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THE EFFECT OF CREATING A MIND MAP ON HOW PROSPECTIVE SCIENCE TEACHERS LEARN ABOUT THE LIVES OF SCIENTISTS: THE CASE OF ALBERT EINSTEIN

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Abstract:
The aim of this study was to determine the effect of creating a mind map on how prospective science teachers learn about the lives of scientists. The study group of this qualitative study consisted of 23 prospective teachers who were studying in the Science Teaching Program of a state university in the 2016-2017 academic year. During the research, the prospective teachers created a mind map about Albert Einstein over a period of one week by using notes given to them. Data were collected from the prospective teachers through pre-test and post-test. The data obtained from the tests were subjected to content analysis. As a result of the study, it was seen that mind maps have a significant positive effect on the teaching of lives of scientists. With regard to incorrect information detected in a number of prospective teachers, it was inferred that it may have occurred while the mind map was being created or it may already have been present before.

Keywords: mind map, scientist, science education, prospective teacher

1. Introduction

In recent years, educational programs are constantly being revised based on the results of research conducted on the problems experienced in education nationally and internationally and how these problems can be solved. In this process, educating

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students to be science literate individuals has been prioritized. While this is directly stated in the curricula of some countries, in others it remains an indirect aim. For example, in Turkey, it has been directly emphasized in the recently published science curriculum that science literate individuals need to be educated and the aims of the program also include that "*the students understand how scientific knowledge is created by scientists, the processes this knowledge goes through and how it is used in new research*" (Republic of Turkey, Ministry of National Education, 2018).

In relation to science literacy, the objectives of the Australian science curriculum include "*an interest in science as a means of expanding their [the students'] curiosity and willingness to explore, ask questions about and speculate on the changing world in which they live*". In explaining the structure of the curriculum, it was emphasized that studying scientists and studying the nature and development of science should be integrated into each other (Australian Curriculum, -). In relation to scientists, one of the objectives of New Zealand's national science curriculum, is that "*students learn about the ways in which the work of scientists interacts with society*". In the section where the learning area structure of the curriculum is defined, the importance of scientists' working and research processes is emphasized (Ministry of Education, The New Zealand Curriculum Online, -).

In the UK national science curriculum, primarily emphasizing that a quality science education provides the basics for understanding the world, it is stated that students' feelings of interest, curiosity and excitement about natural phenomena should be encouraged to develop. To that end, it is recommended that the working methods of various scientists should be integrated into the teaching processes where necessary (National Curriculum in England, 2013). In the United States in 2013, New Generation Standards (NGSS), which influenced the way science subjects are taught in the United States, were published. Within the context of these standards, students are required not only to learn the subject, but also to understand the methods used by scientists and engineers (Timss & Pirls International Study Center, -). In the Singapore national science curriculum, it is emphasized that science teaching should go beyond merely presenting the facts and results of scientific research and should show students how scientists produce scientific research (Ministry of Education Singapore, 2013). As can be seen from these examples, many countries that are constantly striving to improve their education systems attach importance to scientists who have made major contributions in scientific fields and favor their integration directly or indirectly into educational processes. The importance that should be given to scientists themselves has been recognized by many educators working in various countries and it has been and still is at the center of a number of research studies. As a result of this research, it has been found that students have the perception that scientists generally wear lab coats and glasses (Barman, 1997; Chambers, 1983; Gonsoulin, 2001; Küçük & Bağ, 2016; Mead & Metreaux, 1957; Toğrol, 2000), conduct experiments in the laboratory (Chambers, 1983; Küçük & Bağ, 2016; Mead & Metreaux, 1957) and are mostly male (Barman, 1997; Küçük & Bağ, 2016; Gonsoulin, 2001; Mead & Metreaux, 1957; Toğrol, 2000). In other words, it was observed that students have a stereotypical perception of scientists.

However, if students realize that scientists have lives that are similar to those of other people, and if they learn detailed information about scientists, they might become more interested in them and in science and develop positive attitudes. Teachers (including today's prospective teachers) are the people who will ensure this. In their research, Özdemir & Üstündağ (2007) observed that prospective teachers' current knowledge about the life stories of scientists and their contributions to science is minimal. However, when the teachers/future teachers know about the lives of scientists, it is clear that they will be able to integrate parts of their lives into their teaching processes, answer students' questions about scientists and increase their general knowledge of this topic.

