



ANALYSIS OF THE CHANGE IN THE AWARENESS OF PRIMARY SCHOOL PRE-SERVICE MATHEMATICS TEACHERS ON FAMOUS MATHEMATICIANSⁱ

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Abstract:

This study is a qualitative study that seeks to analyse the awareness of primary school pre-service mathematics teachers on famous mathematicians and to examine the change in their awareness. It is designed as exploratory case study. The study group consists of 30 primary school pre-service mathematics teachers, who are senior-level students in the department of primary school mathematics teaching in the 2017-2018 academic year. The data were gathered through the open-ended forms with questions on a total of 27 famous mathematicians, who lived from the Ancient Greek Period to the Modern Period. The data analysis was performed using content analysis. The information of the pre-service teachers on famous mathematicians were analysed under two categories: scientific contributions and personal characteristics. The analysis of the data obtained from the pre-service teachers showed that the famous mathematicians most known by them before the course of History of Mathematics were Euclid, Pythagoras, Pascal, Thales, Newton, Bernoulli and Gauss whilst the pre-service teachers were most knowledgeable about Euclid, Pythagoras, Pascal, Newton, Bernoulli, Fermat, Fourier, Al-Khwarizmi, Thales, Gauss, Euler, Omar Khayyam and Leibniz after the course of HoM (History of Mathematics). This study also revealed that the pre-service teachers had less information on the personal characteristics of mathematicians whereas they had more information on their scientific contributions. Moreover, some pre-service teachers had inaccurate information on famous mathematicians. In conclusion, it is notable that the awareness of the pre-service teachers on famous mathematicians increased after the course of HoM, but the increase was not at the desired level.

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1. Introduction

Mathematics, which is an indicator of development and plays a major role in shaping societies, has become an integral part of human beings' survival. So much so that individuals who do not have basic math skills are expected to experience difficulties even in their daily life. Mathematics is a cornerstone from many aspects and in many areas from knowing what time it is, shopping at a market, to industry, zoology and space science, medical sciences and social sciences. Further, many examinations such as student selection examinations and professional competency exams measure mathematical reasoning (Gür, 2004). As such, it is requisite that students become mathematically literate individuals. Indeed, *“a mathematically literate individual has the capacity of identifying and understanding the role played by mathematics in the world, of making sound judgements and using and engaging with mathematics as a constructive, concerned and reflective citizen.”* (OECD, 2006, p.10). Moreover, according to Tekin and Tekin (2004), the characteristics of a mathematically literate individual consist of four components as the dimension of subject area of mathematics, the dimension of mathematical processes, the dimension of topicality and the dimension of historical development of mathematics; in order to become mathematically literate, one needs to know about the history of mathematics (HoM) including the historical development process of mathematics, famous mathematicians and their contributions.

It is essential that one is able to look mathematics from different angles, to take inspiration from the life of famous mathematicians and to discover the philosophical aspect of mathematics in order to learn about the history of mathematics, which is a component of mathematical literacy (Ponce Campuzano, Matthews and Adams, 2018; Schubring, 2018). Many researchers explained why one needs to learn about HoM, which is prerequisite to be a mathematically literate individual, or why HoM should be integrated to math courses. For these questions, the following answers can be listed: HoM enables students to learn mathematics more easily, increases their motivation, allows them to see how concepts are developed and understand concepts, helps them explain the role of mathematics in the society, highlights the human aspect of mathematics, makes mathematics more interesting and comprehensible, reduces students' fears of mathematics, provides alternative approaches to mathematical problems, improve teachers' repertoire of teaching, supports students 'and teachers' attitudes and motivations towards mathematics (Ho, 2008; Panasuk and Horton, 2012; Jankvist, 2009; Tzanakis et al., 2002; Gulikers and Blom, 2001; Fauvel, 1991; Liu, 2003).

