IJEMST

International Journal of Education in Mathematics, Science and Technology

International Journal of Education in Mathematics, Science and Technology (IJEMST)

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To cite this article:

Erten, S., Kiray, S.A., & Sen-Gumus, B. (2013). Influence of scientific stories on students ideas about science and scientists. *International Journal of Education in Mathematics, Science and Technology*, *1*(2), 122-137.

International Journal of Education in Mathematics, Science and Technology
Volume 1, Number 2, April 2013, 122-137 ISSN: 2147-611X

Influence of Scientific Stories on Students Ideas about Science and Scientists

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Abstract

This study was conducted to determine whether a lesson, in which context-based learning approach and scientific stories were used, changed students' (aged 11-12) stereotypical images of science and scientists. Data was collected from two separate sources: Interviews conducted with six students and Draw a Scientist Test (DAST) document that was given to 80 students (before and after the intervention). In the study, context-based learning approach with scientific stories was used as intervention after which a change in students' ideas about science and scientists was observed. At the end of the study, changes were observed in various categories of stereotypical images of scientists, such as use laboratory tools (test tubes, glass bottles, magnifying glasses, chemicals, etc.), use of technological appliances (computers, microscopes, telescopes, machines, robots, etc.), scientists who study living things (plants, animals, humans), scientists who study inside a laboratory, scientists who study outdoors (nature, space, etc.). At the same time changes in students' understanding of nature of science were observed. After the intervention, clues about student ideas such as, there is more than one scientific method, there is no single criteria for doing science, scientists use their imagination in their studies, and scientists' studies are not limited to one field were observed. In the course of the study, student's ideas about science changed from a positivist philosophy toward a heuristic philosophy.

Key words: Scientists Images, Scientific Stories, Nature of Science, Context-based Learning

Introduction

School programs that are designed based on constructivist approach, which suggest students should discover knowledge by following the methods of scientists, are common in contemporary education. Educators emphasize inquiry-based learning based on this approach. With this type of educational approach, educators are faced with questions such as "how scientists work?" and "is there a single way of doing science?" more often.

Guiding students to work like scientists change or reinforce their images of scientists. The Process of gaining knowledge by doing experiments and observations, which was popularized by Galileo, in time, contributed to the perception of science as an activity that is mainly done in laboratories. Together with positivist philosophy and empiricism, this perception contributed to the image of science and method of doing science (Lederman, 1992; Tao, 2003). In the period after Einstein, assumptions about nature of science started to shatter and ideas about science and scientific method have been replaced with new ones (Abd-El-Khalick & Lederman 2000). The change in nature of science has brought about flexibility in the image of scientists in students' minds.

Nature of Science and Scientist Image

The discussion on whether doing science or producing scientific knowledge has a method has been brought about by the positivist philosophy. Aguste Comte, who established positivism in the 19th century, believed that it is possible to know the natural world through methods of physics. In Comte's time, methods of physics were based on Galileo's experimental approach. Carnap, a member of the logical positivists of the Vienna School, took the issue a step further and claimed that the only science is physics and its related fields. Philosophers of the Vienna School claimed that there is a method of doing science. They accepted experimental way of

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obtaining knowledge in physics as the method of science. With positivist philosophy, it is accepted that science has a method, which is the scientific method. Dewey, a pragmatist, explained the scientific method as a six level problem solving method (Dewey, 1933; Hermanovicz, 1961; Kıray & İlik, 2011). These developments in science and philosophy inevitably reflected in society through various means. Newspapers, magazines, and television in the 19th and 20th century popularized scientific discoveries. Frequent news about these discoveries created interests in society. Interest in new discoveries necessitated primary school programs to include scientific inquiry in their programs.

From the middle of the 20th century, inclusion of all scientific process skills in science education programs has become important. Today science process skills are one of the seven learning areas in Turkish science education program (MEB, 2011). It can be argued that positivist and pragmatic philosophy in school programs created an image of science as something being done in laboratories and scientists as the people who do science. However, today, philosophers of science reject the idea that science has a definite method. As Einstein dethroned Newton with a scientific revolution, increased discussions about science and scientific method took place.

Einstein's physics is not based on experiments done in laboratories but rather on thought experiments. The situation shook the idea that science has a definite method, popularized by positivist and pragmatic philosophy. Philosophies, such as heuristic philosophy after Einstein, accepted that the source of knowledge could be the mind as well as the experiments. Because of this, the idea of science does not have a definite method have been accepted more widely (Kiray, 2010). Feyarabend took it a step further by saying that defending a scientific method is bigotry (Sonmez, 2008).

Scientific knowledge is not obtained only through experiments and observations. To some extent, it is obtained as a result of all human imagination and inferences. There is a consensus among scientists that scientific knowledge depends on observations and experiments, but not totally. Scientific knowledge can change, it is subjective, and it includes social and cultural activities (Lederman, 1999; Ibanez-Orcajo ve Martinez-Aznarbanez, 2007). Science also has historical dimensions. Historical dimensions of science include how scientists worked, how they discovered, what were the difficulties in their discoveries, how many scientists worked on a discovery, why were they successful or unsuccessful (Aydoğan, 2008).