It is recommended in the revised curricula that student-centered methods be used. In other words, prospective teachers are asked to use student-centered methods in their classrooms when they start working as teachers. If prospective teachers experience student-centered education during their university education, this will increase the prospects of them both learning permanently by developing positive attitudes, and actively and effectively using the student-centered approaches and methods they have learned in their courses when they start working as teachers. One of the teaching tools in which the students are at the center and responsible for their own learning process is mind maps. The mind map was originally developed by Tony Buzan as a method of taking notes as briefly and strikingly as possible (Brinkmann, 2003). According to Buzan (2009), mind-mapping is a technique of storing, organizing and prioritizing information using keywords and key images (as cited in Kan, 2012). Mind maps are based on the fact that the two halves of the human brain perform different tasks. The left side is generally responsible for logic, words, arithmetic, linearity, sequences, analysis and lists; the right side often performs tasks related to multidimensionality, imagination, emotion, color, rhythm, shapes, geometry and synthesis. During the process of creating a mind map, both lobes of the brain are used (Buzan 1976; as cited in Brinkmann, 2003), the right and left lobes work together, thus productivity and retention in memory increase (Brinkmann, 2003). Although mind maps were first developed as a note-taking technique, they have been subsequently used for different purposes (Brinkmann, 2005). No matter how they are classified, whether as a learning tool, a teaching tool, a note-taking technique, or a learning technique, all the definitions and explanations emphasize the main characteristics of the mind maps as facilitating the learning of the individual. The research on the use of mind maps in educational processes also supports this finding. According to the results of research on the use of mind maps in science education, creating a mind map increases students' academic achievements/level of understanding of concepts (Abi-El-Mona & Abd-El-Khalick, 2008; Evrekli & Balım, 2010; Gömleksiz & Fidan, 2013; Çakmak, Gürbüz & Oral, 2011; Steyn & Boer, 1998) and positively affects their attitudes towards and interests in science (Gömleksiz & Fidan, 2013; Bastem, 2012; Trevino, 2005; Yaşar, 2006). In addition, there are studies confirming that the use of mind maps in physical sciences increases knowledge levels permanently (Akıncı, 2015; Gömleksiz & Fidan, 2013; Yaşar 2006). In their research, Zubaidah, Fuad, Mahanal & Suarsini (2017) found that when the

differentiated scientific inquiry model was integrated with mind maps, it increased the creative thinking of the students more than when it was used by itself.

Beginning with the question "Can mind maps, whose effectiveness in science education has been proved in various ways, be effective in learning about the lives of scientists?" the aim of this research was to determine the effect of creating mind maps on how prospective science teachers' learn about the lives of scientists.

2. Method

This study examines what ideas the students construct in their minds and what they emphasize about the life of the selected scientist when creating mind map. In a way, the researchers tried to see from the students' perspective, and investigate the effects of mind maps on learning by questioning how the students interpret the life of the scientist. For these reasons, qualitative research was conducted.

2.1. Study Group

The study group of the study consisted of 32 prospective teachers who were studying in the Science Teaching Program of a state university in the spring semester of the 2016-2017 academic year. As there were 23 prospective teachers who participated in both the pre-test and the post-test, the data obtained from 9 prospective teachers were excluded from the analysis.

2.2. Implementation and Data Collection Process

First, a presentation was made to prospective teachers about mind maps. The presentation included information such as what a mind map is, how it can be created, for what purposes it can be used, and detailed explanations were given using various visual examples. Then, a sample implementation was conducted in order for prospective teachers to gain experience in creating a mind map. Following this, pre-test was applied to the students. They were asked: "What do you know about Albert Einstein? Please explain."

Immediately after the pre-test, prospective teachers were given 14 pages of notes (James, 2004) about Albert Einstein's life. They were also given three pages of notes including 20 instructions and visual examples about how to create a mind map, and were asked to prepare a mind map about Albert Einstein. The 20 instructions were those suggested by Buzan and Buzan (2007: 97-104) (as cited in Kan, 2012).The prospective teachers were given one week to create and submit their mind maps. Immediately after the submission of the mind maps, the pre-test question was asked again as the post-test. The reason why the prospective teachers were asked only a single question without further elaboration or diversification was to prevent the possibility of this question, which was asked before the implementation, affecting the students in the classifications they would make when creating the mind maps. The most basic aim of this study was that the prospective teachers should determine what points were important for them and make their own classifications while reading – and if necessary

re-reading – about Einstein's life, and connect them with their existing knowledge. It was thus seen as an important requirement for this research that only a single question be addressed. The prospective teachers answered the question in writing before and after the implementation.

2.3. Data Analysis

Content analysis was performed on the data obtained from the research. Before moving on to content analysis, a pilot study was conducted on data gathered from another group of students on another scientist. Through this pilot study, researchers identified a common means of formulating codes and categories. Then the content analysis of the original study was performed. In this process, one of the researchers created a list of codes. The other researchers then read the data and re-encoded the data according to this list. During this process, the number and quality of the codes were changed by rearranging the codes and the codes were finalized. After the coding, as a result of the coordinated work of three researchers, categories and sub-categories were derived.

In order to assess the results of the content analysis, the mind maps submitted by the prospective teachers were considered. The mind map submitted by each prospective teacher was analyzed by the researchers in terms of its quality. To find out to what extent the prospective teachers had followed the instructions they were expected to follow while preparing their mind maps, a checklist of 20 instructions was prepared, and their level of compliance was scored out of 20 points for each mind map. The mind maps prepared by the prospective teacher with the highest score, the lowest score and the average score, and the codes derived as a result of content analysis of the mind maps of these three prospective teachers were analyzed together.