Given the positive effect of HoM on teaching mathematics, a new question arises: *“How one can integrate HoM into math courses?”* There are numerous different arguments on how to integrate HoM into math courses. Bidwell (1993) reported that showing the pictures of famous mathematicians and telling their life stories, providing

historical materials, discussing the historical development of course subjects a part of the lesson are ways to integrate HoM into math courses. Reimer and Reimer (1995) stated that HoM can be integrated into math courses through reading stories on mathematics in the classroom, asking students to write articles about HoM, playing games about HoM as well as through hands-on experiences, arts and visual arts. Jahnke (2000) argued that reviewing the biographies, handwritings and original documents of famous mathematicians, and creating visual images such as birthday celebrations, timelines and portraits are ways to integrate HoM. Tzanakis et al. (2002) claimed that historical snippets, research projects, primary sources, worksheets, historical packages, historical problems, mechanical instruments, experiential mathematical activities, plays, films and other visual means, outdoors experiences and the World Wide Web can support the integration of HoM into math courses. Swetz (2001) emphasized that it is possible to integrate HoM through explaining the historical origins of operations and mathematical terms, using short stories about the life and work of mathematicians about the course subject, asking students to perform active historical activities, creating timelines, discussing real historical problems in the classroom, using appropriate visual aids, assigning research projects on a specific achievement or mathematician. According to Fried (2001), HoM can be integrated into math courses through addition and adaptation strategies. Examples of addition strategies can be the use of some historical problems and short biographies of mathematicians in the course. Adaptation strategies involve the use of historical developments in explaining a technique or opinion. Another approach in the integration of HoM into math courses was introduced by Jankvist (2009); this approach consists of the illumination, the modules and the history-based approaches. In the illumination approaches, math courses are supported by historical information in varying scope. This approach is similar to historical snippets proposed by Tzanakis et al. (2002) and addition strategy introduced by Fried (2001). On the other hand, the modules are instructional units that vary in size. Historical packages proposed by Tzanakis et al. (2002) are similar to the modules. The history-based approaches are based on the development of HoM and deal with the study of HoM in an indirect fashion, unlike the modules.

It is notable that there are many ways of integrating HoM into math courses and using the life stories of famous mathematicians are included in almost all strategies put forward.

In fact, it is known that using famous mathematicians to teach math has many benefits for students. According to Siu (1993), different approaches embraced by different mathematicians regarding a specific mathematical concept encourage students to adopt different perspectives. This enriches the learning experience and supports the creativity of students. Kathumba (2017) reported that students can draw on the knowledge and skills of famous mathematicians to enhance their own reasoning skills and to become critical thinkers and make sense of mathematical concepts by imitating them. Further, students can acknowledge the challenging, struggling and problematic life adventures of some mathematicians involved in a process whereby they discover certain concepts or

theorems, and see that these mathematicians continue to work without giving up despite everything; this will improve their diligence and perseverance and encourage them to believe that they can be successful in mathematics (Fauvel, 1991; Jankvist, 2009, Mersin, 2019). Philippou and Christou (1998) argued that students thus realize that even great mathematicians may make mistakes and it is normal to make mistakes and become confident that even though they make mistakes, they can still understand and be successful in mathematics. Kayan Fadlelmula (2015) stated that students can improve themselves intellectually by learning about famous mathematicians.

The knowledge of students on the contributions of mathematical scientists to science and their ways to access information may be indicator for the level of their mathematical literacy. Moreover, they can act like mathematicians during HoM-related activities. In this way, students can get more from the lesson as their attitudes and motivations towards the lesson increase. Teachers play a great role as they apply curricula and organize the learning environment for students to learn about the life stories of famous mathematicians, including their contributions to science, the methods they used to solve problems and the difficulties they faced. The four-year higher education process for teacher training is considered ideal for learning such information. The course of HoM, which was a compulsory elective course for the senior-level students in the department of primary school mathematics teaching before 2018, is now a compulsory course for the freshman-level students in the same department and regarded as a key step for pre-service teachers to learn about famous mathematicians and their contributions to science or to improve their existing knowledge. These being said, this study seeks to the awareness of pre-service teachers about their knowledge on famous mathematicians prior to the course of HoM and after attending the course of HoM.

