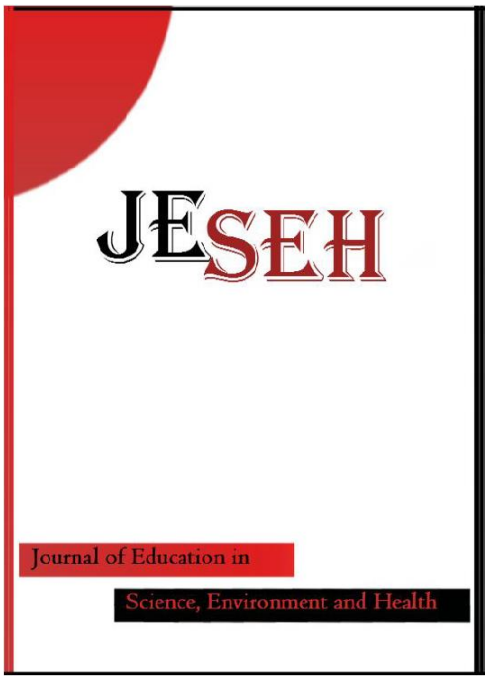

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Use of Biographical Recount of Famous Scientists to Enhance Scientific Literacy for New Pre-Service Primary Science Teachers at the Lebanese University

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Abstract

The preparation of scientifically literate citizens able to use science in their daily life is becoming a major goal in science education. In light of this, Boujaoude (2002) developed a framework to investigate the balance of scientific literacy themes within the Lebanese school science curriculum. He reported the neglect of "science as a way of knowing" in the Lebanese science curriculum and national textbooks. The purpose was determining the perception of pre-service primary science teachers, at the Lebanese University- Faculty of Education, of science and scientists, and examining their scientific literacy according to BouJauode (2002) framework. In addition, the study investigated whether the use of biographical recounts of famous scientists would enhance scientific literacy, and promote science as "a way of knowing" in classrooms. It was found that participants perceived science mainly as a body of knowledge, and that the implementation of the biographical recount activity exposed them to other aspects of science, and helped them enhance their scientific literacy.

Key words: Scientific literacy, Perception of scientists, Pre-service primary science teachers, Biographical recount of famous scientists

Introduction

Science educators around the world are currently trying to switch the emphasis of science education from the focus on academic scientific education within schools to the application of science in everyday life. Therefore, the preparation of scientifically literate citizens able to use science in their daily life and to take related decisions is becoming a major goal in teaching and learning science (BouJauode, 2002). The call for the reforms has led to an international effort aiming to promote scientific literacy as a major goal and outcome of science education in various countries around the world (Bybee, 2008).

Scientific Literacy

The term "scientific literacy" includes a wide variety of different definitions in the literature. It was first introduced in science education by Hurd (1958), who expressed a deep concern of how fast the world was changing and the urgent need of a new approach to education. The author emphasized on the quick change and developments in science and technology. The necessity to educate children adequately to enable them to meet the challenge and become good citizens living in a society full of scientific and technological advancements, by providing them with the necessary knowledge and skills. Hurd (1958) addressed the gap between scientific achievement and scientific literacy. He reported that the problem lies within the fact that scientific achievement was high, but scientific literacy was poor among students. Although Hurd introduced the concept of scientific literacy, he did not provide a clear definition for it.

Since the 1960s, the main focus of science education has become to educate people to be aware of scientific and technological developments. Many efforts have been exerted, to cite only, "Science for All Americans" (American Association for the Advancement of Science [AAAS], 1989) and "Benchmarks for Science Literacy" (AAAS, 1993) that were the products of one of the most important projects in USA, known as Project 206. They considered scientific literacy as a main goal for science education and initiated reform in science education. In addition, The National Science Education Standards (National Research Council [NRC], 1996) contributed to the reform in science education by setting the standards for achieving scientific literacy.

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During the 1970s and early 1980s, scientific literacy came to be even more strongly identified with science in its social context (DeBoer, 2000). In his historical review about scientific literacy, DeBoer (2000) concluded that there are many ways to reach scientifiy literacy; and the main outcome of scientific literacy is to lead students to find something interesting in science, and continue to study science both formally and informally in the future. The author added that scientific literacy changes and grows over time, and it primarily exists in the adult population. He stated that "few if any students can be said to be "scientifically literate" upon graduation from high school in any meaningful sense of the word. At best, students have been introduced to science and the issues that science raises in society, and they like science and care enough about it to stay informed as adults"(p. 597-598).