Today, changes in views on nature of science by the influence of history and philosophy of science, necessitates a change in students' images of scientists. The old image of science limited science to laboratories, shaped image of scientists as male, middle aged with untidy appearance, wearing glasses, mostly working in a laboratory with a lab coat and various technological equipment and glassware around, performing dangerous experiments, unsocial with no interactions outside the laboratory (Dikmenli, 2010). Research shows that this traditional view of scientists still exist in students' minds (Mead and Metraux, 1957;Chambers, 1983; Rosenthal, 1993; She, 1998; Song & Kim, 1999; Finson, 2002; Rubin, Bar, & Cohen, 2003; Losh, Wilke, & Pop, 2008; Fralick, Kearn, Thompson, & Lyons, 2009; Korkmaz & Kavak, 2010; Çakmakçı, Tosun, Turgut, Örenler, Şengül, & Top, 2011). It is important to be aware of the sources of the stereotypical images of scientists in students' mind to expand and change these images in accordance with the changes in nature of science. Research in this area showed that media that students interact with such as comics, novels, newspapers, movies, television and other forms of mass media as well as bibliographic information about scientists in text books, friends and family have influence on students' images of scientists (She, 1995; Song & Kim, 1999; Jane, Fleer & Gipps, 2007; Turkmen, 2008; Çakmakcı et al., 2011).

Currently to make students' stereotypical images of scientists more flexible and more compatible with the current nature of science perspective, educators continue to try different techniques and strategies. Flick (1990) found that inviting scientists to classroom is effective in changing students' ideas about scientists. Çakmakcı et al (2011) suggested four approaches, namely 1) "Using a Concept Cartoon to Present a Scientist's Life", 2)"Visiting Scientists", 3)"A Scientist's Visit to the School", and 4)"A Presentation on Scientists' Lives" are effective in changing students ideas about scientists. Mason, Kahle, and Gardner (1991) investigated "a teacher intervention program" that they developed to change high school students' stereotypical images of scientists. Their program was applied to 549 high school students by 14 biology teachers. Half of all participants were given strategies that included materials about role models, sexual equality and career information. When the DAST data from their research was analyzed with chi-square test, they found that the students in the experimental group have drawn more female scientist pictures than the ones in the control group. Reap, Cavallo, and McWhirter (1994) designed a treatment for pre-service teachers that utilized inquiry strategies and learning cycle. They found that the treatment was effective in decreasing pre-service teachers' stereotypical science images. Literature suggests that one of the effective methods for changing students' stereotypical scientist images is scientific stories.

Science Stories and Scientist Image

Scientific stories are usually stories about scientists' real lives and scientific phenomena and events. Scientific phenomena and events that students have difficulty understanding may become easier to understand when given with in a story. Because of this, scientific stories are occasionally given in textbooks. Milne (1998) has separated scientific stories into four groups. 1– Heroic science stories: science hero single-handedly contributed to the development of science. 2 – Discovery science stories: scientific information that was discovered as a result of an accident or coincidence. 3–Declarative science stories: science stories that presents scientific concepts or scientific processes objectively. 4– Politically correct science stories: stories that tell the contribution of people from different cultural, sexual and ethnic backgrounds. There are many evidential supports that using these story forms improve the value of teaching and learning (Martin & Brouwer, 1991; Klassen, 2007; Klassen, 2010, Frisch, 2010).

In inquiry-based courses, where students see scientists' successes and failures through stories, help them identify themselves with scientists. Story becomes more meaningful when it is combined with students' dreams (Solomon, 2002). Especially biography type stories and documentaries about scientists' lives are effective in shaping students images of all scientists (Milne, 1998; Tao, 2003; Koch, 2005, Dagher & Ford, 2005). Because of this, to identify students' ideas about scientists or to change their ideas about scientist, scientific stories can be utilized. Reis & Galvao (2004) have identified students' concepts about scientists through science fiction stories. In their other study, Reis and Galvao (2007) had high school students write fiction stories through which they obtained their stereotypical images about scientists. Tao (2003) found that scientific stories influenced students' ideas about the nature of science significantly. Ermani (2010) claim that stories about DNA changed students' scientific ideas.

This study was focused on determining whether scientific stories used in a fifth grade science and technology class for seven weeks were effective in changing students' stereotypical images of science and scientists rather than evaluating scientific stories. The following research questions were explored for this purpose:

1. What are students' ideas about the materials that scientists use in their studies? How do scientific stories may influence these ideas?
2. What are students' ideas about scientists' working conditions? How do scientific stories may change these ideas?
3. How do scientific stories may influence students' ideas about scientists working environments and methods?
4. How do scientific stories may influence students' ideas about doing science and accepting a study as scientific?

Methods

Data Collection Instruments

We combined data from two sources: The DAST and individual interviews. To determine changes in students' images of scientists and their perception of science DAST document was given to students at the beginning and end of the treatment that was developed by Chambers (1983). Later six students, who had differences in the pre- and post-drawings, were interviewed.

Draw a scientist test (DAST)

DAST was developed by Chambers (1983) is an easy to use instrument. A piece of paper is given to students and they're asked to picture a scientist (Fung 2002). DAST is not based on a verbal ability (Newton & Newton, 1992). The biggest advantage of it is that it does not require writing or reading skills. Because of this, it can easily be used in all levels from preschool to university.