In the literature, there are studies offering an analysis of the knowledge of high-school students about famous physics scientists (Kapucu and Çılgın, 2016), the level of knowledge of pre-service science teachers about scientists (Bozdoğan, Şengül and Bozdoğan, 2013; Görecek Baybars, 2018; Şahin, Sarıtaş and Tufan, 2019), the perceptions of pre-service teachers on scientists (Ürey, Karaçöp, Göksu, Çolak, 2017; Erdoğan, 2018; Çermik, 2013; Şenel and Aslan, 2014) as well as the images of pre-service teachers on mathematicians (Yazlık and Erdoğan, 2018). However, there is no research on the informational awareness of primary school mathematics teachers on famous mathematicians and the change in this awareness with the course of HoM. The findings of this study will also provide insights into how pre-service teachers can improve their knowledge on HoM.

2. Method

This study seeks to explore the current awareness of primary school pre-service mathematics teachers on famous mathematicians in history and to find out how it changed after the course of HoM. For that reason, this study, which aims to explore how this awareness changes after the course of HoM, is designed as exploratory case study

with its analysis unit being “the awareness of pre-service teachers on famous mathematicians.”

2.1. Study Group

The sample of the study consists of 30 primary school pre-service mathematics teachers (25 female, 5 male), who currently pursue their education in the department of primary school mathematics teaching in a university located in the Western Black Sea region in the 2017-2018 academic year. The pre-service teachers are senior-level students and previously attended the courses of special teaching methods I, special teaching methods II and history of science in the junior level. Also, they are to attend the course of HoM for the first time.

2.2. Data Collection Tools and Practice

As the data collection tool, this study utilized a written form that presents 27 mathematicians who lived in the Ancient Greek, Ancient China, Indian Civilization, Turkish-Islamic and Modern mathematics periods. This form was administered to the pre-service teachers before and after the course of HoM to analyse the change in the informational awareness of the pre-service teachers on famous mathematicians. The following mathematicians were included in the form: Thales, Pythagoras, Euclid, Eratosthenes, Ptolemy, Heron, Diophantus, Liu Hui, Brahmagupta, Al Khwarizmi, Khayyam, Cardano, Napier, Descartes, Fermat, Pascal, Newton, Leibniz, Bernoulli, Euler, Fourier, Gauss, Cauchy, Labachevsky, Abel, Hilbert and Ramanujan. These mathematicians were obtained from the web-site <https://mathshistory.st-andrews.ac.uk/> and attention was paid to ensure that these mathematicians are those most encountered by the pre-service teachers. For the validity purposes of this form, an expert specialized in HoM was consulted. The expert confirmed the suitability of the form for determining awareness on famous mathematicians. The written form was applied by two researchers. There was no time limit for the application, but it took about 25 minutes. The pre-service teachers were asked to answer the form honestly without interacting with each other.

The course of HoM, which lasted for 14 weeks, provided information on early number systems and symbols, Ancient Egyptian Mathematics, Babylonian Mathematics, Ancient Greek Mathematics and mathematicians, Chinese mathematics and mathematicians, Turkish-Islamic Mathematics and mathematicians, Indian Mathematics and mathematicians, Modern period mathematics and mathematicians. Also, tasks involving the use of Lattice multiplication method, Mayan numeral system, the Spiral of Theodorus, Al-Khwarizmi’s method of completing the square, Babylon-Archimedes-Heron’s method of computing square root, Ancient Egypt multiplication and division methods, Russian peasant multiplication method, the calculation of an approximate value of Pi number, the calculation of a Pythagorean triple, ancient algebraic symbols, calculating the GCD with Euclid algorithm, Chinese remainder theorem and decryption activities were performed during the course. The pre-service teachers watched

documentaries on HoM (The Bright World of Mathematics, Math Stories, Andrew John Wiles).

2.3. Data Analysis

The data obtained from the primary school pre-service mathematics teachers were analysed through qualitative data analysis methods. In the data analysis, a code was given to each meaningful statement written by the pre-service teachers. These codes were later grouped under categories. First, the information of each pre-service teacher on famous mathematicians was coded. For example, codes such as 'Euclid's division algorithm', 'space geometry', 'triangle similarity theorem', 'The Bernoulli family' were developed. More meaningful statements were used to present these codes. For instance, the coded identified as 'Euclid's division algorithm' was expressed as 'the student discovered Euclid's division algorithm.' The common features of codes and studies in the literature were considered in determining the categories. That is, the codes developed were grouped under two main categories: the contributions of famous mathematicians to science and personal characteristics.

