International Journal of Progressive Education, Volume 16 Number 2, 2020

What Messages a Documentary and Biographical Film Give About the Nature of Science to Prospective Science Teachers?

Davut Sarıtaş [i]
Nevşehir Hacı Bektaş Veli University

Abstract

In this study, the experience of prospective science teachers, who watched a cinema film adapted from the life story of a well-known scientist for the first time in an informal environment, was examined. Answers of two questions were sought in the study; (1) what aspects of the nature of science did the prospective science teachers experience through which scenario elements of the film? (2) how do pre-service teachers interpret these experiences? In this study, being conducted based on hermeneutic phenomenology design; the data were collected through focus group interviews with semi-structured questions prepared by taking into consideration the aspects of the nature of science. Participants were 29 (23 girls, 6 boys) prospective science teachers. The collected data were analyzed by qualitative methods. The findings showed that the participants experience and interpret some aspects of the nature of science through specific scenario elements (representations). It was determined that participants highlighted certain sections (e.g. process of discovery, social reaction) in the story. It was observed that the participants correlated these sections with the nature of science in a positive or negative way and interpret them. The results show that these kinds of films adopted from history of science, which are recommended in the literature, can give positive messages about the nature of science. In addition, it was observed that the film caused misconceptions about the nature of science, especially due to the scenario. Therefore, it can be said that such films produced for different purposes may lead to some problems in the teaching of the nature of science. From this point of view, even if such films are used, it is obvious that rather than an informal environment, it is necessary to integrate these films into a more structured learning environment where inappropriate messages given by the film can be seen critically.

Keywords Nature of Science, History of Science, Prospective Science Teachers, Documentary and Biographical Film, Hermeneutic Phenomenology

DOI: 10.29329/ijpe.2020.241.18

---

[i] **Davut Sarıtaş,** Assist. Prof. Dr., Science Education, Nevşehir Hacı Bektaş Veli Üniversitesi, ORCID: 0000-0002-5108-4801

Correspondence: davutsaritas@gmail.com

INTRODUCTION

The quality of the science education of the countries is the clearest indication of importance given to the science. Giving importance to science is only possible through understanding and appreciation of it. Apart from doing science to understand science, it is necessary to evaluate science in a historical, philosophical, sociological and even psychological context (McComas, Clough and Almazroa 1998). Science in the most general sense, operationally, can be described as "what scientists do". Therefore, history of science can be a unique tool in this respect. Besides, it is also necessary to look at science not only from a scientist's view but also from a more external perspective (Yıldırım 2008). What stands out here is the philosophy of science. Rather than studying science as an object of its history, a philosophical approach to the HOS may be more effective in understanding and appreciation of science. Therefore, the combination of history and philosophy of science and a philosophical view towards the historical adventure of science reveal many important products that are milestones in understanding science. For instance, K.R. Popper, T. Kuhn, P.K. Feyerabend and others, bringing out books that were effective on shaping today's understanding of science, always defined science through examples from the history of science and philosophical approaches to science.

Understanding the nature of science in science education has been emphasized as a goal for a long time. According to this, scientifically literate individuals should have an understanding and act about some features and aspects of science and scientific knowledge (American Association for the Advancement of Science [AAAS] 1990, 1993; National Research Council [NRC] 1996, 2007, 2013; Ministry of Turkish National Education [MONE] 2005, 2006). There are different views on how the nature of science should be addressed in science education literature (e.g. "consensus / family resemblance / integrated" Niaz, 2016, p. 7). When the literature is examined, it can be said that the most widely accepted view is consensus view. According to this view, the nature of science in school science should be dealt with its aspects that include general knowledge and that are least controversial (Lederman, Abd-El-Khalick, Bell and Schwartz 2002; Smith, Lederman, Bell, McComas and Clough 1997; Smith and Scharman 1999). These aspects 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). On the other hand, within the framework of the standards of science (Next Generation Science Standards; NRC 2013) taught in schools in the United States recently, the assumptions of science are expressed as follows: *(1) scientific research uses a variety of methods, (2) scientific knowledge is based on empirical evidence, 3) scientific knowledge is open to change in the light of new evidence, (4) scientific models, laws and mechanisms and theories disclose natural phenomena, (5) science is a way of knowing (6) scientific knowledge assumes an order and consistency in natural systems, (7) science is a humane activity, (8) science deals with questions about the natural and material world.*

Science is one of the most frequently used concepts in educational environments and daily life. It is also quite normal to attribute different meanings to such a frequently used concept. Many inaccurate assumptions related to science are expressed as myths of science (McComas 1996, 1998). Perhaps one of the greatest obstacles to understand the nature of science correctly is these myths about science. McComas (1998) lists the myths of science as follows; (1) *hypotheses become theories that in turn become laws*, (2) *scientific laws and other such ideas are absolute*, (3) *a hypothesis is an educated guess*, (4) *a general and universal scientific method exists*, (5) *evidence accumulated carefully will result in sure knowledge*, (6) *science and its methods provide absolute proof*, (7) *science is procedural more than creative*, (8) *science and its methods can answer all questions,* (9) *scientists are particularly objective*, (10) *experiments are the principal route to scientific knowledge*, (11) *scientific conclusions are reviewed for accuracy*, (12) *acceptance of new scientific knowledge is straightforward*, (13) *science models represent reality*, (14) *science and technology are identical*, (15) *science is a solitary pursuit.* Considering the literature about how to teach the nature of science, it is seen that three different approaches namely historical, implicit, and explicit-reflective approaches are used (Khishfe and Abd-ElKhalick 2002; Duschl and Grandy 2012). Among these, historical approach

aims to teach the aspects of NOS through events that took place in the history of science (Abd-El-Khalick and Lederman 2000). Essentially, the need for philosophical and historical perspectives in the understanding of science in science education is not a new idea (e.g. Niaz 2016; Matthews 2015; Schwab 1964). However, although the integration of HOS into the teaching process is difficult (Abd-El-Khalick and Lederman, 2000), it is known that this approach is effective for PST to understand the nature of science (Lin and Chen 2002). A possible opportunity to integrate HOS into science teaching can be the informal learning environments.