In his/her study, Chambers (1983) suggested seven standard indicators. DAST is still a valid document to determine the stereotypical indicators about scientists that students still have today such as eyeglasses, laboratory coat, facial growth of hair (beards, moustaches, sideburns, etc.), research symbols such as scientific instruments and laboratory equipment, knowledge symbols such as books and file cabinets, technology products and relevant captions such as formulae, taxonomic classification. Other researchers in other countries also found similar indicators after Chambers (Fung, 2002).

Interviews

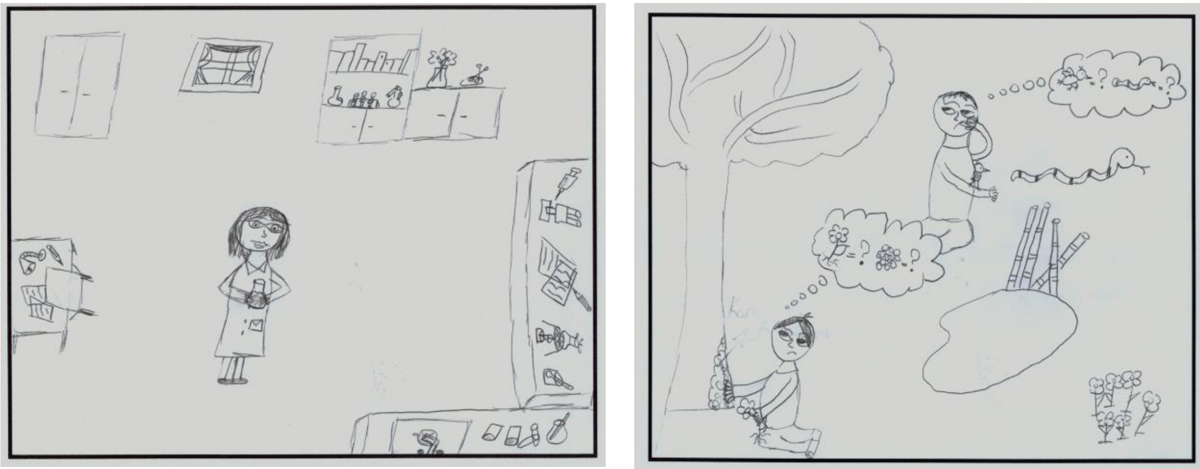
Interviews were conducted with students who were in the experimental group and who had differences in their pre-and post-drawings of scientists in categories such as use of laboratory tools, use of technological equipment, scientists working in a laboratory environment, scientists working outdoors, scientists working on living things. Interviews were utilized in two ways, i) to determine reasons for changes in students drawings, ii) to determine whether changes in drawings reflect current understanding of nature of science and scientific method.

Reliability and Validity of Data Collection Instruments

To determine the reliability coefficient, the DAST documents were scored by three scorers based on five criteria and the correlation coefficient between the first scorer and the others were determined to be 0.902 and 0.806 respectively.

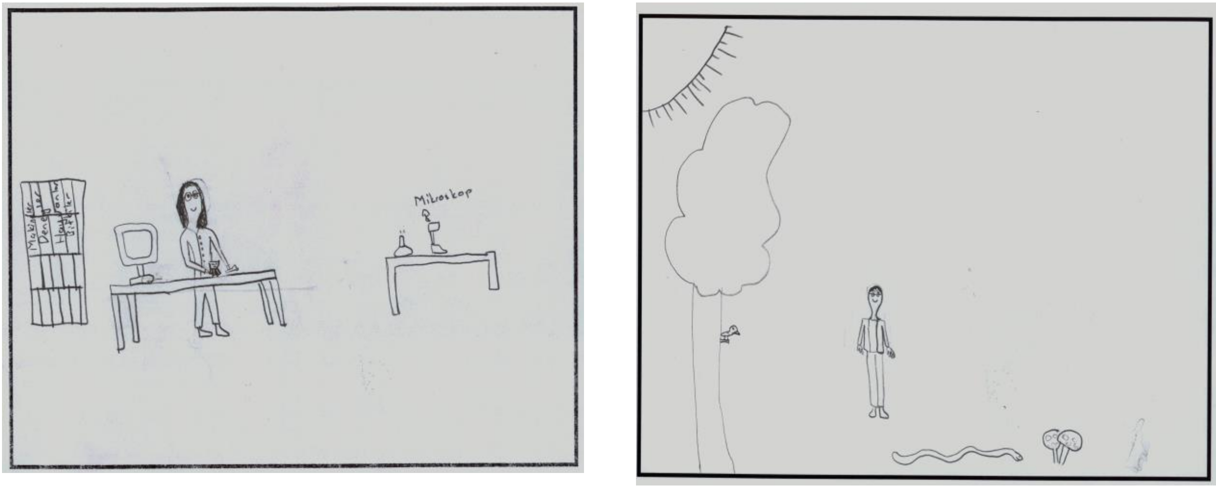
The interview protocol and the questionnaire was reviewed by an academician , who had studies in nature of science and philosophy of science, and a doctoral student, who studied nature of science in his Masters' degree. Necessary revisions were made based on these two experts' opinions and the interview protocol and the questionnaire were finalized based on their suggestions. Their opinions suggested that the data that will be obtained from the interviews would serve the purpose of the study. Content validity for the interview instruments was obtained this way.

Figure 1 and Figure 2 shows two examples of pre and post drawings obtained by DAST during the study.



before *after*

Figure 1: Drawing of student 3 before and after the application.



before *after*

Figure 2. Drawing of student 5 before and after the application.