The science education community has no consensus about the definition of scientific literacy (Laugksch, 2000). Roberts (2007) discusses that although scientific literacy has been defined as a goal of science education, there is no agreement about its meaning and implication. He outlined two visions of scientific literacy: the first emphasizes on students' understanding of human affairs like a scientist does, and the second includes citizen understanding of science and the scientific investigation.

Nowadays researchers and science educators consider scientific literacy as multidimensional concept including science concepts and ideas, the nature of science, and the interaction of science and society (Laugksch, 2000). Dani (2009) considered that a scientifically literate person can identify scientific issues underlying national and local decisions, and express positions that are scientifically and technologically informed, while being able to evaluate the quality of scientific information on the basis of their source and the methods used to generate them. Holbrook and Rannikmae (2009) have examined the concept of scientific literacy within two major camps: the first one focusses on the knowledge of science, and builds on the notion that the content of science is a crucial and essential component of scientific literacy. This view is very common among science teachers today. Whereas the second point of view among researchers focusses on the longer term view; as it sees scientific literacy as a requirement for any individual in the society to be able to adapt to the challenges of a rapidly changing world. This view of scientific literacy aligns with the development of life skills.

The Program for International Student Assessment PISA (2015) targeted scientific literacy, and assessed how well 15 year-old students from over 80 countries were prepared for life beyond the classroom. PISA defines Scientific Literacy as the ability to engage in science-related issues, and in the ideas and concepts of science, as thoughtful and reflective citizens. Therefore, a scientifically literate person is someone who is willing to engage in the world of science and technology, which requires the development of three competencies: "Explain phenomena scientifically" **(**recognize, offer and evaluate explanations for a range of natural and technological phenomena); "Evaluate and design scientific enquiry" (describe and appraise scientific investigations and propose ways of addressing questions scientifically) and "Interpret data and evidence scientifically" (analyze and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions).

Chiapetta, Sethna, and Fillman (1993) proposed four dimensions or themes for scientific literacy: Science as a way of thinking, science as a way of investigation, science as a body of knowledge, and science and its interaction with technology and society. Based on these four dimensions, BouJauode (2002) developed a framework that includes four characteristics or aspects of science literacy: aspect 1 the knowledge of science, Aspect 2 the investigative nature of science, Aspect 3 science as a way of knowing, and Aspect 4 the interaction of science, technology and society.

Scientific literacy in the Lebanese educational system

The general objectives of the Lebanese science curriculum highlight the importance of conceptual and procedural components of science. It stresses on the understanding of scientific concepts and their implications to everyday life (National Center for Educational Research and Development, 1995). BouJaoude (2002) conducted an analysis of the Lebanese science curriculum to investigate the balance of scientific literacy themes within it, as well as its potential to prepare scientifically literate citizens. He used the four aspect framework he developed and found great emphasis in the Lebanese curriculum on the knowledge of science" (Aspect 1), "the investigative nature of science" (Aspect 2), and the "interactions of science technology, and society" (Aspect 4), and a neglect to the third aspect of the framework, which is "science as a way of knowing" (2002, p. 153). The author claims that the curriculum's emphasis on the "interaction of science, technology, and society" holds a potential for the development of decision-making citizens who use scientific knowledge meaningfully in their lives. However, he cautions, "Teaching, assessment, and the quality of textbooks used are also important factors

that need to be considered if students' experience with science is to be complete and fulfilling" (BouJaoude, 2002, p. 154).

Dani (2009) examined Lebanese teachers' purposes for teaching science against the backdrop of BouJaoude's (2002) framework of scientific literacy. The author interviewed eight intermediate and secondary Lebanese science teachers, five males and three females, conducted classroom observations, and collected various artifacts such as lesson plans and classroom handouts. The results of his study showed that participants' purposes for teaching science corresponded with the aspects of "the knowledge of science," "the interaction of science, technology, and society," and "the investigative nature of science" aspects of scientific literacy described by BouJaoude. In addition, all participants considered that the national textbooks and exams facilitate the operationalization of their "knowledge of science," and "investigative nature of science" goals since these documents emphasize on these two aspects of scientific literacy. These results reflect the aspects of scientific literacy emphasized in the Lebanese science curriculum as reported by BouJoaude (2002).