Informal learning can be defined as learning outside the classroom in its most general form (Gerber and Marek, 2001). The effective role of media in informal learning, creating perception, developing views and understanding is an undeniable fact. Films that are one of the media channels convey ideas and knowledge more effectively than written texts (Cohen 1999 'as cited in Trier 2002). In this aspect, media can be an effective tool especially in teaching processes aiming at understanding, vision and awareness. Use of films in teaching (Dale, Fannie, Charles and Etta 1937; O'Connor 1987) and teacher training has been suggested for a long while (Öztürk 2017; Robertson 1995; Tan 2006; Trier 2002). In this context, it can be said that films can be used in teaching difficult but important phenomena such as developing an understanding of science. Films are one of the tools indirectly affecting people's cultural views (Vidal 2018; Moylan 2018; Jarvie 1970) and science is a human activity like culture (Driver, Leach, Millar and Scott, 1996). Therefore, films can be used to develop the public understanding of science. Films and television programs affect science learning informally (Shaw and Dybdahl 2000; Dhingra 2003). When the literature is examined, it is seen that science fiction films are used in science education (Cavanaugh and Cavanaugh 2004; Segall 2002; Sürmeli 2012). Although the results obtained are generally positive, some researchers reported that science fiction films cause misconceptions (Bixler 2007; Barnett, Wagner, Gatling, Anderson, Houle and Kafka 2006). On the other hand, there are also suggestions that biographies and historical documentary films can be effective in science education, especially on developing NOS (Özcan, 2013; Kapucu, 2016; Yenice, 2015). There are also studies suggesting that scenes from documentary films that encourage thinking are useful in explicit-reflective teaching of certain dimensions of nature of science in a context-based learning environment, allowing the open discussions on historical processes and practices (Seçkin Kapucu, Çakmakçı and Aydoğdu, 2015; Çakmakcı, 2017).

The purpose of the study

In brief, the debate on NOS in science education (e.g. Irzık and Nola 2016; Niaz, 2016; Mathews, 2015) shows the importance of philosophy of science. On the other hand, the studies on philosophy of science show that in order to understand science, guidance of HOS is needed. Historical approach used in teaching of NOS can perform this task in science education. In this context, for the understanding of NOS in a society, science teachers should be aware and knowledgeable on history and philosophy of science. More importantly teachers should have a sophisticated view on nature of science. In order to achieve this goal, it is possible to make use of HOS because it has the potential to be a peerless tool in understanding science. One of the ways that can be used to integrate HOS into science education is the use of films about scientists and scientific events. Both formal and informal effects of the films produced by inspiring from history of science on the nature of science is 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 the nature of science. Therefore, it is important to examine the individual experiences in the informal use of such films.

Aim of the study and Research Questions

The aim of this study is to examine the experience of prospective science teachers, who watched a cinema film adapted from the life story of a well-known scientist for the first time in an informal environment. The following research questions have been determined for this aim;

1. What aspects of the nature of science have the prospective science teachers experienced through which scenario elements of the film?

2. How did prospective science teachers make sense of their experiences?

METHOD

Considering the purpose, the focus of the study is on the experiences of the prospective teachers. For this reason, this study is a hermeneutical phenomenology research conducted within the framework of qualitative researches paradigm (Denzin and Lincoln, 2000). Like phenomenology, hermeneutical phenomenology is also concerned with human experiences and focuses on reaching to an understanding about meanings of experiences. However, the main difference between these two approaches is methodological. In the phenomenology, the researcher's self-reflection on the process is limited to the preparation stage. In the research process, the researcher does not include his / her assumptions and prejudices but enclose them in parentheses. On the other hand, hermeneutic phenomenology is an interpretive process. Therefore, the prejudices and assumptions of the researcher are not included in the parenthesis or put aside but are embedded and essential for the interpretation process. In this respect, the results of the research are revealed by the researcher's interpretation (Allen, 1996; Polkinghorne, 1989, as cited in Laverty, 2003). On the other hand, in all phenomenological researches, questions are asked in two ways in order to understand what and how the participants experience; first, what they experience about the phenomenon and the second, which environment or cases affect the experience of the phenomenon (Moustakas, 1994). The phenomenon experienced by the participants in this study is the depiction of science and scientific knowledge in the film.

Participants

This study was carried out with the third-year prospective (in 5th semester) science teachers attending to science education department of a university in Turkey. A total of 29 (6 man and 23 women) PST participated to the study. Participants were selected from PST who haven't taken HOS and NOS courses. PST with high, medium and low-grade averages participated to the study. In addition, the participants were selected among the pre-service teachers who could not have any knowledge and experience about the film.

Data collection

Semi-structured interview questions

A self-report form consisting of semi-structured questions prepared by researcher was used to collect data. While preparing the questions, literature about nature of science was examined ("consensus view", Lederman 2007; Mc Comas et al. 1998). In the interview form, the aspects of the nature of science were also taken as dimensions. There are seven main questions each of which is a main dimension, and some sub questions. The general structure of the interview-form is as follows;

Dimension	Questions
D1. Scientific knowledge is reliable and tentative	What did you experience in the film you watched about the reliability and tentativeness of scientific knowledge? • What happened in the film about this? • Can you justify it? • Which stage is the reason for your idea? (etc.) • Did you experience something different?