Example interview questions that probed the changes in drawings were;

Why did you prefer a different drawing than the one you did seven weeks earlier? Explain your thoughts.

Probe 1: Do you think your previous drawing was wrong? Explain your thoughts.
Probe 2: Can you compare both drawings? What are the differences?
Probe 3: Why do scientists do science?
Probe 4: Is there a method that scientists use to obtain knowledge?
Probe 5: In which environments do scientists do their studies that you talked about?

Pilot study was conducted by one of the researchers in a classroom one year earlier than the main study. Interviews were conducted with five students to determine unclear questions which were eliminated. The remaining questions were evaluated to be understood and answered properly by students. This process provided empirical support for the instruments.

Participants

80 participants (11-12 years of age) took the DAST test, 40 of them were in the experimental group and 40 of them were in the control group. Six participants, who had different pre and post drawings from the experimental group, were chosen for interviews.

Data Collection Process

The students completed DAST at the beginning and at the end of the application. Students were asked to draw a scientist to a white paper that was provided to them. This process took about 20 minutes.

Interviews were conducted individually. Each interview took about 15 minutes. Pre-prepared interview and probe questions were asked to obtain explanations about changes in drawings.

The Instruction

The research started with developing five stories related to a fifth grade Science and Technology course unit named "Explore and Learn the World of Living Things." The stories were developed based on the Turkish Ministry of Education curriculum guidelines. Sentences in the stories were not longer than 15 words and were easy to understand. In the pilot study, to determine whether students understood the task, they were given a story map and asked to fill it based on the story. In the pilot study, students were able to complete the story maps successfully which indicated that the story texts were suitable for the fifth grade level. In the control group, the textbook that was normally used in the school was used. In the experimental group, content was given based on science stories. In both groups, content was structured with a context based and 5E learning cycle model. The main difference between the applications was that in the experimental group scientific stories were used during the "engage" stage, while in the control group, scientific stories were not used. In the "explore" stage, same activities were used in both groups. The conclusions after activities were related to scientific stories in the experimental group, while in the control group, conclusions were related to given situations. Five different contexts were used to teach unit objectives with a context-based approach. Each context was divided into subtitles and unit objectives were taught within these subtitles.

Context 1:

Story 1: First Step to Classification with Aristo

In very old times, a child was born in Macedonia. He was named Aristo and his father was a doctor… He investigated and observed animals' way of life, their movements, their body shapes and their habits. As a result of his observations, he concluded that he can classify animals with four features. He thought that if I don't share my observations with other people, they would be worthless… He continued his studies as a scientist.

Context 2:

Story 2: Linneaus's Scientific Stories

Linneaus was always interested in plants… As a scientist, he thought he should find a way to distinguish them. He thought people should be able to distinguish them easily. He needed to specify the steps of his investigation and continue with those steps. First of all he distinguished plants with flowers from others. With the results he obtained from this, he was able to distinguish others easily. He worked for months. He made observations. He investigated. At the end, he noticed the differences among the structure of the flowers. He classified them into kinds… Linneaus became a famous scientist in history.

Context 3:

Story 3: Ray's Observations

John Ray was a young person who lived in England in the 17th century. He was interested in plants since he was a child… Ray and his family were living in a rural area. Because of this he saw plants with different kinds of roots, trunks, leaves and flowers. He investigated them. He shared his investigations with his friend Francis… Ray stood up quickly. He ran toward the lake. He saw a plant that he never saw before. This plant had a root, a trunk, leaves but no flowers. He took a leave from the plant and investigated. He was excited to discover a new plant. … He became history as the first person who classified plants.

Context 4:

Story 4: Alexander Fleming's Journey to Discover Penicillin

… He noticed that a new formation was emerging in the dish where bacteria were forming. The bacteria in this dish died spontaneously. He started to investigate right away. He found that a mold fungus coming from the air caused this… It formed the penicillin in the dish. Fleming noticed that this showed an effect of a medicine. He thought he should share this medicine called antibiotic with everyone. This was a scientific investigation. Sharing makes science more valuable. Patients could be cured this way…

Context 5:

Story 5: On the Road to Science, Louis Pasteur

… Diseases such as anthrax, cholera, rabies attracted his attention. He was not a doctor. He was a scientist. He thought that he should do what he has to do. He started to investigate these diseases. Medical doctors of his time criticized him a lot… He thought, "I should not give up on this research as a scientist." … After a long study, he found the rabies vaccination. One day, a boy who was bitten 14 times was brought to him by his parents. They asked him to try the vaccination on their child, which was only been tried on animals. There was no treatment for the disease at the time and the child was likely to die. So he applied the vaccination to the child with the permission of medical doctors. The child was cured. It was discovered that the vaccination that he developed was effective on humans as well. He took his place among the scientists who served the humankind.

Subject titles within the unit (experimental group)

1. How would Aristo classify animals, if he lived today?
2. Classifying animals based on Aristo' method.
3. Do the animals that Aristo observed still exist?
4. Why did Linneaus separated plants that have flowers from others?

5. How did Linneaus discovered the differences in plant leaves?
6. Classifying plants based on Ray's method.
7. Which category did Ray put mushrooms in?
8. Why some of the plants that Ray observed don't exist today?
9. Were the bacteria that Fleming observed alive?
10. Let's learn about the diseases that Pasteur worked on.