To ensure the reliability of the study, the data analysis was reviewed by two researchers. The data were first analysed by one of the researchers and then converted into MS Excel. Later, the two researchers together reviewed the data and checked the written forms. There were few disagreements between the two researchers, which were eliminated later. Lastly, the two researchers grouped the codes under categories and ensured the reliability of the findings.

3. Findings

The data were gathered from the pre-service teachers through the open-ended forms that presented questions on famous mathematicians. First, the knowledge of the pre-service teachers on mathematicians was examined. Those who wrote anything on mathematicians in the form were considered knowledgeable whilst those who left it blank were not considered knowledgeable. Table 1 presents the percentages and frequency distributions.

Table 1: The Frequency Distributions and Percentages of the Pre-Service Teachers Knowledgeable on Famous Mathematicians Before and After the Course of HoM

No	Mathematicians	Those Knowledgeable Before the Course of HoM		Mathematicians	Those Knowledgeable After the Course of HoM	
		f	%		f	%
1	Euclid	21	70	Euclid	30	100
2	Pythagoras	20	66.6	Pythagoras	27	90
3	Pascal	18	60	Pascal	25	83.3
4	Thales	17	56.6	Newton	23	76.6
5	Newton	17	56.6	Bernoulli	23	76.6
6	Bernoulli	17	56.6	Fermat	23	76.6

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7	Gauss	15	50	Fourier	23	76.6
8	Fermat	14	46.6	Al-Khwarizmi	23	76.6
9	Fourier	12	40	Thales	22	73.3
10	Omar Khayyam	9	30	Gauss	22	73.3
11	Descartes	9	30	Euler	20	66.6
12	Cauchy	9	30	Omar Khayyam	19	63.3
13	Leibniz	8	26.6	Leibniz	18	60
14	Euler	8	26.6	Heron	14	46.6
15	Al-Khwarizmi	6	20	Descartes	12	40
16	Hilbert	5	16.6	Cardano	11	36.6
17	Ramanujan	5	16.6	Cauchy	9	30
18	Liu Hui	4	13.3	Brahmagupta	9	30
19	Heron	3	10	Diophantus	7	23.3
20	Abel	3	10	Hilbert	6	20
21	Eratosthenes	2	6.6	Ramanujan	6	20
22	Diophantus	2	6.6	Liu Hui	6	20
23	Brahmagupta	2	6.6	Napier	6	20
24	Ptolemy	1	3.3	Abel	5	16.6
25	Cardano	1	3.3	Eratosthenes:	4	13.2
26	Napier	0	0	Ptolemy	2	6.6
27	Lobachevsky	0	0	Lobachevsky	1	3.3

As seen in Table 1, more than half of the pre-service teachers were knowledgeable about Euclid, Pythagoras, Pascal, Thales, Newton, Bernoulli and Gauss before attending the course of HoM. Also, more than 80% of them were not knowledgeable about Hilbert, Ramanujan, Liu Hui, Heron, Abel, Eratosthenes, Diophantus, Brahmagupta, Ptolemy, Cardano, Napier and Lobachevsky. It is notable that the number of the pre-service teachers providing information on all famous mathematicians increased after the course of HoM. Further, this study revealed that more than half of the pre-service teachers were knowledgeable about Euclid, Pythagoras, Pascal, Newton, Bernoulli, Fermat, Fourier, Al-Khwarizmi, Thales, Gauss, Euler, Omar Khayyam and Leibniz and that more than 80% were not knowledgeable about Abel, Eratosthenes, Ptolemy and Lobachevsky. It can be thus argued that the course of HoM effectively increased the awareness of the pre-service teachers on famous mathematicians.

The information that the pre-service teachers had on famous mathematicians, which was obtained through the open-ended form, were divided into two categories: information on the scientific contributions of famous mathematicians and information on their personal characteristics. Table 2 presents the information of the pre-service teachers on Euclid and Pythagoras as well as the frequency distribution of these data.