Figure 1. General structure of the questionnaire

Other dimensions in the form are;

D2. *scientific knowledge is empirical (based on and/or derived from observations of the natural world);* D3. *scientific knowledge is subjective and/or theory-laden; D4. scientific knowledge is partly the product of human imagination and creativity;* D5. *scientific knowledge is influenced by social and cultural factors;* D6. *scientific knowledge is subject to a distinction between observations and inferences;* D7. *theories and laws are different types of knowledge.*

Procedure

The film was watched at the beginning of the semester (2017-2018) before the beginning of nature and philosophy of science course. In order to create an informal environment, 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 because it was not a science fiction. 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 (Kapucu 2016; Yenice 2015). Scenarist Peter Moffat, who writes science fictions, 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 (English native speaker) who knows Turkish and necessary corrections were made.

Approximately one hours after the watching the film, focus groups interviews were conducted with prospective science teachers in a suitable classroom. PSTs were divided into three groups (10-10-9 PSTs) and interviews were conducted with each group one after the other. The interviews were in semi-structured form and took about one hour for each group. The interviews were recorded in the video.

Data Analysis

Data analysis was conducted in two stages depending on the research questions. First, participants' responses about the relationship between the conventional aspects of NOS and the film scenario were analyzed qualitatively. In this way, it is determined which scenario elements (representations) of the film are related to which conventional aspect of the nature of science (1st research question). In qualitative analysis, codes were determined by assigning meaningful units to descriptive and interpreted knowledge. Coding is a process required to reduce and present data, initiating a qualitative analysis and continuing at different stages throughout the analysis (Miles and Huberman 1994). In this study, it is aimed to determine whether there are scenario elements belonging to the film in the explanations of the participants. If there are certain elements of the film in the explanations of the participants, they were tried to be determined. Since it was not possible to obtain a specific code list related to the scenario elements of the film from the literature, codes for determining the elements of the film were obtained inductively from the data (Strauss and Corbin 1998). Significant data units have been open coded. Then the data carrying the same and similar codes were combined and categorized. Thus, codes were combined to form a pattern and more abstract pattern codes (or categories) were obtained (Patton 2002). An exemplary coding process is given in a quotation as follows;

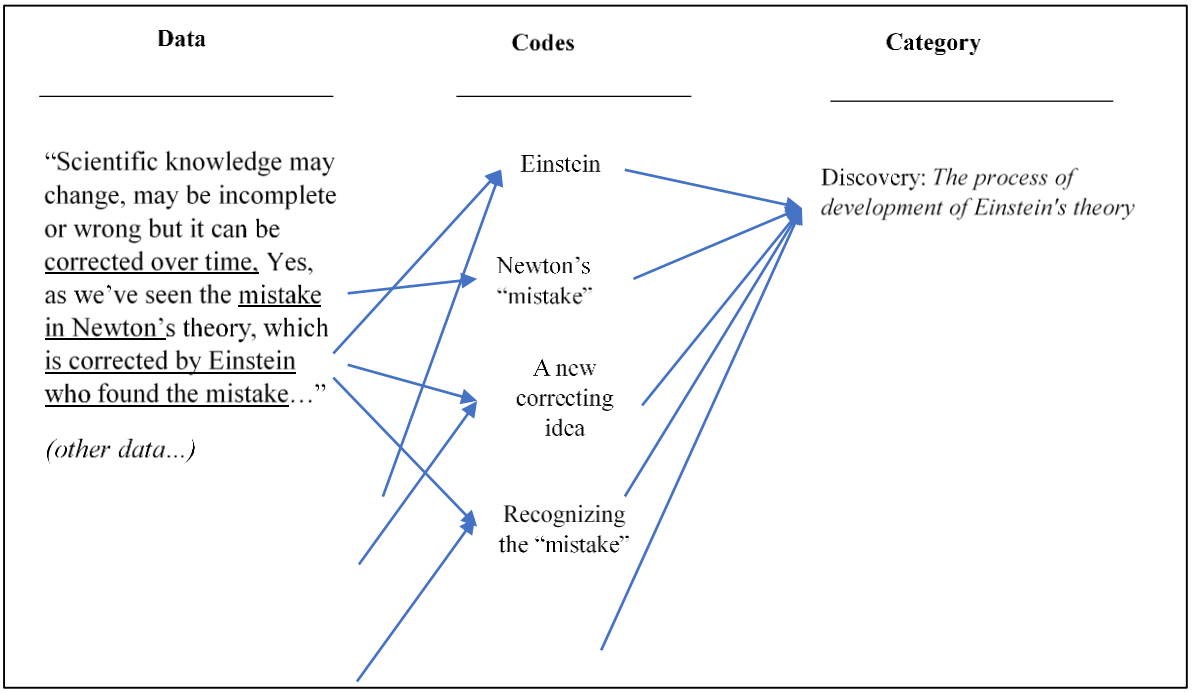

Figure 2. An example of the qualitative analysis

These categories correspond to scenario elements that enable participants to experience the conventional aspects of NOS associated with the film, or corresponds to the representations that participants interpret. In the second stage, a thematic descriptive analysis was performed to understand how the participants interpret these representations (question 2). Descriptive analysis is a type of qualitative data analysis which includes summarizing and interpreting data according to predetermined themes (Yıldırım and Şimsek, 2003). In the descriptive analysis, the themes were determined by taking into account the dimensions of the interview form (conventional aspects of NOS) and the data were organized according to the sub-themes (*interpretations*) obtained under these main themes.

Validity and reliability

The semi-structured interview questions were prepared based on experts' opinions. After the study, qualitative analysis of some of the data (N: 9) were graded by a different researcher. Following these two-independent evaluations, it was observed that there was a complete agreement on quantitative scoring. In the analysis, the concordance in most of the code list was found to be about 93% according to Miles and Huberman (1994)' formula. In addition, in phenomenological studies, it is an important aspect to confirm the findings by returning to participants (Laverty, 2003). Therefore, participants were provided with the opportunity to verify the representations and the themes regarding how they interpret these. This verification was done by presenting the relationships obtained between the scenario elements of the film and the thematic propositions of the nature of science. As a result of this process, some of the relations were revised and rearranged according to the opinions of the participants.