3. Findings

This section consists of two subsections, "3.1. Pre-Test and Post-Test Findings" and "3.2. Findings Regarding to the Coordination of Mind Maps and Pre-Test–Post-Test Findings". In the first subsection, content analysis results for all the prospective teachers are given, and in the second subsection, results for the three prospective teachers who were selected according to their level of compliance with the instructions are given.

3.1. Pre-test – Post-test Findings

When the information provided by the prospective teachers in the pre-test and post-test was subjected to content analysis, six categories were formed. These were the birth and death of Albert Einstein, his individual characteristics, his family, his studies, his places of residence and a category for other information. The categories generated as a result of the content analysis and the numbers and percentages of the prospective teachers who provided information according to the categories are given in Table 1.

Table 1: Categories and Number and Percentages of Prospective Teachers Who Provided Information according to the Categories

Categories	Pre-test		Post-test	
	f	%	f	%
Birth and Death	4	17	19	83
Individual Characteristics	8	35	22	96
Family Information	0	0	18	78
Studies	18	78	23	100
Places of Residence	1	4	7	30
Other	1	4	12	52

As seen in Table 1, in relation to the birth and death of Albert Einstein, 17% of the prospective teachers provided information in the pre-test and 83% in the post-test; in relation to individual characteristics, 35% of them provided information in the pre-test and 96% in the post-test. In relation to his family, while there were no prospective teachers who provided information in the pre-test, 78% of them provided information in the post-test. In relation to his studies, 78% of them provided information in the pre-test and 100% of them provided information in the post-test. In relation to his place of residence, 4% of the prospective teachers provided information in the pre-test and 30% in the post-test. In relation to other issues, 4% of them provided information in the pre-test and 52% of them provided information in the post-test. An overview of the Table 1 makes it obvious that the percentages in the post-tests were significantly higher than the percentages in the pre-tests.

Category 1: His Birth and Death

Table 2 shows the subcategories in the category of his birth and death and the number and percentages of their presence in the responses of the prospective teachers.

Table 2: Subcategories and Codes in Birth and Death Category and Number and Percentages of Prospective Teachers

Sub-Categories	Codes	Pre-test		Post-test	
		f	%	f	%
Birth	Born in Germany/He was originally German.	4	17	15	65
	He was born in March.	0	0	2	9
	He was born in the 19th Century.	0	0	1	4
Diseases	At least one of cardiovascular diseases/aneurysm, digestion or anemia was mentioned.	0	0	11	48
	He had various health problems during the last years of his life.	0	0	1	4
Death	He died at 76.	0	0	3	13
	He died at 66.	0	0	1	4

When the codes that stand out in Table 2 are examined, in relation to the country where Albert Einstein was born, four of the prospective teachers (17%) in the pre-test and 15 (65%) of the prospective teachers in the post-test provided information. Three of the

four prospective teachers who provided information about the place where he was born in the pre-test wrote that he was German and one of them wrote that he was born in Ulm.

Among those four prospective teachers, A17 only wrote two sentences in the pre-test about Einstein and those sentences were "*He was a German physicist. He studied the atom*". The relevant sentence written by A24 was "*Einstein is a German scientist known as the father of physics*" Ö25 wrote that he was German, Ö12 wrote that he was born in Ulm. Nine of the 16 prospective teachers who provided information about where he was born in the post-test provided the detail that he was born in the town of Ulm, Germany, while others stated that he was born in Germany or that he was German.

For example, Ö20 wrote that "*He is a German physicist*"; Ö24 wrote that "*Einstein was born in Germany*", and Ö1 wrote that "*He was born in Ulm, a German town*". While no prospective teacher mentioned his health problems in the pre-test, almost half of them provided information about the health problems he had in the post-test. Some of the students mentioned only one of the health problems he had and some of them mentioned more than one. For example, while giving information about the last years of his life, Ö14 wrote "*He had many health problems, he died because of digestive disorder and bleeding in the aorta as a result of cardiac dilatation*", Ö22 wrote that "*He had health problems such as cardiac dilatation and anemia*", Ö6 wrote that "*Einstein had health problems such as anemia and digestive system problems. Then he died as a result of aortic aneurysm in the abdominal region*", Ö10 wrote that, "*He had cardiac dilatation*", Ö13 wrote that "*He had anemia*".

Category 2: His Individual Characteristics

The subcategories in the individual characteristics category and the numbers and percentages of their presence in the responses of the prospective teachers are given in Table 3.