The following was aimed by using the stories:

1. To make students stereotypical understanding of nature of science more flexible by using the stories as a context.
2. To make students stereotypical images of scientists more flexible by using the stories as a context.

Data Analysis

Phenomenographic analysis was used to analyze DAST data. Phenomenography was developed by Marton (1981, 1986) in the beginning of the 1980s and it became popular worldwide in educational research. Initially it was proposed as an approach for empirical research (Akerlind, 2012). Later, it was widely used as a descriptive qualitative research method. In this method, the main strategy used is conducting clinical interviews to collect data and analyzing the data through content analysis. Also to collect information about individuals' experiences or their opinions about concepts, data collected through group interviews, observations, answers given to open ended questions, drawings and historical documents are also within the scope of phenomenographic studies (Didiş, Özcan, & Abak, 2008). In this study, from the methods mentioned, collecting and analyzing data from students' drawings was preferred. To increase the persuasiveness of the research questions, two more approaches were utilized beyond the phenomenographic analysis of students' drawings. These were, i) using chi-square test when needed, ii) conducting face-to-face interviews with students who exhibited changes in images of scientists in their drawings.

Findings

In this study, data obtained from two different methods were used. First, data obtained from student drawings related to scientists' working environments, tools and methods they use when doing science were used. Second, based on these findings, data obtained from face-to-face interviews with students that probed their images of scientists and nature of science was used.

Table 1. Categories of students' drawings

Category 1: Use of laboratory tools (test tube, glassware, magnifying glass, chemicals, etc.)
Category 2: Use of technological equipment (computers, microscopes, telescopes, machines, etc.)
Category 3: Scientist studying living things (plants, animals, humans)
Category 4: Scientists working in a laboratory (indoors)
Category 5: Scientists working outdoors (nature, space, etc.)

The frequencies of the occurrence of above categories in students' drawings are given in Table 2.

Table 2. The frequency of the occurrence of five categories in students' drawings in control and experimental groups

Category	Group C(Control)		Group E (Experimental)	
	N	%	N	%
Category1	28	70.0	34	85.0
Category2	17	42.5	16	40.0
Category3	7	17.5	1	2.5
Category4	32	80.0	35	87.5
Category5	4	10.0	2	5.0

Laboratory equipment was exhibited in most student drawings in both control (70%) and experimental (85%) groups (test tube, glassware, magnifying glass, chemicals, etc.). There was no statistically significant difference between Group C and Group E ([$\varkappa^2(1)=2{,}581$; $p=0.108$]). Group C and Group E exhibited similar percentages of use of technological equipment (computers, microscopes, telescopes, machines, etc.) and there was no statistically significant difference between the groups ([$\varkappa^2(1)=0{,}052$; $p=0.820$]). One of the least exhibited feature in both groups was drawing of scientist studying living things; Group C (17.5%), Group E (2.5%) and there was no statistically significant difference between the groups ([χ^2(1)=5,000; p=0.025]). The most common drawing in both groups (80% in control, 87.5% in experimental) was scientists working indoors and there was no statistically significant difference between groups ([χ^2(1)=0,827; p=0.363]). The other least exhibited feature in both groups was drawing of scientist working outdoors (5% in control, 10% in experimental) and again there was no statistically significant difference between groups ([χ^2(1)=0,721; p=0.396]).

Table 3. The frequency of the occurrence of five categories in students' drawings in control and experimental groups after the application (treatment)

Category	Group C		Group E	
	N	%	N	%
Category1	20	50.0	7	17.5
Category2	17	42.5	5	12.5
Category3	5	12.5	21	52.5
Category4	28	70.0	12	30.0
Category5	6	15.0	23	57. 5

After the application, there was a significant difference between drawings of control (50%) and experimental (17.5%) group students regarding laboratory equipment (test tube, glassware, magnifying glass, chemicals, etc.) in category 1. There difference was statistically significant between Group C and Group E ([χ^2(1)=10,769; p=0.001]). There was an important difference between control (42.5%) and experimental groups (12.5%) in drawings of the use of technological equipment (computers, microscopes, telescopes, machines, etc.) in category 2 and the difference was statistically significant ([χ^2(1)=9,028; p=0.003]). In category 3, there was a statistically significant difference between drawings of scientist studying living things in Group C (12.5%) and Group E (21%) ([χ^2(1)=14,587; p=0.001]). Category 4, scientists working indoors, was another statistically significant difference between the groups (70% in control, 30% in experimental) ([χ^2(1)=12,800; p=0.001]). Finally, there was statistically significant difference between groups in category 5 drawings, scientist working outdoors (15% in control, 57.5% in experimental) ([χ^2(1)=15,632; p=0.001]).

In category 5, there were small changes between pre and post drawings in the control group, however, no statistically significant difference was found in any of the categories ($p>0.05$). In the experimental group, there were statistically significant differences between pre and post drawings ($p<0.05$).

Equipment in the work environment of scientists

After the application, there were significant differences between students' pre and post drawings. Students' initial drawings dominantly included laboratory equipment (test tube, glassware, magnifying glass, chemicals, etc.) in category 1; however, in later drawings equipment for observation of nature became more dominant. The following conversation about this issue took place with Student 3.