FINDINGS

The findings were given under two headings depending on the research questions;

Scenario elements associated with NOS (Representations)

The scenarios that the participants associate with the nature of science, in other words, elements of the film which represents some aspects of the nature of science according to the participants are given in the table below.

Table 1. Categories of scenario elements obtained from qualitative analysis

Main Categories	Sub-Categories
Discovery (E-1)	The process of development of Einstein's theory Recognizing the anomaly Alternative explanation and process Presenting a new proposal
Reaction (E-2)	British Academy of Science – German University scientists' response Social environment affecting science societies Commitment to current theory
Testing (E-3)	Determination of an experimental method for Einstein's theory by Eddington and positive results of the method Determining methods for new suggestions Observation Success of the proposal
Acceptance (E-4)	Acceptance of Einstein's claims by scientists and others (British Academy of Sciences-German University) Adoption of the result by different scientific societies Universal announcement of the result

The conventional aspects of NOS to which the participants relate these representations are given as follows;

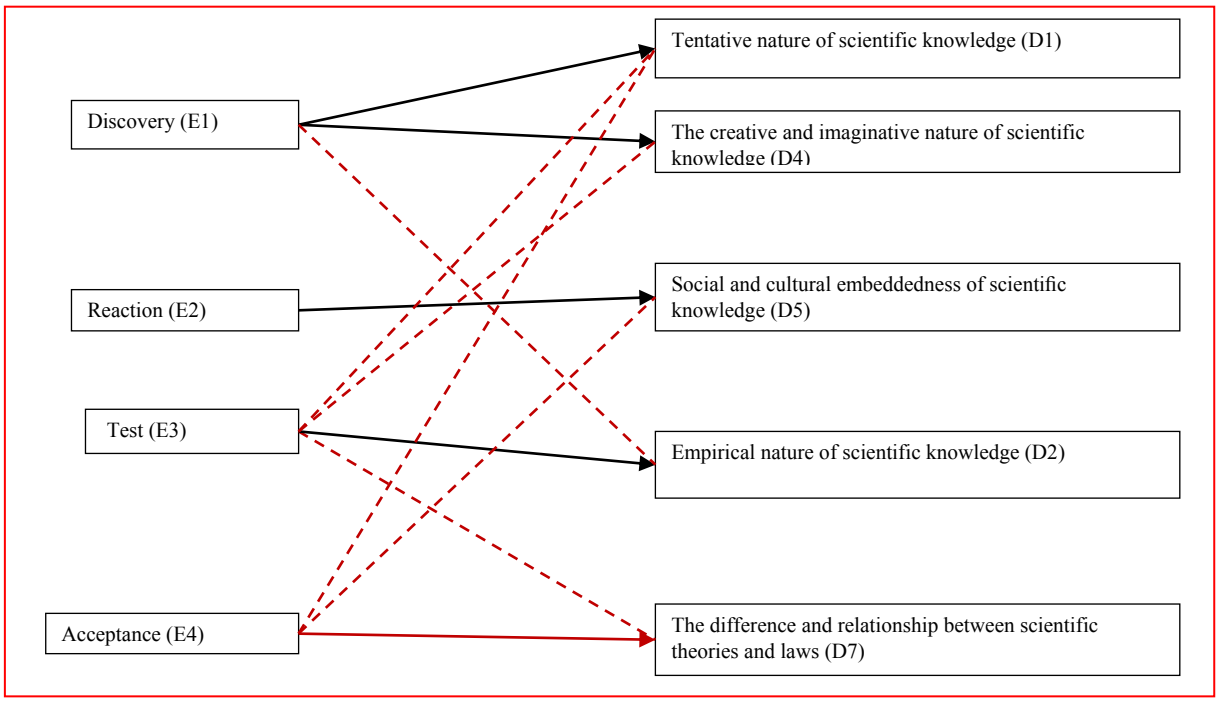

Figure 3. The relationship between representations and conventional aspects of NOS experienced over them

In the figure, the black arrows show that the representation is mostly interpreted as supporting the conventional aspects of NOS, while the red arrows show they are interpreted in a way not to support them. In addition, frequently preferred relationships by the participants were expressed in full arrows, less preferred relationships with dashed arrows.

When the figure is examined, the most effective representation between which a positive correlation is established in conventional aspects of NOS is "Discovery" (*E1. Einstein 's process of developing the theory*). On the other hand, the relationship between the "Acceptance" (*E4. Acceptance of Einstein's claims by scientists and others (British Academy of Sciences-German University*) and D7 has been established frequently with a negative interpretation. In addition, the representation "Test" (*E3. Eddington's experimental method for Einstein's theory to be determined and tested and positive*

results) was also positively associated with more than one NOS aspect. Participants did not make any evaluations in the interviews for other NOS aspects D3 (*Scientific knowledge is subjective and / or theory-laden*) and D6 (*Scientific knowledge is subject to a distinction between observations and inferences)*. This means participants have not experienced any representations in terms of these two aspects of the nature of the science.

Interpretations for representations

Below are the findings on how participants interpret the representations they experienced from the film. The findings are presented with the "interpretation themes" under the main themes (NOS conventional aspects) and quotations. The quotations are coded with Q.