Table 3: Subcategories in the Individual Characteristics Category and the Numbers and Percentages of Prospective Teachers

Subcategories	Codes	Pre-test		Post-test	
		f	%	f	%
His childhood	He had aphasia.	3	13	12	52
	He was not generally very successful.	2	9	10	44
	He liked to be alone.	1	4	5	22
	He had particularly difficulty in mathematics classes.	0	0	5	22
	Other.	1	4	11	48
His physical characteristics	He was of medium height/He was 170 cm.	0	0	7	30
	He had brown eyes.	0	0	6	26
	He had black hair.	0	0	5	22
	He had a mustache.	0	0	5	22
	He wore glasses.	1	4	1	4
	His had distinguishing facial characteristics.	0	0	1	4
Individual characteristics	He liked to be alone.	1	4	7	30

	He was sincere.	0	0	5	22
	He was a questioner.	0	0	5	22
	He had a sense of humor.	0	0	5	22
	He was clever (wise, smart, creative, a genius).	1	4	4	17
	Other.	2	9	4	17
One of his hobbies	Music.	0	0	15	65
	Boat trips.	0	0	6	26
	Other.	0	0	6	26

When Table 3 is examined, it is observed that the percentage of prospective teachers who provided information about the individual characteristics of Albert Einstein was higher in the post-test.

When the codes that stand out in terms of number and percentage in the "childhood" subcategory are examined, the prospective teachers,13% of whom provided information in the pre-test and 52% of whom provided information in the post-test, emphasized that Albert Einstein had aphasia or he started speaking late. Two prospective teachers who stated that he was not generally very successful in the pre-test, added that he was thought to have mental retardation by his parents/teachers. While three of the ten prospective teachers directly stated that Einstein was not successful in his childhood, the others mentioned it indirectly. For example, Ö7 wrote that "*In his childhood, his teachers believed that he was unsuccessful and had difficulty in understanding*", Ö17 wrote that "*He had echolalia and was suspected to have dyslexia*". In the "other" code in this subcategory, prospective teachers pointed out that he received help from his uncle with algebra and geometry, and was impressed by a compass he received as a present.

In the sub-category of "physical characteristics", only one person provided information in the pre-test, and only by writing the word "glasses". In the post-test prospective teachers directly mentioned characteristics such as his height, eye, and hair color, and that he had a mustache.

In the "personality characteristics" category, one student stated that he was a genius and two people stated that he was a Piscean in the pre-test. In the post-test, the prospective teachers mentioned that he was a sincere, wise, questioning and humorous person who liked being alone. In the other code here, various information was provided such as that he had an eccentric personality and that he was a Piscean. The words of Ö5's, "*He used to ask people about everything he did not know, he was curious about science*" and of Ö8, "*Sincere, curious, answering a question with a question*" can be given as examples in this category.

In the "one of his hobbies" subcategory, while no prospective teachers mentioned this category in the pre-test, 65% of the prospective teachers mentioned that he was interested in music and 26% of them mentioned that he liked going on boat trips in the post-test. Three of the four prospective teachers whose information was evaluated under the other code stated that he could not drive, two of them mentioned that he liked watching western movies and one of them wrote that he liked going for

walks with his friends. His interest in music was emphasized by the most of the prospective teachers. For example, Ö3 wrote that "*He had a special interest in music, he liked playing the violin, the composers he listened to were musicians like Mozart*" and Ö6 wrote that "*He liked the violin and he could play it; he liked Mozart, Bach, Schubert the most. He liked to listen to their works*."

Category 3: Family Information

The subcategories in the family information category and the number and percentages of their presence in the responses of the prospective teachers are given in Table 4.

Table 4: Subcategories in the Family Information Category and Numbers and Percentages of Prospective Teachers

Subcategories	Codes	Pre-test		Posttest	
		F	%	f	%
Parents and siblings	He had a sister.	0	0	4	17
	His father was quiet and his mother was dominating.	0	0	3	13
	Other.	0	0	3	13
Marriages and children	Two marriages. / He was married more than once.	0	0	15	65
	He had three children.	0	0	4	17
	He gave one of his children up for adoption.	0	0	4	17
	Other.	0	0	12	52

According to Table 4, while none of the prospective teachers provided information about Einstein's family in the pre-test, in the post-test the prospective teachers stated that he had sister, and that he had a quiet father and a dominant mother. Similarly, with regard to his marriages and children, 65% of the prospective teachers stated that he was married twice. In addition, some prospective teachers mentioned the number of children he had and that one of his children was given up for adoption. For example, Ö8 wrote that "*He had two wives. He had three children from his first wife. He had no children from his second wife*", Ö15 wrote that "*Meanwhile, he met a woman of Serbian origin and got married to her and had two sons. His children, Eduard and Hans…He got divorced from his wife and married his aunt's daughter, Malive."*

In the "other" category, it was stated that one of his sons was schizophrenic and that one of his sons was a faculty member.

Category 4: His studies

The subcategories in the studies category and the number and percentages of their presence in the responses of the prospective teachers are given in Table 5.

