is effective for prospective science teachers to understand the nature of science (Lin & Chen, 2002). On the other hand, science and history of science are phenomenon in which individuals interact in informal environments, especially through media such as films, documentaries, etc (van Dijck, 2006; Lewenstein, 1995).

Media has a dizzying effect in guiding individuals and hence societies (Çelebi & Çopur, 2019; Aydemir & Demirkan, 2018). Therefore, it is an undeniable fact that the media, which is a part of the out-of-school learning environment, plays an important role in learning, creating perception, developing opinions and understanding. Films, which are one of the media channels, carry ideas and information more effectively than written texts (Cohen, 1999 as cited in Trier, 2002). In this regard, movies are one of the tools that indirectly affect the cultural views of people (Jarvie, 1970). The use of movies in teaching and teacher training has been suggested for some time (Tan 2006; Trier 2002).

From the point of view of science education, there are many factors (TV, social media, magazines, newspapers, travels, etc.) in out-of-school learning environments, as well as movies and television programs, and it is known to be effective in the development of science literacy (Kavak, Tufan & Demirelli 2006; Dhingra, 2003). When the science education literature is analyzed, it is seen that the use of films in science education is also recommended (Sürmeli, 2012; Cavanaugh & Cavanaugh, 2004; Segall, 2002). However, the results obtained from some studies on the use of films and television programs show that especially films based on fiction and science (eg science fiction) cause misconceptions (Bixler, 2007; Barnett, Wagner, Gatling, Anderson, Houle & Kafka, 2006). On the other hand, there are studies showing that presenting biographies and scenes that encourage thinking from historical documentary films in a context-based learning environment are useful in open-reflective teaching of certain dimensions of the nature of science (Seçkin Kapucu, Çakmakçı & Aydoğdu, 2015; Çakmakcı, 2017).

Apart from the studies for the formal use of different film types; the informal and incidental (encountered in daily life out of the school) effect of films inspired by the history of science on their understanding of the nature of science is also important. It is also known that such films are not produced with specific didactic purposes, such as the teaching of the nature of science. No studies have been found on the informal effect of such films on views about the nature of science. On the other hand, it is clear that the use of media tools in science education is a requirement today. For this

reason, teachers have the greatest responsibility in the development of science students' ability to evaluate such films and in the effective use of such films in science education (e.g. Critical Media Literacy, Torres & Mercado, 2006). At this point, it may be important to determine the impact of such films on teachers 'and prospective teachers' views on nature of science. As a matter of fact, in the teaching of the nature of science, it is necessary to focus primarily on teachers who are the determinants of the teaching environment (Lederman, 1992). In this respect, the aim of this study is to determine the effects of the film adapted from the well-known scientist's biography on the prospective science teachers' views about NOS.

For the NOS framework, this study was based on a consensus view. According to the consensus view, instead of detailed discussions, science and scientific knowledge characteristics that are widely accepted in all fields (science, sociology, history of science and philosophy) should be taught (Brunner & Abd-El-Khalick, 2020). The aim of this view is to provide an appropriate and accessible understanding of both k12 and university students (Irzık & Nola, 2011). Different criticisms have been made for this view for a while (Allchin, 2017). However, in recent years, this view has become very effective as a specific NOS specification and has been adopted in many countries of the world as a template for curriculum creation and research for students 'and teachers' NOS insights. (Hodson & Wong, 2017). The aspects of the nature of general science in the field mentioned by the consensus view are as follows; (1) scientific knowledge, which includes "facts," "theories," and "laws" is both reliable and tentative, (2) empirically based, (3) subjective and/or theory-laden,(4) partly the product of human imagination and creativity,(5) subject to a distinction between observations and inferences, (6) and influenced by social and cultural factors; (7) and theories and laws are different types of knowledge (Lederman, 2007). These aspects adopted by the consensus view can be taught through the historical approach, which is one of the methods for teaching the nature of science (Niaz, 2016). For this reason, in this study, it is insulted from the idea that the consensus view constitutes a minimum ground that can be encountered in the history of science in general.