D1. **Scientific knowledge is tentative**

Interpretation 1. *An anomaly recognized in the existing scientific knowledge indicates that scientific knowledge is subject to change and correction.*

According to most of the participants, the most important indicator of the tentativeness of scientific knowledge is the recognition of the "mistake" (with the expression of the participant) / anomaly (Newton) in the current scientific knowledge given in the film and a new alternative scientific proposal (Einstein) (E1). For example;

"Scientific knowledge may change, may be incomplete or wrong but it can be corrected over time, Yes, as we've seen the mistake in Newton's theory, which is corrected by Einstein who found the mistake" (Q1)

Interpretation 2. *Scientific knowledge is eventually universally verified.*

The participants who received a different message from the film, although very few, have interpreted that the change of scientific knowledge was a temporary situation and that it would ultimately come to an unchanging format. The reason for this is that the new alternative proposal is successful when tested (Edington) and it is accepted by everyone (British and German Science Society) (E3, E4). For example;

"There may be times when scientific knowledge should be accepted unchangeably. As we have seen in the film, Einstein's idea, which explained some things about the universe without any doubt, was finally proven and confirmed. Everyone agreed." (Q2)

D4. Scientific knowledge is partly product of imagination and creativity

Interpretation 3. *Creativity as well as imagination can contribute to scientific discovery*

Accordingly, it is seen that the participants were influenced by the presentation of a new alternative scientific proposal in the film (Einstein) and the scenes related to the nature of the discovery process. It is stated that they understand the effect of imagination more clearly (E1). For example;

"…because; to make a scientific suggestion, it is necessary to think creatively and have a good imagination. In science, imagination has also contributed a great deal, Einstein is setting up his theory by imagination and then it is proved. This is something very different." (Q3)

Interpretation 4. *In science, the accuracy of knowledge obtained by imagination can only be determined by logic and method.*

It is seen that a few of the participants have expressed the success of the new alternative proposal (Edington) as it is in the D1 given above (E3). These participants suggest that other skills such as logic and observation are more important in scientific knowledge. For example;

"I think more important than imagination is logic and observation. The theory would be invalid if Einstein's theory had not been proved by observation and experiment." (Q4)

D5. Science is socially and culturally embedded

Interpretation 5. *Wars, forms of government, and ideologies of society can influence scientists' preferences and thus science.*

Most of the participants interpreted the reflection of the war in the film and the reaction of scientists and scientific societies (British Science Academy-German University) (E2) as a signifier of this NOS aspect. For example;

"The social structure of each state is different; it can affect the viewpoints of scientists. People who rule society, rather than the wishes of society, can influence science, it is difficult to be an objective scientist at the time of war. Cultural differences, national feelings and wars can adversely affect science" (Q5)

Interpretation 6. *Although initially influenced by local factors, scientific knowledge can become immediately acceptable and universal by observations and proofs.*

However, a few participants have adopted the view that this situation is temporary and does not have a significant effect on science. According to their explanation, it is seen that the acceptance of the new alternative proposal by everyone (British and German Science Society) at the end of the film (E4) is the reason for this view. For example;

"In my opinion, science, as in the film, should attain the results that everyone would eventually accept. Science is universal. My idea is that even if science is affected (by social and cultural factors) for a while, this effect is eliminated when it comes to a place, it is not affected (by social and cultural factors)." (Q6)

D2. Scientific knowledge has an empirical nature (based on observation of the natural world)

Interpretation 7. *Observation is the best way to demonstrate the correctness of a scientific idea of the working principles of the universe.*

Majority of the participants thought successful testing of the proposal (Edington) as evidence that scientific knowledge is based on observation (E3). For example;

"Einstein theory is first created in the film. It's hard to make people believe it. Couldn't be proved without Eddington's observation. However, this is ensured by appropriate observation" (Q7)

Interpretation 8. *The important thing is that the natural world can inspire people. Observation only indicates the accuracy of this.*

However, few participants interpret Einstein's process of developing the theory (E1) as an indication that scientific knowledge is more pre-observational. For example;

"Observing things is not enough. I think theory does not fully rely on observation, as seen in the film, observation can be made later, and important thing is imagination and thinking well. Because scientific knowledge can sometimes only be revealed theoretically, it does not have to be experimental. Just like Einstein" (Q8)

D7. Scientific theory and the law are different kinds of knowledge

Interpretation 9. *Although the theories and laws are initially different, the theories are sooner or later turn into laws with empirical evidence.*

The majority of the participants commented that positive results of testing (E3) the experimental method and acceptance of Einstein's theory by scientists and other authorities (E4) are the indicators of the idea that scientific theories would eventually have the same nature with the scientific laws. For example;

" A theory could emerge and become law. In fact, some theories cannot be proved; it's the only difference between them. In other words, theories become laws by being proved sooner or later."(Q9)

"If scientists work at the desired level, theories can be like laws. Just like Einstein did,it is more to think and practice. Einstein is a great scientist. Edington's observation results showed everyone that Einstein is right." (Q10)

"If scientific knowledge is proven, for example, if the theory becomes law, it must be the same for everyone and (scientific knowledge) becomes objective through more comprehensive observations" (Q11)

DISCUSSION

The findings of the study supported studies showing that media tools, especially films, can influence attitudes, understanding, perceptions and views related to science (Laprise and Winrich 2010; Sürmeli 2012; Cavanaugh and Cavanaugh 2004; Segall 2002). In this study, the analysis of the film was done through the statements of the participants. The messages that this film gives to a viewer rather than a researcher are examined. In general terms, it can be said that the film gives messages that can be interpreted as meaningful in a positive way for the nature of science aspects accepted in the literature. On the other hand, they also have negative consequences.

When the literature is examined, it is seen that this film is suggested by Kapucu, (2016). Kapucu (2016) emphasized in his study, 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 *(scientific knowledge is tentative; that it includes logical, mathematical, and empirical inferences; that it is subjective; that it is partly the product of human imagination and creativity; and that it is influenced by social and cultural factors).* Although the findings obtained in this study are not for formal education, they seem to support Kapucu (2016)'s prediction partly.