Table 5: Subcategories in the Studies Category and Numbers and Percentages of Prospective Teachers

Subcategories	Codes	Pre-test		Post-test	
		f	%	f	%
Study field/fields	Physics.	6	26	13	57
	Physics and Mathematics.	4	17	2	9
	Physics and Chemistry.	0	0	1	4
Subjects of study	The theory of relativity.	3	13	14	61
	Space-time.	0	0	4	17
	Electromagnetism/magnetism.	0	0	6	26
	Photon/photoelectric incident.	0	0	8	35
	Other issues in modern physics (quantum physics, $E=mc^2$etc.).	13	57	9	39
	Other.	0	0	10	44
Awards	He was awarded the Nobel Prize.	0	0	11	48
	He was awarded the Nobel Prize in Physics.	2	9	3	13

Examining Table 5, the number of prospective teachers who provided information about Albert Einstein's studies was higher in the post-test.

When the codes that stand out in the "study fields" subcategory are examined, it can be seenthat the highest number of prospective teachers stated that he studied physics, both in the pre-test and the post-test. In the "subjects of study" subcategory, the prospective teachers mostly emphasized (61%) the theory of relativity. Two prospective teachers stated that he had received the Nobel Prize in the pre-test and 14 prospective teachers (61%) in the post-test. For example, in the post-test, Ö2 wrote that "*He studied the photon, heat, electromagnetism, the theory of relativity, e = mc2. He received the Nobel Prize in Physics for the photon*", Ö12 wrote that "*He made great achievements in fields such as photo electricity, space-time, relativity, and the atom*", Ö24 wrote that "*He conducted many studies in the field of physics. He was awarded the Nobel Prize…He put forward the theory of relativity. He said there is no speed in space faster than the speed of light*."

Category 5: Places of Residence

The subcategories in the category of places of residence and the number and percentages of their presence in the answers of the prospective teachers are given in Table 6.

Table 6: Codes in the Places of Residence Category and the Number and Percentages of Prospective Teachers

Codes	Pre-Test		Post-Test	
	f	%	f	%
Germany	0	0	5	22
Switzerland	0	0	1	4
USA	1	4	1	4
Other	0	0	2	9

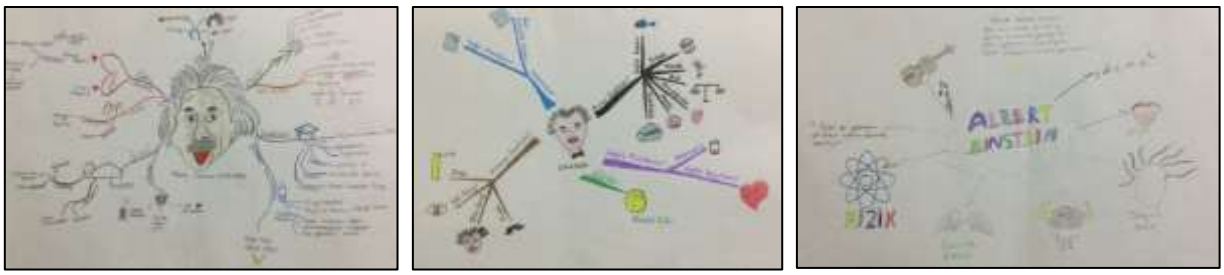
According to Table 6, in the pre-test, one prospective teacher stated that Einstein lived in the USA; in the post-test, five of the prospective teachers stated that he lived Germany, one of them Switzerland, and one of them stated that the USA was among the countries he lived in. In the other part, one of the two prospective teachers stated that he had crossed the Atlantic Ocean and the other stated that he visited countries such as the USA, Germany, France, China, Israel and Japan.

Category 6: Other

Some information that could not be categorized in the five categories described above was evaluated under this category. The fact that only one prospective teacher has mentioned in the pre-test that Einstein also worked as a teacher was placed in this category. Other information provided by 12 prospective teachers was also evaluated in this category. Five of these prospective teachers provided information about his religious beliefs, three of them have stated that he requested that his brain be examined after death, two of them mentioned that he was interested in the fields of mathematics and geometry, two of them mentioned that he also worked as a teacher and one stated that he failed to pass the university exam at his first attempt.

3.2. Findings on the Coordination of Mind Maps and Pre-Test Post-Test Results

The mind maps created by the prospective teachers who got the highest, average and lowest scores are given in Figure 1, according to the assessment made to determine to what extent the students had followed the instructions given while creating their mind maps.



a. The highest score (Ö4) b. The average score (Ö1) c. The lowest score (Ö19)

Figure 1: The mind maps prepared by the prospective teachers who got the highest, average and lowest scores

3.2.1 The Prospective Teacher Who Received the Highest Score

The codes derived from Ö1, who received the highest score, in the pre-test and the post-test are given in Table 7.

Table 7: Codes derived from Ö1

Category	Pre-TestCodes	Post-TestCodes
Birth and Death		-He was born in Germany. -Among the health problems he had during the last years of his life were at least one of the following: cardiovascular diseases / aneurism, digestion problems, anemia.
Individual Characteristics	-He was wise.	-He had aphasia during his childhood. -He was 170 cm tall. -He had brown eyes. -He had black hair. -He had a mustache. -He had distinguishing facial characteristics.* -He was sincere. -He liked being alone. -One of his hobbies was music. -One of his hobbies was taking boat trips.* -He could not drive (subcode of other).*
Family Information		-He was the only son in the family (subcode of other).* -He had a sister. -He got married twice. -His son Hans became a Hydraulics Professor (subcode of other).
His Studies	-He studied mathematics and physics.	-One of his areas of study was the theory of relativity. -One of his areas of study was magnetism. -He was awarded the Nobel prize.
Places of Residence		
Other	-His brain is an exhibit in a museum.	-He requested that his brain be examined.