In an unpublished thesis, Miski (2013) measured the scientific literacy of Lebanese grade 10 students on the basis of PISA framework. The study included 14 students from public and private high schools in Beirut. Miski reported that students were able to "explain phenomena scientifically" and to "interpret data and evidence scientifically", however the competence of "evaluate and design scientific enquiry" was not developed.

Research Problem

Being an Assistant Professor at the Lebanese University, Faculty of Education, in the Science Education Department, the research conductor of the current study has noticed over years of instruction that pre-service teachers in science department perceived science as mainly being a body of knowledge, ignoring the procedural aspect of science. It is well believed that teachers are one of the most important factors that play a key role in promoting scientific literacy. Therefore, they must be well prepared in both science subjects and science teaching education. Thus, they must have a thorough understanding of the implication of science in society and of the current technological advances affecting society every day. In this vein, Shulman (1987) stated that the role of teachers is crucial in promoting science literacy in both schools and society, and therefore research on teachers' education suggests that both teachers' subject matter knowledge and teachers' pedagogical knowledge are crucial to good science teaching and student understanding.

Consequently, scientific literacy requires, to be achieved, more than teaching and learning science as a body of knowledge. In fact, developing it requires a wider view of science where three principal components are included: the knowledge of science, the methods of science, and the nature of science (Lederman, 1998). Unfortunately, candidates entering the pre-service science teaching program at the faculty of Education at the Lebanese University are mainly exposed to science as body of knowledge during their academic journey, and this is mainly due to the lack of an epistemological view in the Lebanese Science curriculum (BouJauode, 2000). For these reasons, the purpose of this study was first to determine the scientific literacy of new candidates of pre-service science teaching program at the Lebanese University, Faculty of Education, according to BouJauode's (2002) framework, and also to investigate possible ways of promoting science as "a way of knowing" in classrooms. This aspect of scientific literacy was featured by the framework as being where the emphasis is on thinking, reasoning, and reflection in the construction of scientific knowledge and the work of scientists which includes all the mental and experimental activities of "doing Science" (see table 1).

Biographical recounts of famous scientists were chosen as a way to promote "science as a way of knowing". The main reason behind the use of the biographical recounts activity, was that searching the life and main achievement of scientists will allow the exploration of the main components of "science as a way of knowing". Through biographical recounts, students would be exposed to the work of scientists, how they detect problems, use assumptions, test their ideas and find evidence; and thus students will be able to explore the empirical nature of science. The following specific research questions were addressed:

1- How do pre-service science teachers, namely first year students' of primary science teaching program at the Lebanese University, Faculty of Education perceive "Science" and "Scientists"?
2- Does their "science" perception correspond with the four aspects of scientific literacy presented in BouJauode (2002) framework?
3- Does the use of biographical recount of famous scientists promote the development of scientific literacy, and mainly the development of "science as a way of knowing" aspect of scientific literacy?

It is assumed that through the "Biographical recounts of famous scientists" activity, scientific literacy would be enhanced, especially the aspect of "science as a way of knowing". It is also suggested that this sort of activity does not develop the skills of science as "way of knowing", but rather promotes awareness among students regarding this aspect of scientific literacy, since it is completely denied and neglected in the curriculum and the practice.

Method

The framework developed by BouJauode (2002), presented in table 1, was used to find out the degree of congruence between the participating pre-service science teachers' perception of science, and aspects of scientific literacy, as well as to investigate the effect of the use of biographical recounts of famous scientists in promoting scientific literacy i.e. mainly the "science as a way of knowing" aspect, which was reported as neglected in previous studies.

Table 1. BouJaoude (2002) framework of scientific literacy

Aspects of scientific literacy	Components
Aspect 1: The knowledge of science	• Facts, concepts, principles, laws, hypotheses, theories, and models of science.
Aspect 2: The investigative nature of science	• Using methods and processes of science such as observation, measuring, classifying, inferring, recording and analyzing data; • Communicating using a variety of means such as, writing, speaking, using graphs, tables, and charts; • Making calculations; • Experimenting.
Aspect 3: Science as a way of knowing	• Emphasis on thinking, reasoning, and reflection in the construction of scientific knowledge and the work of scientists; • Empirical nature of science Ensuring objectivity in science; • Use of assumptions in science Inductive and deductive reasoning; • Cause and effect relationships; • Relationships between evidence and proof; • Role of self-examination in science; • Describes how scientists experiment.
Aspect 4: Interaction of science, technology, and society	• Impact of science on society; • Inter-relationships between science, society, and technology; • Careers Science-related social issues; • Personal use of science to make everyday decisions, solve every- day problems, and improve one's life Science related moral and ethical issues.