> Researcher: In your first drawing, there were glass bottles on the table, paintings on the wall, and cabinets. In your last drawing, there is a scientist with a magnifying glass investigating a forest, and dreaming about flowers and trees.
>
> Student 3: I have forgotten what I have drawn in the first picture. I redraw it. That is okay too but I draw this like the story of Aristotle and Linneous. I didn't think they were scientists initially. Actually in the cartoons that I watched before, there were people like that, but I taught of them as detectives. After reading the stories, I understood that scientists don't always work in laboratories. I realized that they also work like detectives… of course some of them work in the laboratory, but some are like detectives.
>
> Researcher: Which drawing do you think is correct? The previous one or the later one?
>
> Student 3: I think both are correct. Here (later drawing) he/she can take the works from nature to laboratory. He/she can investigate the gathered living things in the laboratory like Fleming.

A similar situation was observed for the use of technological equipment (computers, microscopes, telescopes, machines, etc.) as in category 2. In the following, Student 1's views are given.

Researcher: Your first and second drawings are different. Why?

Student1: Yes. In this drawing (previous drawing) I was thinking that scientists are using weird appliances. This year, I learned that they work in different ways… even when they are wandering about in a forest. In this drawing (post drawing) I draw based on what I learned this year.

Researcher: Which drawing do you think is right? The previous one or the later one?

Student1: In fact, mostly the previous drawing is right. What I knew until now was like this (previous drawing). We learned in this class… they can work differently. They can also work in laboratories. We worked like scientists in the science course this year.

Some students' drawings include changes in both categories at the same time. Student 4's views that include both categories are given below.

Researcher: Your first and second drawings are different. Why?

Student 4: Yes. This year we read about many scientists' studies. Before I read them, I used to think that all of the scientists were working with test tubes, glass bottles, and big equipment. I taught that they used computers. But none of the scientist we read about had a computer. So I thought about them while drawing.

Researcher: Which one of your drawing is correct do you think? Previous one or later one?

Student 4: The second one of course.

Researcher: Do you think that your previous drawing is wrong?

Student 4: No. Before reading about Aristotle and of course others I always taught like that (previous drawing). What I saw on TV was like that. But the scientists we read about this year are different. I learned later on. Scientists can work without computers or microscopes.

Scientists' working environments and methods

After the application, significant differences were observed in students' drawings of scientists' working environments and methods. In students' initial drawings, laboratory (indoor) working environments were dominant, as in category 4, however, in later drawings, category 5, outdoor environments, became dominant. Student 4's views about this issue are in the following.

Researcher: How do you think scientists work?

Student 4: I think most of them work in laboratories. I used to think all of them were like that. Now, I learned that they also work in other places.

Students' views changed so that they started to think that scientists may use laboratories when they need to, but they don't always have to do so. Student 3 expressed the following views about this.

Researcher: Do you think scientists work this way? Do they do their research like this? Do they bring everything they collected to the laboratory to investigate?

Student 3: I think they have to bring small living things. For example, when they work on bacteria, they have to. They can't see them without bringing them to a laboratory. They need a microscope. Of course, they don't need to go for big animals. For example, they can't take whales to a laboratory. I saw it when my father was watching. They were watching them from a ship. I think they are scientists too. They have computers. They look from a computer. They find out how they live.

Some students' views changed to think that scientists may use different scientific methods. Student 1's views about this are as follows.

> Researcher: How do you think scientists work?
>
> Student 1: They work like us. They find solutions to problems. They also do experiments. They wonder about in nature. They are interested in animals and living things. They find animals' properties. They find very small living things. Of course they also know the space… but the ones we heard about were interested in living things. I like living things as well. I have a cat. I wrote about its features. My teacher liked it very much. She said "you became a small Aristotle."

Some students' views change in a way that they thought scientists may conduct scientific research in different ways in different environments. Student 5 had the following views about this.

> Researcher: How do you think are the working environments of scientists?
>
> Student 5: In the old days, scientists have worked everywhere. For example, Fleming… He found bacteria in a dish when he was tidying his room. Now the ones on TV always work in places where there is equipment.
>
> Researcher: Is this your last decision? Do you prefer to separate scientists' work places as old and new?
>
> Student 5: Scientist may work in places like forests today as well… but on TV… my father watch them all the time… they find big snakes in the forest; they observe ants' properties that no one knows about. They magnify small things. My father likes watching them.

Scientists' working areas

After the application, important differences in students' drawings regarding scientists' working areas were detected. In students initial drawings, the number of scientists working on living things (plants, animals, humans) (category 3) was very low, but after the application, in the experimental group, nearly half of the drawings included scientists working on living things. As a result of combining students' prior knowledge with their new learning, nearly half of them preferred to draw scientists working on living things, while other half preferred to draw scientists working on other things. Student 2 provided following views related to this finding.

> Researcher: What do you think about the working environments of scientists? How do they determine their work subjects?
>
> Student 2: They work outdoors a lot. There are more things to investigate outdoors. There are many things in a forest and near a lake. There are trees. There are plants. They can investigate all of it. They can also do camping with camp fire…
>
> Researcher: But they are working in a closed environment in your first drawing. Aren't they doing scientific study?
>
> Student 2: They can do that as well. But there are more things to investigate outdoors, of course, in laboratory as well. We went to the laboratory a lot this year. We also investigated stuff that we brought from outside. They bring from a forest to laboratory of course. They can also bring pets. They can investigate without bringing them too.
>
> Researcher: Please think that you become a scientist in the future. Would you want to work indoors or outdoors?
>
> Student 2: Outdoors of course. It is nice to work outdoors. I would work outdoors. Of course, sometimes I would go to the laboratory but not much. I would want to work in a forest where there are birds and animals. I would like to be like a scout.