*These codes do not exist in the mind map prepared by the prospective teacher

When the sentences in the post-test from which the codes were derived were analyzed, it was seen that Ö1 mentioned the points marked in the circles in Figure 2. Figure 2 shows that most of the information that Ö1 included in the mind map was mentioned in the post-test. It was found that the prospective teacher provided additional information which had not been included in the mind map. The incorrect information that "his brain is an exhibit in a museum", which was found in the pre-test was not found in the post-test and in relation to this information, the information that "he requested that his brain be examined", was found instead in the post-test, and was a fact in the notes given to the prospective teachers.

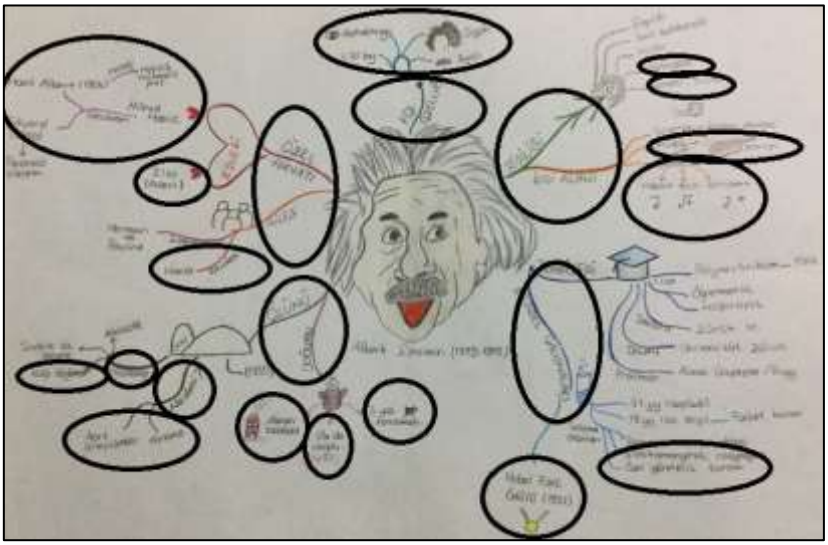


Figure 2: Mind map on which information given by Ö1 in the post-test is marked

3.2.2 The Prospective Teacher Who Received the Average Score

The codes derived from Ö22, who received the average score, in the pre-test and post-test are given in Table 8.

Table 8: Codes derived from Ö22

Category	Pre-TestCodes	Post-TestCodes
Birth and Death		-He was born in Germany.* -He was born in the 19th Century.* -Among the health problems he had during the last years of his life were at least one of the following: cardiovascular diseases/aneurism, digestion problems, anemia. -He died at the age of 76.*
Individual characteristics		-He had aphasia during his childhood.* -He was 170 cm tall. -He had brown eyes. -He had a mustache. -He was sincere. -He had a sense of humour. -He liked being alone.*
Family information		-His father was quiet and his mother was domineering.*
His studies	-His field of study was physics. -One of his areas of study was the theory of relativity.	-One of his areas of study was the theory of relativity. -He was influenced by Planck's studies (the subcode of other).* -He was awarded the Nobel Prize of Physics.
Places of residence		
Other	-He was expelled from the school because of mental retardation.	

* These codes do not exist in the mind map prepared by the prospective teacher

When the sentences in the post-test from which the codes were derived were analyzed, it was found that Ö22 mentioned the points marked in the circles in Figure 2. Figure 2 shows that observed that Ö22designed the mind map as a summary and that most of the information it included was mentioned in the post-test. In addition, it was found that Ö22provided information which was not included in the mind map. This information was more compliant with the instructions about how to create the mind map than in the case of Ö1, who received the highest score. The incorrect information that "he was expelled from school because of mental retardation", which was found in Ö22 's pre-test was not found in the post-test.