Research questions

In this context, research questions are;

1. Is the film effective to change the NOS views of prospective science teachers?

2. Is the change on NOS views of prospective science teachers, permanent?

3. How do prospective science teachers express the reasons for the change in their views?

Method

Desing

In the study, qualitative data were collected concurrently within the experimental model as the single group pretest-posttest form and the retention was measured one month after the study. The sub-questions of the study expand the scope of the study and required different data sets in this context. The 1st and 2nd problems require quantitative and the 3rd problem requires qualitative data. The quantitative and qualitative data collected were analyzed and identified separately with appropriate methods but interpreted together. Considering these basic features of the study, it seems to be appropriate from the methodological point of view that embedded design of the mixed method can be used in the study. The main goal in a mixed methods research, based on multiple data collection by using different strategies, methods, and approaches, is to understand research problems better by combining qualitative and quantitative approaches (Johnson & Turner, 2003; Creswell, 2006). On the other hand, one of the important aims of mixed method researches is to expand the scope of the study by using different methods for the components of the research (Greene, Caracelli & Graham, 1989). Embedded design from mixed methods research designs allows a better understanding of what is being studied by enabling broad and alternative viewpoints (Creswell, 2003). The qualitative stages are integrated to support the experimental design (pre-experimental, post-experimental or on-experiment), which is recommended for situations where single data sets are not enough and different questions requiring different data sets need to be answered (Creswell & Plano Clark, 2011).

Participants

This study was carried out with the second- and third-year prospective science teachers (PTS) attending to science education department of a university in Turkey. A total of 72 (16 men and 56 women) PST participated in the study (43 are in the 3rd semester and 29 are in the 5th semester). Participants were selected from PST who haven't taken HOS and NOS courses. PST with high, medium and low-grade point averages participated in the study. In addition, the participants were selected among the pre-service teachers who could not have any knowledge and experience of the film that was used in this study.

Data Collection Instrument

A questionnaire consisting of open-ended questions prepared by the researchers was used to collect data. While preparing the questionnaire literature about nature of science in science education was examined ("consensus view", Lederman, 2007; Mc Comas et al., 1998). In this respect, the questionnaire includes seven propositions expressing the aspects of NOS and participants are required to write their justifications about each proposition. The general structure of the questionnaire is as follows (Table 1).

Table 1. The general structure of the questionnaire

Propositions	Question
P1. Scientific knowledge has a changeable feature.	What do you think about this claim? Please explain with justifications.
P2. Scientific knowledge is based on experiment and observation.	
P3. Scientific knowledge has a subjective side.	
P4. Imagination and creativity have an impact on the production of scientific knowledge.	
P5. Scientific knowledge is affected by the social and cultural structure of the environment in which it is produced.	
P6. Observation and inference are different actions in science.	
P7. Theories and laws in science are different types of knowledges.	

Procedure

The pre-application of questionnaire (pre-test) was at the beginning of the semester (2016-2017) in the first week. After the application, the prospective teachers were informed about watching the film. In the second week, the film was watched together with the participants. Participants were reminded that they can take notes. In order to create an informal environment. Informal and more flexible incidental learning take place in an environment that is not structured and has no clear orientation (Marsick and Watkins, 1990). Therefore, the film was watched at the weekend and a comfortable environment was created for the participants. In the study, the film named "Einstein and Eddington", which was broadcasted in 2008 and was not broadcasted in Turkey was watched. This film is both biographical and documentary (Martin, 2008). The film was chosen due to it was not science fiction. Because science fiction movies can hamper individuals' ability of understanding and critical thinking about science (National Science Foundation [NSF] 2000). It was also reported and advised that this film is about some aspects of the nature of science in a philosophical analytical review (Kapucu, 2016) and handbook (e.g. Yenice, 2015).