Table 2: The Knowledge Provided by the Pre-Service Teachers
on Euclid and Pythagoras and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Euclid (BC 325 -265)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
He is the founder of the Euclidean Geometry based on the 5 postulates.	8	He developed the Euclid division algorithm.	13
He discovered the Euclidean correlation for a right-angled triangle.	4	He is the Founder of the Euclidean (Plane) geometry.	9
He has axioms of geometry.	4	He wrote the book titled The Elements.	7
He worked on plane geometry.	3	He proposed geometry theorems.	6
There is a theorem called Euclid's theorem.	2	He has axioms on geometry.	5
He has a book titled The Elements.	2	He discovered the Euclidean correlation for a right-angled triangle.	4
He was interested in space geometry.	2	He worked on number theory.	1
He studied the surface of the sphere.	1	He studied algebra.	1
He worked on R , R^2 and R^3 .	1	He studied arithmetic.	1
He invented the digital calculator. *	1	He has an academy (Alexandria).	1
He has studies in the field of mathematics.	1		
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a French mathematician. *	1	He lived in the 17 th century.*	1
		He worked with Laplace.*	1
Information on Pythagoras (BC 569-475)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
There is a relationship between the sides of a right triangle known as the Pythagorean Theorem.	17	There is a relationship between the sides of a right triangle known as the Pythagorean Theorem.	23
He showed the importance of the theorem discovered by the Babylonians to the world.	1	He studied geometry.	3
He studied the movements of the world.	1	He worked on perfect numbers.	1
He founded the academy.	1	He worked on figural numbers	
		He worked on mathematics.	1
		The Pythagorean Theorem was not discovered by this person.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Greek philosopher.	1	He is a Greek mathematician.	1
He is a Greek mathematician.	2	He witnessed pyramid construction during his visit to Egypt. *	1

*Inaccurate Information.

Table 2 shows that before the course of HoM, more pre-service teachers had the knowledge that Euclid is the founder of the Euclidean Geometry based on the 5 postulates, discovered the Euclidean correlation for a right-angled triangle, has axioms

of geometry and worked on plane geometry; on the other hand, more pre-service teachers were knowledgeable about the fact that Euclid developed the Euclid division algorithm, is the founder of the Euclidean geometry, wrote the book titled The Elements, proposed geometry theorems, has axioms on geometry, discovered the Euclidean correlation for a right-angled triangle. It is remarkable that the information that the pre-service teachers had on the personal characteristics of Euclid were not accurate. The most mentioned information on Pythagoras, who lived between 569-475 BC, both before and after the course of HoM is that there is a relationship between the sides of a right triangle known as the Pythagorean Theorem. Notably, more pre-service teachers were knowledgeable about Euclid and Pythagoras after attending the course of HoM, which also enriched the type of information possessed. Further, some pre-service teachers had inaccurate information on Euclid and Pythagoras. For example, 3.3% of the pre-service teachers believed that Euclid designed a digital calculator; 3.3% stated that he lived in the 17th century and 3.3% reported that Pythagoras witnessed pyramid construction during his visit to Egypt. Table 3 presents the information of the pre-service teachers on Pascal, Thales and Newton as well as the frequency distribution of these data.

Table 3: The Knowledge Provided by the Pre-Service Teachers on Pascal, Thales and Newton and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Pascal (1623-1662)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
He discovered Pascal's triangle.	16	He discovered Pascal's triangle.	20
He worked on numbers.	3	He worked on number patterns.	6
He discovered pressure.	1	He studied probability.	5
He laid the foundation of the modern theory of probability.	1	He worked on binomial coefficients.	2
He invented the first digital calculator. *	1	He developed the calculator.	1
He studied physics.	1	He studied geometry.	1
He studied sequences.	1		
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-
Information on Thales (624- 547 BC)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He has a theorem pertaining to similar triangles.	11	He has a theorem pertaining to similar triangles.	15
He studied geometry.	3	He studied geometry.	9
He calculated the height of the great pyramid.	2	He worked on mathematics.	3
He introduced Egyptian mathematics to Greece.	1	He introduced Egyptian mathematics to Greece.	3