Considering the positive interpretations, it can be said that some parts of the scenario are effective. For example, the scenario representations for *process of the discovery* (E1) and *social reaction* (E2) are frequently seen in the positive views of the participants. However, it is also clear that the scenario causes negative interpretations (e.g. acceptance (E4)). From this point of view, it can be

thought that the two factors are effective on negative interpretations. Primary factor is the fictional nature of the film scenario and the seconder factor is misconceptions and mythical acceptances of the participants.

The fictional character of the scenario

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, the lack of a direct formal effect while watching the film may have caused informal effects. Therefore, it can be said that the participants received different messages on the same scenario. For example, it can be seen that some of the participants drew a different interpretation in context of D4. *Scientific knowledge includes imagination and creativity"*- by focusing on a different message depending on the scenario of the film (e.g.A4).

It is also possible that one of the reasons for the interpretation on the film's scenario is the effect of well-known character (Einstein) in the film. According to the findings, it is seen that in the themes for the changing views related to the NOS and in the participant quotations, individuals focus on this scientist who they know from textbooks or other sources. This situation caused participants to be more willing to accept the ideas of this character. In short, the influence of the characters in the film increases the acceptability of the message given over them. For example, this is observed in the following descriptions. (e.g. A10).

On the other hand, another reason could be the historical section given in the film. The limitation of the historical section given in the film or reconstructed form of the story may have a negative effect on the views of the participants about the features of science. It is seen that the story which is about the process of the discovery, the presentation, testing and widespread acceptance of a theory, leads to unintended interpretation about the aspects of the nature of science (e.g.A6).

Therefore, the findings indicate the importance of historical context. A holistic approach should be adopted in preparing the historical context of the activities for the teaching of NOS. Thus, desirable interpretation can be achieved in all dimensions of NOS. Otherwise, while a desired result in one aspect of NOS can be achieved, undesirable results can be reached on the other aspects. Someone who considers imagination as an important and desirable factor in science may oppose to another intended view with the effect of the limitation of historical context. (e.g. A8).

Possible pre-mythical assumptions / misconceptions

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 of science (McComas, 1996; 1998). According to the view of the participants who reached to only negative interpretation about the conventional aspects of the NOS (D7), theories and laws were in an evolutionary relation throughout historical process rather than they are different types of knowledge (e.g.A9).

The participants have come to an unintended and profound conclusion that *"an observation supporting a theory turn theory into a law"* since there is no explicit guiding about the difference between theory and law. This shows that the classical misunderstanding or myth (McComas, 1996; 1998) "theories become law over time" is hidden in the explanations. In short, the fact that participants accept these two types of knowledge differently does not mean they accept the idea that theories and laws will not turn into each other. Also, point is that such a misconception arising from the

misunderstandings in concepts such as theory, hypothesis and law affects other interpretation as well (e.g.A11).

CONCLUSION AND IMPLICATION

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 didactic 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.

In this context, the first thing that comes to mind is that the use of such films in teaching the nature of science may be appropriate to use in the context of a more structured method to avoid misleading subjective interpretations. Thus, it is stated that the film contributes to conventional understandings of NOS in the activities prepared within the scope of some studies related to the nature of science (Özcan 2013; Yenice, 2015). In this respect, results of the study are in line with the literature. However, it is difficult to say that this film, which was examined by Kapucu (2016), is a good teaching tool, although it is recommended for the teaching of the nature of science. At best, it can be used by comparing with real historical sources. This use may also contribute to participants' skills in media literacy and critical thinking in the context of the nature of science in addition to developing understanding of the nature of science through film criticism. The use of the film as an instructional material can cause many problems if it is not integrated into a structured teaching environment.

However, some scenario elements (representations) appear to have the potential to give positive messages about NOS. Considering the fact that not cinema films but some short documentaries are effective in teaching NOS (Seçkin Kapucu, Çakmakçı and Aydoğdu, 2015). It is possible to use the scenario sections corresponding to the representations obtained in this study (e.g. E1, E2) more effectively in a suitable teaching environment. However, the integrity of the historical context must be ensured in a way as stated above.

Beyond that, there are some questions that come to mind even if such films are used in a teaching process where these limitations are formally exceeded. For example, even if it is a biography, should a historical story in a certain period of time be given as it is? Or should a historical story with fictions be used? The answer to the first question may be yes if the good examples from real history of science are chosen and used in continuously. As a matter of fact, the absence of a story about what happened before and after the historical section, as seen in the findings, caused the science myths in individuals.

On the other hand, it is necessary to be selective in the preferred history of science. Hence, as Allchin (2003) expresses, many historical narratives are influential in myth formation and share a rhetorical myth structure 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. A positive answer to the second question requires more attention in the selection of history of science. Because if the concepts presented through combination of science and fiction have some wrong aspects, there can be seen unintended effects (Dhingra 2003).

For both preferences, using the history of science in the philosophical discussion environments of contemporary teaching methods can give positive results. These philosophical discussions about science lead students not only to understand concepts but also to develop their ability to think critically and analyze the world (Settlage 2007). To overcome this handicap, students 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 and Coskrey 1990). Furthermore, the nature of science understandings given in the propositional form in the teaching environments can be misleading. What is essential is to

make sure that the content of formal acceptances should be justified with examples. Therefore, it is also possible to give concepts related to the nature of science through historical films. This approach can be used, similar to the integrated approach expressed by Niaz (2016), with the integration of reflective approach (Duschl and Grandy 2012) and the historical approach (Khishfe and Abd-ElKhalick 2002) in which films are used.