Scenarist Peter Moffat, who writes science fiction, wrote about the process of Einstein's developing general relativity theory in the context of that period's social and political environment (Martin, 2008). The film was watched with Turkish subtitles. The subtitle was checked by an expert who knows Turkish and necessary corrections were made. After watching the film, the questionnaire was given for the second time (post-test) to the prospective science teachers (Table 2). After one month, the questionnaire was applied to the same group for the third time to determine the retention of the film. In the first week, there was no content about the nature of science. Therefore, it was assumed that the course did not have content that directly influenced the participants' understanding of the nature of science.

Table 2. Data collection process

Applying Questionnaire	Purpose
1st application of the questionnaire	Determining participants' views before the film.
2nd application of the questionnaire	To investigate the views of the participants and the relation of views of the participants with the film.
3rd application of questionnaire (retention)	Determining retention of the film on participants' views.

Data Analysis

Quantitative analysis

For the first two research questions of the study, the data obtained from the questionnaire were analyzed quantitatively. Qualitative data to be analyzed should be semantically divided into some categories to be graded (Abeyasekera, 2005). The answers of participants are divided into some semantic categories to determine whether they agree with the given propositions about nature of the science. The data were scored using rubric containing the qualifiers of these categories.

Table 3. Rubric format

Category	Justifying the preposition	Accepting the preposition	Opposing the preposition	No relation or No answer
Score	3	2	1	0
Qualifier	Reasonable expressions, justifications, examples	Accepting without justification, confirming	Nonacceptance, refusal expressions	Expressions that are not related to the proposition or no-answers

Qualitative analysis

In order to support quantitative findings and to answers the third research question, after the posttest, data were analyzed qualitatively. In the qualitative descriptive analysis, the propositions given in the questionnaire were used as a framework. The causal explanations made by the participants for these propositions were examined, some themes were formed based on the data that form a whole, even though they were directed towards different propositions. Data were organized and interpreted under the propositions expressing the themes obtained (Miles & Huberman, 1994).

Validity and reliability

The propositions that constituted the items on the questionnaire used in the study were taken from the literature (e.g. Lederman, 2007; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). The rubric used in the evaluation of the answers was prepared based on expert opinions. In addition, after the questionnaire was prepared, it was applied to a group of 27 people for a pilot study. While evaluating the results of the pilot study according to the rubric, Turkish expressions of some of the propositions were revised and edited. Then, the questionnaire has taken its final form. After the main study, both quantitative and qualitative analysis of some of the data (N1: 25) were graded by a

different researcher. Following these two-independent evaluations, it was observed that there was a complete agreement on quantitative scoring and qualitative themes.

Findings

Findings of the quantitative analysis

In order to analyze the data, first descriptive statistical analysis was conducted to determine the inferential statistical analysis that will be used. The results of the descriptive statistics are shown in Table 4.

Table 4. Results of the descriptive analysis

Statistics				
		Pretest	Posttest	Retention Test
N	Valid	72	72	72
	Missing	0	0	0
Mean		16.2917	17.1806	16.5139
Median		16.5000	17.5000	17.0000
Mode		17.00	18.00	17.00
Std. Deviation		1.84953	2.00230	1.92824
Skewness		-.058	-.158	.178
Kurtosis		-.697	-.802	-.348
Minimum		13.00	13.00	13.00
Maximum		20.00	21.00	21.00

As can be seen from Table 4; mean, median and mode scores of pretest, posttest and retention test are very close to each other. Also, skewness and kurtosis values are between +/-1. Therefore, it can be said that the scores show normal distribution (George & Mallery, 2001). Hence, the results can be compared by using parametric tests. In order to compare pretest, posttest, and retention test scores, paired-sample t-test is used. The results are shown in Table 5.

Table 5. Results of paired sample t-test for pretest and posttest

Paired Samples Test						
		Paired Differences				
		Mean Difference	Std. Deviation	t	df	Sig. (2-tailed)
Pair 1	Pre – Post	-.88889	1.76472	-4.274	71	.000
Pair 2	Pre-Ret.	-.22222	1.87813	-1.004	71	.319

According to Table 5, there is a significant difference between pretest and posttest scores in favor of the posttest ($t=-4.274$, $p<.05$). In other words, prospective science teachers' NOS scores have increased after watching the film. This result showed that the film affected PST's NOS views significantly. However, the difference between the pretest and retention test is not significant ($t=-1.004$, $p>.05$). That is, there is no significant difference between the pretest and retention test. Hence, it can be said that the effect of the film is not retentive. After analyzing the total scores, the result of each preposition is analyzed in the following part.