Criteria for doing science

The differences in students' drawings indicated a change in their thinking that for a study to be considered scientific, it must contain an experiment. Student 3's views about this are in the following.

> Researcher: Do you think that the work of a person who observes worms or whales can be considered scientific?
>
> Student 3: Of course… For example, the stories we read were like that. They were all scientists. If they didn't do scientific studies, I think they could not have been scientists. For example there was Ray. He only saw something that nobody did before and because of this he became a scientist. He was a scientist too. So was Linneous. He separated plants, flowers. Since nobody did this before, he became a scientist.
>
> Researcher: Did you see a scientist before?
>
> Student 3: Yes, in cartoons all the time.
>
> Researcher: What kind of a person a scientist is do you think? Would you explain?
>
> Student 3: In the cartoons that I used to watch when I was little, they always boiled something. Usually some colorful thing was boiling in a glass. Scientist was next to it.
>
> Researcher: Do you think the studies of the ones in stories or the ones in cartoons are scientific?
>
> Student 3: The ones in the cartoons can't be scientists, I think. They are cartoon versions of scientists. Since they are important people, the things that they do in cartoons are more difficult. They are scientists.
>
> Researcher: What about the things they do in the stories.
>
> Student 3: They are easier. Also enjoyable.
>
> Researcher: Okay, which one you think is a scientific study?
>
> Student3: I think, both of them.
>
> Researcher: Why do you think that?
>
> Student 3: The ones in the cartoons are copy of the scientists. The ones in the stories are like that, since they are scientists. One wouldn't be scientist for no reason. What they do is important, that is why they are scientists.
>
> Researcher: So the things they do are different, doesn't this effect the scientific acceptance of their work?
>
> Student 3: It doesn't, I think. Only one is difficult, the other is easy. The ones in cartoons are more difficult. We can't do them. Maybe grownups can. We did what they did in the stories. They are easier. We also did science, but the things we did were already known, so we did not become scientists. Maybe we will when we grow up.
>
> Researcher: How do you think scientists do their discoveries?
>
> Student 3: They are smart. They find things that nobody knows about. A cloud suddenly appears in their heads. The find in that could, in their head suddenly.

It was observed that, students' views about science started to become more flexible towards the idea that there is no single method or criteria for doing science. Student 6's views about this are as follows.

> Researcher: We are now chatting face-to-face. Do you think this is a scientific work?

Student 6: No.

Researcher: What do you think needs to be done for a study to be considered scientific?

Student 6: Experiments should be conducted in a laboratory. It could be found from experiments.

Researcher: Do you think studies of Aristotle, Linneaus and Ray are scientific?

Student 6: Hmmm. I don't know. But I think it was written that they were scientists in the stories.

Researcher: Did they work in a laboratory?

Student 6: No, but maybe they didn't write that part. Maybe they could become scientists even if they didn't do things in laboratory. Because, they did not have a laboratory. They didn't have computers either. In fact, most of them work in a laboratory. They use weird appliances. Now I think they could become scientists even if they didn't.

Researcher: What kind of people do you think scientists are? Did you see a scientist before?

Student 6: No I didn't. But I saw in movies. They were working in places where there were weird huge machines. They make smart people scientist. They know everything.

Researcher: Do scientist work in places where there are advanced technological devices?

Student 6: Yes but some don't. I used to think that way. Now I think some work in the nature. Some work while wondering in nature. They try to see new things. When they see it, they become scientists. I drew them in this picture for example.

Discussion

This study was conducted to make students stereotypical images of scientists flexible with the help of scientific stories. Through interviews, it was found that while this flexibility developed, their view of science also changed. Because of the content of the stories, not all stereotypical images reported in the literature were observed, only the images indicated in the stories were changed. The stereotypical image of male, middle aged with untidy appearance, wearing glasses and lab coats, having no social activities and lonely, which was reported for scientists in the literature (Mead & Metraux, 1957; Chambers, 1983; Rosenthal, 1993; She, 1998; Song & Kim, 1999; Dikmenli, 2010) continued to exist after the application in the study. Çakmakcı et al. (2011) reported that, to change students' stereotypical images, different interventions are needed. During the application of this study, no intervention was done to change the aforementioned images, which may be the reason for their continuity.

Regarding scientists' working environments and equipment in these environments, important changes took place in experimental group students' images. In the literature, the stereotypical image of scientists was described as a person working in a laboratory with advanced microscopes, telescopes, technological appliances, experimental setups, glassware, and test tubes around, conducting dangerous experiments, and being stuck in the laboratory (Mead & Metraux, 1957;Chambers, 1983; Rosenthal, 1993; She, 1998; Song & Kim, 1999; Dikmenli, 2010). This image was changed through the use of structured stories and discovery based courses. When scientific stories were used in an inquiry setting, they help students better understand how scientists work, how do they construct knowledge and apply and evaluate it (Tao, 2003). The interviews that took place with students revealed that the source of change in their images was context based learning, structured with scientific stories. At the same time, findings from the interviews showed that the changes in students' images did not lead to new stereotypical images of scientists that, for example, they would not use tools or equipment. Besides the interview transcripts, the fact that some students exhibited changes in their drawing while some continued to draw similar images to their first images support that no new stereotypical images was developed. One of the factors that caused change may be the teaching method.