The framework was used by Lebanese researchers to investigate scientific literacy such as Dani (2009) and by international researchers such as Cansiz and Turker (2011), who investigated the Turkish science and

technology curriculum for the balance of scientific literacy (SL) aspects, and its potential to educate scientifically literate citizens.

Sample

Participants consisted of a convenient sample of 25 first year students of pre-service primary science teaching program at the Lebanese University Faculty of education, where English and French are the languages of instruction. They all hold Lebanese baccalaureate degrees in "Life Science" or "General Science", coming from both private and public high schools in Lebanon. The primary science teaching program at the Lebanese University Faculty of Education consists of a three years full time course, equivalent to six semesters. The study was conducted during the first semester of the first year; so all students were still new to the educational program provided by the Faculty of Education, and therefore their perceptions of science were not yet influenced by the content of the program offered by the teacher training program.

Data Collection and Analysis

In order to explore the perceptions of science and scientists, and before the intervention of biographical recounts of scientists, participants were interviewed, in writing, about their perceptions of

- "Science" by answering the question "what is science?"
- "Scientists" by drawing a scientist of their choice, and answering questions about that scientist, specifying his/her gender, social status, family life, social life and work.

In addition, they were also asked

- Do you think you can be a scientist? Explain why.
- Do you like to become scientists? Explain why.
- Where did you get your information about scientists?

Then, participants were asked to research the biography of famous scientists (scientists who have made major contributions in biology e.g. Claude Bernard, Gregor Mendel, Louis Pasteur and many others) by following a detailed biographical recount template provided by the researcher, focusing on the personal life of the scientist (childhood, teenage, social status), education, major events that affected the scientist's career, and major achievements with all the details provided throughout their work.

Students worked in teams and presented their work in class. After around two weeks of presentations and discussions, they were asked to reflect on their work and answer the following questions:

- Being a pre-service science teacher, what did you learn from this experience about Science and scientists?
- Participants' perceptions about science before and after the intervention were analyzed and classified as belonging to Aspect 1, Aspect 2, Aspect 3, and Aspect 4, then the frequencies and percentages of each aspect of scientific literacy were computed.

Results and Discussion

Before the Intervention

Participants' Perceptions of Scientists

80% of participants perceived the scientist as male, not married, not ready to have a family life, and not engaging in any social or political activities; they drew male scientists, wearing goggles and white coats in labs; 84% of them believed that scientists spent all their life in their laboratories. Figure 1 represents a sample of the participants' drawings of a scientist.

Figure1. Sample of participants' drawings

All participants considered it is very hard to be a scientist. Some of them attributed it to the fact that scientists are born with special talents

> I can't be a scientist…a scientist is a very talented person

others believed that they can't, because they don't have the skills and competencies that enable them to be scientists

> I can't be a scientist… scientist have special skills and competencies

another reason stated by the participants was the scientist's imagination

> it is impossible to become a scientist, he has a wide imagination.

As for the question about whether they would like to become scientists, 10 participants out of 25 (40%) didn't like to be scientists and considered that a scientific career would affect their social and marital life, e.g.

> I wouldn't like to ignore myself or my social life"; "I want to have a normal life"; "I love my life and my family, I don't want to be isolated in lab.

4 participants (16 %) liked to become scientists

> I like to become a scientist and work on new inventions, the work of a scientist does not affect his life"; " I like to be a scientist..";" I think it is not hard to be a scientist if I have specific conditions like knowledge and expertise and I should love to be a scientist.

11 participants (44 %) were hesitant about this questions and their answers varied between "not sure" and "don't know". All participants agreed that the main source of information about scientists was media and science textbook.