Lastly, for the 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). As seen in the findings (figure 3), the discovery category (E1) had a positive interpretation of the NOS of the participants, while the test category (E3) had a negative interpretation. In fact, these categories correspond to an important distinction highlighted in the philosophy of science. According to Reichenbach (2006) in order to understand science from a methodological point of view, it is necessary to separate the contexts of discovery and justification. Therefore, it is advised to take into account this distinction while developing activities to teach the nature of science. On the other hand, it can be argued that there may be advantages and disadvantages depending on the use of the elements of the history of science (e.g. E1 vs. E4). In this respect, the use of the history of science in a structured way can open the door to possible methods which can eliminate disadvantages and make advantages more effective. In summary, the 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.

All of these implications can be valid not only for films but also for textbooks or popular science history books. Research results showed that it is necessary to be careful in the use of history of science. It is clear that a holistic and relational history of science reading is required.

REFERENCES

Abd-El-Khalick, F. & Lederman, N.G. (2000). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching, 37*(10), 1057-1095.

Allchin, D. (2003), Scientific myth-conceptions. *Sci. Ed., 87*, 329–351. https://doi.org/10.1002/sce.10055

American Association for the Advancement of Science [AAAS]. (1990). *Science for all Americans. A Project 2061 Report.* New York: Oxford University Press.

American Association for the Advancement of Science [AAAS]. (1993). *Benchmarks for science literacy: A Project 2061 Report*. New York: Oxford University Press.

Barnett, M., Wagner, H., Gatling, A., Anderson, J., Houle, M. & Kafka, A. (2006). The impact of science fiction films on student understanding of science. *Journal of Science Education and Technology. 15* (2), 179-191. https://www.learntechlib.org/p/166420/.

Bixler, A. (2007). Teaching evolution with the aid of science fiction. *The American Biology Teacher, 69*(6), 337-340. https://doi.org/10.1662/0002-7685(2007)69[337:TEWTAO]2.0.CO;2

Cavanaugh, T.W. & Cavanaugh, C. (2004). *Teach science with science fiction films: A guide for teachers and library media specialist.* Worthington, Ohio: Linworth Publishing, Inc.

Çakmakcı, G. (2017). Using video vignettes of historical episodes for promoting pre-service teachers' ideas about the nature of science. *Science Education International,28 (1)*,7-29.

Dale, E., Fannie W. D., Charles F. H., Jr. & Etta, S. (1937). *Motion pictures in education: a summary of the literature, Source book for teachers and administrators*. New York: The H.W. Wilson Company, 1937.

Denzin, N. K. & Lincoln, Y. S. (Eds.). (2000). Handbook of qualitative research (2nd ed.). Thousand Oaks, CA: Sage.

Dhingra, K. (2003). Thinking about television science: How students understand the nature of science from different program genres. *Journal of Research in Science Teaching, 40*(2), 234–256. https://doi.org/10.1002/tea.10074

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

Duschl, R. & Grandy, R. (2012). Two views about explicitly teaching nature of science. *Science & Education, 22,* 2109-2139.http://www.bu.edu/hps-scied/files/2012/10/Duschl-HPS-Two-Views-on-Explicitly-Teaching-NoS.pdf

Gerber, B. L. & Marek, E. A. (2001). Development of an informal learning opportunities assay. *International Journal of Science Education, 23* (6), 569-583.

Irzik, G. & Nola, R. (2011). A family resemblance approach to the nature of science for science education. *Science & Education, 20*(7-8), 591-607.

Jarvie, I. C. (1970). *Movies and society*, New York: Basic Books, Inc. https://anthrosource.onlinelibrary.wiley.com/doi/pdf/10.1525/aa.1972.74.6.02a00170

Kapucu, S.M. (2016). An examination of the documentary film "Einstein and Eddington" in terms of nature of science themes, philosophical movements, and concepts. *International Journal of Progressive Education, 12* (2), 34-46. http://www.inased.org/v12n2/ijpev12n2.pdf

Khishfe, R. & Abd-El-Khalick, F. S. (2002). Influence of explicit and reflective versus implicit inquiry oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching, 39*(7), 551–578. https://doi.org/10.1002/tea.10036

Laverty, S. M. (2003). Hermeneutic phenomenology and phenomenology: a comparison of historical and methodological considerations. *International Journal of Qualitative Methods 2* (3), 21–35. https://doi.org/10.1177/160940690300200303

Laprise, S. & Winrich, C. (2010). The impact of science fiction films on student interest in science. *Journal of College Science Teaching,* 40 (2),45-49.

Lederman, N. G. (2007). Nature of science: past, present, and future. In Abell, S. K., & Lederman, N. G. (Eds.), *Handbook of research on science education* (pp. 831-879). London: Lawrence Erlbaum Associates.

Lederman, N.G., Abd-El-Khalick, F., Bell, R.L. & Schwartz, R. (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. https://doi.org/10.1002/tea.10034

Lin, H. & Chen, C. (2002). Promoting preservice chemistry teachers' understanding about the nature of science through history. *Journal of Research in Science Teaching, 39*(9), 773–792.

Logan, R. A. (2001). Science mass communication. *Science Communication, 23*(2), 135– 163. http://journals.sagepub.com/toc/scxb/23/2

Martin, P. (Director). (2008). *Einstein and Eddington*. UK: BBC.

Matthews, M.R. (2015). *Science teaching: the contribution of history and philosophy of science* (20th anniversary revised and expanded edition). New York: Routledge

McComas W.F. (1998) The Principal elements of the nature of science: dispelling the myths. In McComas W.F. (eds) *The nature of science in science education*. Science & Technology Education Library, vol 5. Springer, Dordrecht

McComas, W. F. (1996), Ten myths of science: re-examining what we think we know about the nature of science. *School Science and Mathematics, 96,* 10–16. https://doi.org/10.1111/j.1949-8594.1996.tb10205.x

McComas, W.F., Clough, M.P. & Almazroa, H. (1998). The role and character of the nature of science in science education. In McComas (Ed.) *The Nature of science in science education: rationales and strategies* (3-39), The Netherlands: Kluwer Academic Publishers.