The fact that one of the units was designed with a context based approach may have improved the influence of scientific stories. There are evidences in the literature that suggest that context based teaching and learning improves meaningful learning (Klassen, 2009). Besides increasing student motivation, teaching scientific issues and concepts based on stories conform to constructivist principles. After hearing a story, to solve a problem derived from the story, students enter an inquiry process (Klassen, 2007). The context based learning approach used was not limited to providing scientific stories or a problem scenario in the beginning. The objectives of a teaching unit were associated with the stories to construct the content knowledge. This allowed a continuous mentioning of stories about scientists to students. At the same time, discovery based design of unit objectives allowed students to learn new information through scientific stories. The fact that new information was associated with the stories may have increased the effectiveness of the stories.

In the study, presenting stories with a context based learning approach gave flexibility to some of students' stereotypical views. Drawings before the application showed that almost all students saw science as an activity that is conducted in laboratories. After the application, interviews showed that students started to think that science is not necessarily done in laboratories. Positivist philosophers argued that experimentation is a must have criteria for a study to be accepted as scientific. Later on, heuristic philosophers rejected the criteria of experimentation and argued that experiments in laboratories are not a necessity for doing science (Kıray, 2010). After the application, students' views shifted from a positivist view toward a heuristic view. However limited, flexibility of students' views about nature of science may be the result of scientific stories about scientists. The fact that stories were in Milne's (1998) heroic science and discovery science category may have contributed to changes in students' views. In the interviews, students often referenced story characters, which support these possibilities.

Another finding that was found in the study was that students started to think that there was no single scientific method. History of science shows that there is no single scientific method that encompasses all scientific studies. It is possible to see that in a laboratory environment, besides data obtained from step by step performed experiments, there are many discoveries that are not based on structured observations, which were the results of curiosity, creativity, and imagination or just luck (Kıray, Bektaşlı & Erbatur, 2012). The stories of scientists who did their discoveries outside laboratories may have made students ideas about scientific method more flexible. Besides scientific method, students' ideas about scientists' work environments also changed. Before the application, most student drawings have fallen into the category of physics or chemistry experiments conducted in a laboratory. After the application, student drawings shifted towards biology. This may be the result of scientists working on living things expressed in the stories. Before the application, drawings and interviews showed that most students had a positivist outlook of science, which accepted physics and fields that used methods of physics as science. After the application, students' views shifted from a positivist view toward a heuristic view.

In some of the drawings that students had after the application, there were speech balloons that indicated scientists' thinking. A similar finding was observed during interviews. They taught that scientists use their imagination in their studies. This situation showed that students' ideas shifted toward contemporary understanding of nature of science. After Galileo, science was viewed as an objective activity, independent of humans. This view continued until the heuristic philosophers. Today, this view of science has changed and now it is accepted that science is a subjective activity that is influenced by scientists conducting it (Kıray, Bektaşlı & Erbatur, 2012). Contemporary thinking also rejected the idea that science is an activity conducted in a laboratory independently from the observer. The idea that science is an activity influenced by creativity and imagination of scientists was accepted (Akerson, Abd-El-Khalick, & Lederman, 2000).

The findings of the study are parallel to the findings of Flick (1990), Mason et al. (1991), Reap et al. (1994), and Çakmakcı et al. (2011) in that certain treatments may change students' views of science and scientists. At the same time, this study support the findings of Martin and Brouwer (1991), Milne (1998), Tao (2003), Reis and Galvão (2004), Dagher and Ford (2005), Klassen (2007), Klassen (2010), Frisch (2010), and Emani (2010) in that scientific stories are effective in changing students' images of science and scientists.

Conclusion

With the educational approach of having students learn like scientists, the images of scientists that students have become important. Making students stereotypical ideas about scientist more flexible also made their ideas about nature of science more flexible. After using scientific stories, students' stereotypical images of scientists working indoors and using experimental tools and technological equipment have decreased while images of scientists working outdoors with living things have increased. At the same time stereotypical images of male, untidy scientists wearing lab coats have not changed.

The changes in students' stereotypical scientist images have also influenced their views of nature of science. Drawings before the application showed that students viewed science as an activity that is mainly conducted in laboratories and the criteria for doing science is experimentation. After the application, students' views started to shift towards the idea that science is not necessarily done in laboratories and science can be done without experiments. Students' initial image of a single method for doing science shifted toward the idea that there was no single scientific method after the application. Students views about scientists' working environments have fallen into the category of physics or chemistry experiments conducted in a laboratory. After the application, student drawings included biology besides chemistry and physics. This change is important for students' learning of the idea that science cannot be limited to one field. At the same time, in some students' views, changes toward the idea that scientists use their imagination in their studies took place. Before the application, students' view of science was closer to the positivist philosophy, which was dominant 100 years ago; after the application students' ideas shifted toward currently dominant heuristic view of science. The results of the study are important in helping students understand that there is no one type of science or scientist. The applications of the study conducted to change students' stereotypical view of scientists also changed their views of science and scientific method, which shows that images of nature of science and scientists are connected.

For researchers who do research in this area, we suggest thinking of images of science and scientists together. We suggest using context based learning approach and scientific stories for teachers who wish to bring their students' views of science and scientist closer to contemporary views of nature of science.

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