Findings based on propositions

Effect of the film

Descriptive statistics obtained from each preposition in the questionnaire are analyzed. The results are shown in Table 6.

Table 6. Pre-test and post-test statistics of each preposition

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	P1-Pre	2.63	72	.659	.078
	P1-Post	2.82	72	.484	.057
Pair 2	P2-Pre	2.42	72	.666	.078
	P2-Post	2.57	72	.668	.079
Pair 3	P3-Pre	1.49	72	.605	.071
	P3-Post	1.65	72	.715	.084
Pair 4	P4-Pre	2.31	72	.705	.083
	P4-Post	2.53	72	.712	.084
Pair 5	P5-Pre	2.22	72	.587	.069
	P5-Post	2.72	72	.481	.057
Pair 6	P6-Pre	2.43	72	.885	.104
	P6-Post	2.40	72	.833	.098
Pair 7	P7-Pre	2.81	72	.597	.070
	P7-Post	2.49	72	.839	.099

Table 7. Pre-test and post-test comparisons of the prepositions

		Paired Differences				
		Mean	**Std. Deviation**	**t**	**df**	**Sig. (2-tailed)**
Pair 1	P1-Pre / P1-Post	-.194	.664	-2.486	71	.015
Pair 2	P2-Pre / P2-Post	-.153	.597	-2.171	71	.033
Pair 3	P3-Pre / P3-Post	-.167	.650	-2.176	71	.033
Pair 4	P4-Pre / P4-Post	-.222	.676	-2.789	71	.007
Pair 5	P5-Pre / P5-Post	-.500	.805	-5.271	71	.000
Pair 6	P6-Pre / P6-Post	.028	.712	.331	71	.741
Pair 7	P7-Pre / P7-Post	.319	.688	3.937	71	.000

When pretest averages of the participants are examined, it can be said that the NOS scores of the participants are high. However, there is a significant difference between the scores of propositions (P1. *Scientific knowledge has a changeable feature;* P2. *Scientific knowledge is based on experiment and observation;* P3. *Scientific knowledge has a subjective side;* P4. *Imagination and creativity have an impact on the production of scientific knowledge;* P5. *Scientific knowledge is affected by the social and cultural structure of the environment in which it is produced*) in favor of the posttest. In other words, the film has had a positive effect on these propositions. But for P7 (*Theories and laws in science are different types of scientific knowledge*), there is a significant difference between pre and posttest scores in the favor of pretest. This means the film had negatively affected participants' NOS views for this preposition. Also, there was no significant difference in the views of the participants for

P6 (*Observation and inference are different actions in science*). These results showed that the film affected most of the participants' views about NOS.

Retention

In order to determine the retention of the effect of the film on the NOS views of prospective science teachers for each preposition, a retention test was applied one month after the posttest. The descriptive and inferential statistic results are given below.

Table 8. Descriptive statistics for retention test

		Pretest		Retention Test	
	N	**Mean**	**Std. D.**	**Mean**	**Std. D.**
P1	72	2.63	0.65	2.74	0.53
P2	72	2.42	0.66	2.50	0.73
P3	72	1.49	0.61	1.65	0.70
P4	72	2.31	0.71	2.39	0.76
P5	72	2.22	0.59	2.44	0.73
P6	72	2.43	0.89	2.32	0.85
P7	72	2.81	0.60	2.47	0.82

Table 9. Pre-test and retention test comparisons of the prepositions

		Paired Differences				
		Mean	**Std. Deviation**	**t**	**df**	**Sig. (2-tailed)**
Pair 1	P1-pre / P1-ret.	-.11	.72	-1.30	71	.20
Pair 2	P2- pre / P2-ret.	-.08	.67	-1.06	71	.29
Pair 3	P3- pre / P3-ret.	-.16	.63	-2.25	71	.03
Pair 4	P4- pre / P4-ret.	-.08	.75	-.95	71	.35
Pair 5	P5- pre / P5-ret.	-.22	.97	-1.95	71	.06
Pair 6	P6- pre / P6-ret.	.11	.70	1.34	71	.18
Pair 7	P7- pre / P7-ret.	.33	.67	4.21	71	.00