Moylan, T. (2018). *Scraps of the untainted sky; science fiction, utopia, dystopia.* (1st Ed.) New York: Routledge

Moustakas, C. (1994). *Phenomenological research methods.* Thousand Oaks, CA: Sage

Miles, M. B. & Huberman, A.M. (1994). *Qualitative data analysis: an expanded sourcebook*. (2nd ed.). Calif.: SAGE Publications.

Ministry of Turkish National Education [MONE] (2005). *İlköğretim fen ve teknoloji dersi (4. ve 5. sınıflar) öğretim programı*. [Elementary science and technology course (4th and 5th Grades) Curriculum]. Ankara: Millî Eğitim Bakanlığı Yayınları

Ministry of Turkish National Education [MONE] (2006). *İlköğretim fen ve teknoloji dersi (6,7. ve 8. sınıflar) öğretim programı.* [Elementary science and technology course (4th and 5th grades) Curriculum]. Ankara: Millî Eğitim Bakanlığı Yayınları

National Research Council [NRC]. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. [NRC]. (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: National Academy Press.

National Research Council. [NRC].(2013) *Next generation science standards: for states, by states.* Washington, DC: The National Academies Press. https://doi.org/10.17226/18290.

National Science Foundation, [NSF]. (2000). *Indicators: Science and Engineering 2000.* Washington, DC: National Science Foundation.

Niaz, M. (2016). History and philosophy of science as a guide to understanding nature of science. *Revista Científica, 24,* 7-16. https://doi.org/10.14483/udistrital.jour.RC.2016.24.a1

O'Connor, E. J. (1987) *Teaching history with film and television.* American Historical Association

Özcan, H. (2013). Fen bilgisi öğretmen adaylarının fen içeriği ile ilişkilendirilmiş bilimin doğası konusundaki pedogojik alan bilgilerinin gelişimi. *Unpublished Master Thesis.* Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara

Öztürk, Ö.F. (2017). The impact of science-fiction movies on the self- efficacy perceptions of their science literacy of science teacher candidates. *Educational Sciences:Theory & Practice, 17* (5), 1573-1603. https://doi.org/10.12738/estp.2017.5.0058

Patton, M.Q. (2002). *Qualitative research and evaluation methods* (3rd Ed.). London: Sage Publications, Inc.

Reichenbach, H. (2006). *Bilim felsefesinin doğuşu.* [The rise of scientific philosophy] (Trs.C. Yıldırım), Ankara: Bilgi Yayınevi. (The original of the work was published in 1951).

Robertson, J. P. (1995). Screenplay pedagogy and the interpretation of unexamined knowledge in pre-service primary teaching: Taboo. *The Journal of Culture and Education 1,* 25–60.

Schwab, J. (1964). The structure of the natural sciences. In Ford, G.W., Pugno, L. (eds.) *The structure of knowledge and the curriculum.* Chicago: Rand McNally.

Segall, A.E. (2002). Science fiction in the engineering classroom to help teach basic concepts and promote the profession. *Journal of Engineering Education,* October 419-423. https://doi.org/10.1002/j.2168-9830.2002.tb00727.x

Settlage, J. & Southerland, S. (2007). *Teaching science to every child: using culture as a starting point.* Taylor & Francis Group, LLC.

Seckin Kapucu, M., Cakmakci, G. & Aydogdu, C. (2015). The influence of documentary films on 8th grade students' views about nature of science. Educational Sciences: *Theory & Practice, 15*(3), 797- 808.

Shaw, D.G. & Dybdahl, C.S. (2000). Science and the popular media. *Science Activities*, 22-31, Summer.

Smith, M. U., Lederman, N. G., Bell, R. L., McComas, W. F. & Clough, M. P. (1997). How great is the disagreement about the nature of science? A response to Alters. *Journal of Research in Science Teaching, 34*(10), 1101-1103.

Smith, M.U. & Scharmann, L.C. (1999). Defining versus describing the nature of science: A pragmatic analysis for classroom teachers and science educators. *Science Education, 83*, 493-509.

Smith, V., Scott, J. & Coskrey, W. (1990). *Teaching the science in science fiction.* Annual meeting of the American association for the advancement of science. New Orleans, LA, February 15-20.

Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: techniques and procedures for developing grounded theory.* Thousand Oaks, CA: Sage Publications, Inc.

Sürmeli, H. (2012). Examination the effect of science fiction films on science education students' attitudes towards STS Course. *Procedia- Social and Behavioural, 47,* 1012–1016. https://doi.org/10.1016/j.sbspro.2012.06.771

Tan. C. (2006). Philosophical reflections from the silver screen; Using films to promote reflection in pre-service teachers. *Reflective Practice, 7* (4), 483-497.

Trier, J. (2002). Exploring the concept of "habitus" with preservice teachers through the use of popular school films. *Interchange, 33* (3), 237-260. https://link.springer.com/article/10.1023/A:1020941318001

Vidal, F. (2018). Introduction: from "the popularization of science through film" to "the public understanding of science". *Science in Context 31* (1), 1-14. https://doi.org/10.1017/S026988971800008X

Yenice,N. (Ed.) (2015). *Bilimin doğasının gelişimi ve öğretimi* [Development and teaching of nature of science], Ankara: Anı Yayıncılık

Yıldırım, C. (1985). *Bilim felsefesi* [Philosophy of science]. İstanbul: Remzi Kitabevi.

Yıldırım, A. ve Şimşek, H. (2013). Sosyal bilimlerde nitel araştırma yöntemleri (9. Baskı). Ankara: Seçkin.