Participants' Perceptions of Science

In this study, the perceptions of participants were classified as belonging to Aspect 1, Aspect 2, Aspect 3, and Aspect 4, and then the frequencies and percentages of the each aspect of scientific literacy were tabulated. The overall distribution of percentages of participants' perception about science with regards to the four aspects of scientific literacy is shown in Table 2.

Table 2. Distribution of percentages of participants' perceptions about science with regards to the four aspects of scientific literacy

Perception of Science			
Aspect 1 Knowledge of science	Aspect 2 Investigative nature of science	Aspect 3 Science as a way of knowing	Aspect 4 Interaction of science, technology and society
72%	20%	16%	12%

It was found that the knowledge of science (Aspect1) is overemphasized when compared to the other three aspects. The Investigative nature of science (Aspect 2) is fairly emphasized, while science as a way of knowing (Aspect 3) and "interaction of science, technology and society" (Aspect 4) were underestimated.
The distribution of percentages of participants' perceptions about science in regards to single or combined aspects, as well as samples of the participants' answers are shown in table 3.

Table 3. Distribution of percentages of participants' perceptions, and answers samples about science in regards to single or combined aspects.

Aspects	Percentage	Samples of Participants answers
1	56%	- "Laws and theories that deals with physics, chemistry and biology." - "Study of animal, plants and human." - "Knowledge of anything surrounding us."
1 + 2	4%	- "Study and observation of living things surrounding us."
1+3	8%	- "Study to explain and understand what is going on around us." - "Study to understand"
1+4	4%	- "Knowledge and study of the interaction between organism and its surrounding"
2	12%	- "Experiment." - "Validation of hypothesis and observation."
2+3	4%	- "Experimentation and Discovery"
2+4	0%	
3	4%	- "Study of relationships/cause and effect"
3+4	0%	
4	8%	- "Respond to our needs"
2+3+4	0%	
1+2+3+4	0%	

The table above shows that the majority of participants' answers displayed a single aspect of science, with a predominant percentage, 56%, of Aspect 1 representing "knowledge of science, whereas the percentages of Aspect 2 "Investigative nature of science", Aspect 3 "Science as a way of knowing" and Aspect 4 "Interaction

of science, technology and society" were respectively 12%, 4% and 8%. However, for answers displaying more than one aspect of scientific literacy, they all included only two aspects, with predominance of Aspect 1: answers including Aspect 1 with Aspect 2 make 4%, 8 % for Aspect 1 and Aspect 3 and 4% for Aspect 1 with Aspect 4. Only 4 % of answers included two aspects different from Aspect 1 which are Aspect 2 and Aspect 3. None of the answers included three aspects or the four aspects combined together. These findings indicate that the participants perceived science in a single dimension, so they were not aware of the multi-dimensional feature of science.

After the Intervention

Participants' Perceptions of Scientists

Interviews were conducted with all the participants about whether they can and like to be scientists.
17 out of 25 (68%) considered that scientific skills and competencies are learned:

> I think that I can be a scientist but I just need to work more on myself, learn more and get support"; "I can be a scientist, since a scientist's first character is to ask questions… and answering them by experimenting.

20 out 25 (80%) reported that they would like to become scientists, and considered that a scientist is a person that can have a normal life:

> I would like to be a scientist since I love to discover new things… distribute my time or manage it for everything… working and being motivated to reach my scientific goals and having a normal life, getting married, having children and all luxury conditions"; "Scientists may have a social life and a family, divide their time between family and work.

Participants' perceptions of science

After the intervention of biographical recounts of famous scientists, participants were asked to reflect on their work, and describe what they have learned about science, apart from the fact that it is a body of knowledge. Table 4 shows the percentages of the three aspects of scientific literacy, apart from Aspect 1, identified in their answers.

Table 4. Percentages of aspects 2, 3 and 4 of scientific literacy identified in participants perception of science after the usage of biographical recount

Perception of Science			
Aspect 1 Knowledge of science	Aspect 2 Investigative nature of science	Aspect 3 Science as a way of knowing	Aspect 4 Interaction of science, technology and society
-	32%	80%	36%

It was found that the Investigative nature of science (Aspect 2) and interaction of science, technology and society (Aspect 4) increased fairly to 32% and 36% respectively. This biggest difference was with science as a way of knowing (Aspect 3) which increased from 16% to 80%.

The distribution of percentages of participants' perceptions about science after the intervention of the biographical recount of a scientists, in regards of single or combined aspects, as well as samples from participants' answers are presented in table 5.