Although there was no significant difference between pretest and retention test in total scores, it is seen that the film had a retentive effect on P3. Although there is a significant difference between pretest and retention test for P7 propositions, this difference is in the favor of pretest. This means that negative effect of the film on participants' NOS views for this preposition is retentive. The film does not have a retentive effect on the prepositions P1, P2, P4, P5, and P6.

Findings of the qualitative analysis

The justifications made by the participants in the questionnaire were also analyzed qualitatively for supportive purposes. The following thematic propositions have been reached explaining the approaches of teacher candidates towards the reasons for changing their views. These propositions are aimed at the reasons for the views which are determined to change significantly as a result of quantitative analysis.

Generation of the theory

1. The history of a new theory emerges that scientific knowledge is open to change, and the most important indicators of the impact of imagination and creativity (P1 and P4).

According to almost all of the participants who changed their views; The reason Einstein wanted to put forward a new theory is that he imagined that the old knowledge was inadequate and that it should change.

> *"Einstein recognizes a lack that he encounters in the old knowledge and thinks that new knowledge is needed. He daydreams and asks questions. In the end, he suddenly becomes enlightened, finding the mind ... He tests new scientific knowledge with his imagination and proposes a new one, completely replacing old knowledge."* (Q1)

Social environment

2. One of the reasons behind the scientific reactions to a new scientific idea may be the socio-cultural environment in which science is made and the commitment to the previous theory (P3 and P5).

According to the participants who changed their views in the desired direction, the reactions of British scientists who supported the old theory in the film stem from both their commitment to the old theory and the war between the two countries. This influenced Einstein's work.

> *"The film reveals that some British scientists are opposed to Einstein's ideas, and it turns out that the son of the most opposed person died in battle. He reflects his anger on the Germans to Einstein. They remove Einstein's book from the library. However, Einstein is not satisfied with the situation."* (Q2)

Observation; testing the theory

3. The test of the new idea in science shows that scientific knowledge is empirical (P2).

According to the participants, although Einstein's views have been criticized in advance, the fact that his theory has been tested by Edington shows that science must be based on observation.

> *"I think that no matter how logical a scientific idea is produced; it should be corrected by experiment or observation. For example, the idea of Einstein's herpes in the film is accepted scientifically after the observation of Edington"* (Q3)

Verification and subsequent events

4. If knowledge in science is initially a theory, it may eventually become a definitively acceptable law (P7).

According to the participant explanations for the only view (P7) that changed in an undesirable direction; In spite of those who react to Einstein, the fact that his theory aroused great influence in the world of science at the end of the film is an indication that scientific knowledge will ultimately come to an invariable form that everyone can accept.

> *"Initially, Einstein's idea was a theory, which eventually became a more acceptable theory thanks to Edington. Recently (relativity) was confirmed. I think there will be something like the law in the future."* (Q4)

Discussion

The results showed that, although in the pretest, the participants' views were relatively high on the consensual aspects of the nature of science, the film caused significant and desired changes in the views of PST in terms of both total scores and propositions (P1, P2, P3, P4, P5). However, the quantitative results of the persistence test, which was performed approximately one month after the study, indicated that the persistence of the effect of the film is not significant. On the other hand, when the results of qualitative data obtained from the causal explanations of the participants are examined, it is seen that the opinions are based on the scenario of the film. Accordingly, some elements of the story in the scenario gave messages that are reasonable and unreasonable messages about the nature of science.