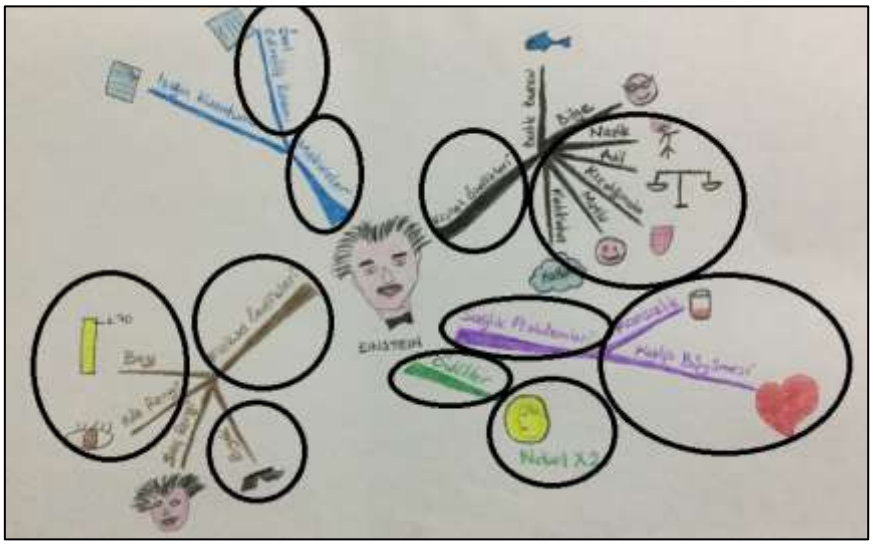


Figure 3: Mind map on which information provided by Ö22 in the post-test is marked

3.2.3 The Prospective Teacher Who Received the Lowest Score

The codes derived from the pre-test and post-test of Ö23, who received the lowest score, are given in Table 9.

Table 9: Codes derived from Ö23

Category	Pre-TestCodes	Post-TestCodes
Birth and death		
Individual characteristics	-He was wise (smart). -He was a person who did not give up.	-One of his hobbies was music
Family information		
His studies	-He invented the light bulb.	-He studied physics. -He discovered the formula "$E=mc^{2}$" (the subcategory of the other: modern physics subjects). -He split the atom(the subcategory of the other: modern physics subjects).* -He wrote many articles (the subcategory of other).* -He was awarded the Nobel prize.*
Places of residence		
Other		

* These codes do not exist in the mind map prepared by the prospective teacher

When the sentences in the post-test from which the codes were derived were analyzed, it was seen that Ö23 mentioned only three pieces of information that are marked in the circles in Figure 4. He additionally mentioned three other pieces of information which were not included in the mind map. The information that "he split the atom", which was included in the post-test is incorrect. The incorrect information that "he invented the light bulb", which was found in the pre-test, was not found in the post-test.

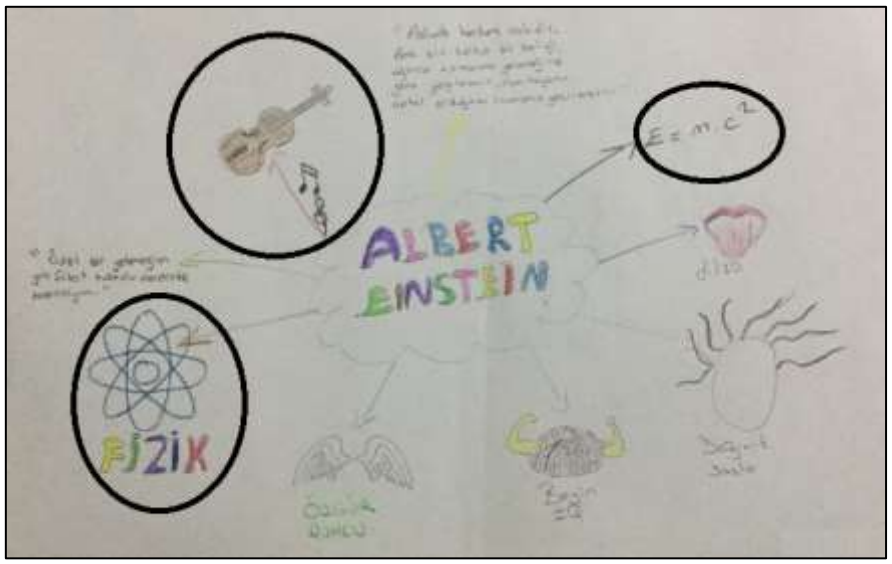


Figure 4: Mind map on which the information provided by Ö23 in the post-test is marked

When the mind maps were examined in general, the prospective teachers whose mind maps were of higher quality provided more information about the life of Einstein, as can be seen by comparing the three mind maps presented here.

4. Discussion and Conclusion

This research investigated the effects of creating a mind map on prospective science teachers' learning about the lives of scientists. During the research, prospective teachers individually created a mind map about Albert Einstein's life using notes given to them. The prospective teachers were asked what they knew about Albert Einstein before and after creating the mind map. When the research was evaluated, it was determined that prospective teachers provided very limited information about the birth and death of Albert Einstein, his individual characteristics, family information, studies, places of residence and various other subjects before creating a mind map. However, they provided comprehensive information after creating the mind map. Therefore, it is possible to say that mind-mapping had a positive effect on prospective science teachers' learning about lives of scientists. Although a study conducted with mind maps to teach the lives of scientists could not be found in the literature, research on the use of mind maps in science education has shown that creating a mind map increases students' academic achievement and level of understanding of concepts (Abi-El-Mona & Abd-El-Khalick, 2008; Gömleksiz & Fidan, 2013; Çakmak, Gürbüz & Oral, 2011; Steyn & Boer,

1998). In fact, in some studies that investigated the retention of the information (Akıncı, 2015; Gömleksiz & Fidan, 2013; Yaşar 2006), it was determined that the use of mind map permanently increased levels of success.