Table 5. Distribution of percentages of participants' perceptions, and answers samples about science in regards to single or combined aspects after the usage of biographical recount of scientists

Aspects	Percentage	Samples of participants' answers
2	0%	
2+3	12%	- "Through biographical recount we discover many things about science and scientists: how they think, their reasoning, inductive or deductive reasoning, analyzing, how they used differences and similarity." - "Discover the methods they (scientists) applied and lead them to their discoveries. They have applied the scientific method, in a deductive or inductive approach, experiments, and the observations that triggered the first torch of their investigation."
2+4	0%	
3	36%	- "Science is not stable." - "Scientific thinking includes curiosity, creativity and objectivity" - "The great work and contribution of these scientists is the results of hard work…it helped us know how does the scientific thinking go, how does a theory evolve …and good scientist is the scientist that use the other scientists work and build on it in order to reach his goals."
3+4	16%	- "Scientists are ordinary people, their discoveries are result of hard work. Science includes thinking, interaction within scientific community".
2+3+4	20%	- "Scientists formulate hypothesis, interact with their environment. Science includes curiosity, and scientific work results in making laws". - "Scientists react with their surroundings, they use scientific investigations to discover things, and they use skills."

What is interesting in the findings above, that the answers combining the three aspects 2, 3 and 4 increased from null before the intervention to 20%. This finding suggests that the participants were exposed to different aspects of science through the activity of biographical recount.

Conclusion

The first purpose of this study was to explore participants' perceptions about scientists and investigate ways to improve their views about scientists. The results show that participants relied mainly on information presented by media and in science textbooks, where mostly male scientists are presented. At first participants considered it to be very hard to be a scientist, as they perceived scientists to be naturally skilled and talented. After the introduction of the biographical recount project, participants changed their perceptions, as they discovered that scientific skills and abilities are acquired through education and experimentation. They also learned that scientists lead normal lives. The findings of the study are parallel to the findings of Erten, Kiray and Sen-Gumus (2013) in that certain treatments may change students' views of science and scientists.

Another purpose of this study was to investigate the degree of congruence between the participants' (primary science teaching program first year students) perceptions of science with aspects of scientific literacy as per BouJaoude's (2002) framework. The results of this study show that participants' perceptions of science were mostly focused on "the knowledge of science" (Aspect 1), that reflect scientific knowledge such laws and facts, whereas the other views of science represented in "Investigative nature of science" (Aspect 2) that focalize on the science process skills, and those presented in "science as a way of knowing" (Aspect 3) and "interaction of

science, technology and society" (Aspect 4) vary from fair representation for Aspect 2, to almost missing for aspect 4. Those findings are by large in line with BouJaoude's (2002) and Dani's (2009) findings about the Lebanese curriculum, teachers and textbooks literacy in science. However, it is found in this study that the participants underestimate the aspect of "interaction with science, technology and society"; a finding not reported in previous studies.

In addition, the study highlighted that most participants hold a unidimensional view of science, as they were not able to perceive the multidimensional identity of science. However, the usage of biographical recounts of famous scientists has helped participants to shift their perceptions from a unidimensional view of science to a more comprehensive one that includes more than one dimension of scientific literacy.

Recommendations

Regarding the intervention proposed in this paper about the use of the biographical recounts to enhance scientific literacy, the results suggest that this activity is beneficial to promote scientific literacy among students, mainly "science as a way of knowing"- the missing aspect in the Lebanese curriculum. The activity allows them to discover how scientists think, reason, and reflect in the construction of scientific knowledge. In addition, it highlights the empirical nature of science by ensuring the objectivity in science. Moreover, thorough biographical recounts of scientists, students would discover careers in sciences, and how science is related to everyday life. It is recommended that this activity would be used by science teachers, where students may research the biography of scientists related to the studied topic. It is also advisable that teachers choose Lebanese scientists, when available, to highlight the impact of science in society. However, this activity is not enough to develop scientific literacy, it helps to give an insight to the "investigative nature of science", "science as a way of knowing" and "interaction of science, technology and society". It may be one of many instructional processes used by teachers. As Abd-El- Khalick and Lederman (2000) reported that science teachers should use explicit and reflective instructional processes to promote "the nature of science" perspectives that lead to the development of scientific literacy.

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