The findings of the study supported studies showing that media tools, especially films, can influence attitudes, understanding, perceptions, and views related to science (Laprise & Winrich, 2010; Sürmeli, 2012; Cavanaugh & Cavanaugh, 2004; Segall, 2002). In general, it can be stated that the film led to an increase in agreement on the views related to the understanding of the nature of science in an intended way. When the literature is examined, it is seen that this film is suggested. Kapucu (2016) emphasized in his philosophical analytical review, where he examined the scenario of this film in term of philosophy, that the film could be used for teaching the nature of science in certain dimensions. In another aspect, this study examines the messages this film gives to the audience rather than the researcher. Although the findings obtained in this study are not for formal education, they seem to support Kapucu (2016)'s prediction. However, the effect of the film was not significantly retentive. A possible reason for the decrease in the retention test may be different informal factors in this process. On the other hand, the negative effects of the film were also seen.

There may be three possible main reasons for the unintended changes in the views of participants. These are the way that film is used in the study, misconceptions of the participants and scenario quality. In studies where films are used in science teaching; it is stated that science fiction films can develop misunderstandings depending on the scripts of the films (Dhingra, 2003; Bixler, 2007; Barnett et al., 2006). Although the film used in this study is a documentary, it was filmed for a different purpose. The goal of the filmmakers is to inform the public about science or to portray it in a

funny and engaging way-not, to tell the truth of science (Logan, 2001). In this respect, while watching the film, participants were not directed for educational purposes. Therefore, it can be said that the participants received different messages from the same scenario.

Another important factor is the lack of prior knowledge of the participants related to the concepts of science. This effect is highly possible since there is no guidance in the film. The lack of prior knowledge of the participants related to some concepts (theory, hypothesis, etc.) may cause some myths (e.g. P7) of science (McComas, 1996; 1998)

Apart from the fictional character of the film scenario and possible pre-mythical assumptions/misconceptions of the participants, it can be said that there are possible limitations of the study that are effective in the results of the study. These limitations can be listed as; not watching the film in a teaching program or in a teaching environment, lack of discussions while watching the film, watching the film for the first time and some other factors in the process until retention test.

Conclusion and Recommendations

In this context, findings provide some important clues in terms of the teaching of the nature of science. First of these is that it may be appropriate to use such historical approaches in the teaching of the nature of science in the context of a more structured method to avoid misleading subjective interpretations. This can also increase retention. For example, it is stated that the film may contribute especially in terms of conventional understandings of NOS in the activities prepared within the scope of some studies related to the nature of science (Özcan, 2013; Yenice, 2015).

However, it is difficult to say that this film is a good informally teaching tool, although it is recommended for the teaching of the nature of science. The results of this study show that some measures are necessary for the context of the use of the history of science. At best, it can be used by comparing with real historical sources. Hence, as Allchin (2003) expresses, many historical narratives are influential in myth formation and share a rhetorical myth architecture that misleads them. For this reason, we need a different history type that conveys the nature of science in a more effective way rather than have more history in science education. For history of science to be meaningful, the philosophy of science must be considered in the teaching process because the philosophy of science emerges spontaneously in the usual teaching environments (Matthews, 2015). The second clue is that if the concepts presented through combination of science and fiction have some wrong aspects, there can be seen unintended effects (Dhingra, 2003). Thus, combination of the use of films and the discussion environments of current teaching methods can give positive results.

These discussions about science lead students not only to understand concepts but also to develop their ability to think critically and analyze the world (Settlage & Southerland, 2007). Thirdly, it is also possible to give concepts related to the nature of science explicitly through films. This

approach can be used, similar to the integrated approach expressed by Niaz (2016), with the integration of a reflective approach (Duschl & Grandy, 2012) and the historical approach (Khishfe & Abd-ElKhalick, 2002) in which films are used. Another important clue is that if NOS understandings are measured through agreeing or disagreeing with a given proposition, it may be misleading. To overcome this handicap, participants should be given opportunity to justify their argument and exemplify their point. Indeed, even in science fiction films, a proposed approach at this point is to discuss how certain scientific concepts are used in a story (Smith, Scott & Coskrey 1990). In summary, history of science has a unique value for understanding the nature of science. Therefore, the methods of using history of science in teaching environments should be appropriate to this value.

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