In this study, some prospective teachers were found to still have incorrect knowledge after the activity. For example, one prospective teacher stated that Einstein died at the age of 66, another prospective teacher stated that he could not walk until the age of three, and another stated that Einstein was the person who discovered the atom. There may be various reasons for how this incorrect information came about. For example, in the one-week period in which the prospective teachers were creating their mind maps using the notes, they may also have done research on the internet and have found incorrect information online. Or they may have misremembered some of the information in the notes they read (for example, a prospective teacher stated Einstein died at the age of 66, although the notes given stated that he died at76).Another reason for incorrect information persisting after the activity might be that the mind-mapping itself might have helped them to recall that incorrect information. Such incorrect information is always a problem in teaching processes. To minimize such problems, one solution may be the use of mind maps in coordination with other methods, techniques and tools. Various studies have been conducted with results that support this solution. These studies have included the use of mind map software in a computer environment during the course (Al-Jarf, 2009), the use of mind maps and concept maps in coordination (Evrekli & Balım, 2010), the use of mind maps in cooperative learning (Ismail, Ngah & Umar, 2010), the use of the vee diagram and the mind map together (Bütüner, 2006), the use of mind maps within the 7E model (Aydin et al., 2008). Another way to minimize the problems related to incorrect information in students might be to include mind-mapping activities in the course as in the abovementioned research. In this way, the teacher will be able to better monitor the process.

Although the fact that students retained incorrect information is a problem, there is also a positive aspect in terms of educational processes. In this study, it was clearly seen that mind maps revealed students' incorrect knowledge. These tools can thus be used before the teaching in order to determine the students' prior knowledge in detail; they can also be used in a process of data collection after teaching for evaluation and troubleshooting. Brinkmann (2005) states that teachers can easily detect and correct the incorrect connections that occur in the minds of their students with mind maps. He also states that the students' structures of knowledge can become visible for the students themselves as well as for the teacher by using mind maps. Wheeldon (2011), on the other hand, found that the participants' desire to provide summarizing and reflective answers in the data collection process increased after completing mind maps. In addition, he found that participants who had completed the mind maps made more contributions with longer responses and provided more concrete examples.

Another noteworthy point in this research is that some of the prospective teachers provided information about some aspects of Einstein in the post-test that they did not mention in the pre-test and which were not included in the reading notes. One of the reasons for this may be that mind-mapping might have helped them to recall

information they did not remember during the pre-test, in the process of organizing the existing information in their minds. Therefore, mind maps can be used to help students to remember and organize their preliminary information at the beginning of the teaching, since they reveal the existing structure of knowledge in individuals and at the same time help them to recall information in the process of organizing it. Another reason for the different information given in the post-test may be that prospective teachers might have made inferences based on the notes they read. This can be seen as an indication that their minds were active during this process. Another reason why prospective teachers provided information which they have not mentioned in the pre-test and which were not included in the notes may be that they had viewed additional resources in the process of creating the mind map. This possibility can be considered as an indication that their interest and curiosity may have increased, which is very important in science education. In relation to this interest and curiosity, there are also studies in which it was found that mind maps positively affected students' attitudes towards and interests in the course (Gömleksiz & Fidan, 2013; Bastem, 2012; Yaşar, 2006). In his study, Trevino (2005) found that students had a positive attitude towards mind-mapping and found mind-mapping fun. Keles (2012) found, in his research conducted with teachers that they thought that the mind maps made the classes more enjoyable. According to Weinstein (2014), mind maps are the antidote for sleepy classes and boring summaries.

Another noteworthy finding in this study is that the incorrect information such as “his brain is an exhibit in a museum”, “he was expelled from school because of mental retardation”, and “he discovered the light bulb”, which were found in prospective teachers’ answers before they had created a mind map, as in the examples of Ö1, Ö22 and Ö23 above, were not found in the post-test. One of the reasons for this may be that the prospective teachers might have noticed and corrected the incorrect information during the process of creating the mind map.

Finally, an important finding in this study is that the prospective teachers who had prepared mind maps of a high quality provided much more information in the post-test than those who have prepared less high quality ones. This finding should be taken into consideration by educators who plan to conduct mind-mapping activities with their students or plan to use mind maps in their teaching processes. If educators help students to adopt the process of creating mind maps by designing a large number of mind maps and creating their own styles, this will affect the teaching process positively.

To sum up, as a result of this research it was seen that mind maps had a significant positive effect on the teaching of scientists' lives. However, the incorrect information detected in some of the prospective teachers' responses may have been inculcated in the process of creating a mind map, or may have been present beforehand. Conducting different studies to investigate how this incorrect information comes to be present may contribute to the literature.

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