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		He proved that any inscribed angle in a circle that subtends the diameter is a right angle.	1
		He calculated the height of the great pyramid.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Greek philosopher.	1	There is a museum on him in Aydın.	1
He is a Greek mathematician.	1	He is Greek.	1
		He lived in Aydın.	1
		He is one of the Seven Sages of Greece.	1
Information on Newton (1643-1727)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He discovered the force of gravity.	11	He discovered the force of gravity.	9
He studied analysis.	5	He developed Newton's square root method.	6
He discovered Newton's laws of motion.	1	He worked on mathematics.	5
He studied force in physics.	1	He worked on physics.	5
He developed Newton's square root method.	1	He studied analysis.	5
He worked on physics.	1	He introduced integral calculus to mathematics.	1
He worked on mathematics.	1	He discovered Newton's laws of motion.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is the best scientist in the world.*	1	He prevented Leibniz from publishing his works.	2
He is the third person in the book of 100 people who changed the world. *	1	He is one of the great mathematicians.	1
		He was the head of a committee.	1

*Inaccurate Information.

As seen in Table 3, regarding Pascal, who lived between 1623-1662, more pre-service teachers stated that he discovered Pascal's triangle and he worked on numbers before the course of HoM whilst more pre-service teachers reported that he discovered Pascal's triangle, that he worked on numbers and he studied probability after attending the course of HoM. It is also notable that the pre-service teachers were not knowledgeable about the personal characteristics of Pascal both before and after the course of HoM. The fact that Thales has a theorem pertaining to similar triangles and studied geometry was emphasized by the pre-service teachers before the course of HoM regarding Thales, who lived between 624-547 BC. Similarly, after the course of HoM, the pre-service teachers highlighted that he has a theorem pertaining to similar triangles and studied geometry and mathematics, introduced Egyptian mathematics to Greece. Their knowledge of the personal characteristics of Thales increased after the course of HoM and they reported that Thales lived in Aydın, is one of the seven sages of Greece and there is a museum on him. The most reported information on Newton before the course of HoM was that he discovered the force of gravity and he studied analysis; on the other hand, the pre-service

teachers stated after the course of HoM that he discovered the force of gravity, developed Newton's square root method and worked on mathematics, physics and analysis. The information on his personal characteristics provided after the course of HoM were accurate whereas those provided before the course were partially accurate. Indeed, it is no doubt that he is one of the best scientists in the world, but it cannot be proven whether he is the best one. Also, he is the second person in the book of 100 people who changed the world, not the third one. Table 4 presents the information of the pre-service teachers on Bernoulli, Gauss, Fermat and Fourier as well as the frequency distribution of these data.

Table 4: The Knowledge Provided by the Pre-Service Teachers on Bernoulli, Gauss, Fermat and Fourier and the Frequency Distributions

Information on Mathematicians Before the Course of HoM	Information on Mathematicians After the Course of HoM		
Information on Bernoulli (1700-1782)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
There is a random variable called a Bernoulli random variable.	4	He studied probability.	11
He studied statistics.	3	He discovered Bernoulli's principles.	6
He studied probability.	3	He found a method of solution for differential equations.	3
He found a method of solution for differential equations.	3	He studied statistics.	2
He discovered Bernoulli's principles.	2	There is a random variable called a Bernoulli random variable.	2
There is an experiment called Bernoulli trial.	1	There is distribution named after Bernoulli, known as the Bernoulli Distribution.	2
He studied physics.	1	There is series expansion named after Bernoulli.	1
He studied mathematics.	1	He studied physics.	1
		He studied mathematics.	1
		He studied fluid mechanics.	1
		He is one of the pioneers of number theories.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a member of Bernoulli family.	1	He is a member of Bernoulli family.	2
		He is a Swiss physicist and mathematician.	1
Information on Gauss (1777-1855)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He developed Gaussian elimination method.	6	He found the formula for the sum of consecutive natural numbers.	9
He found the formula for the sum of consecutive natural numbers.	5	He developed Gaussian elimination method.	7

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He worked on Linear Algebra.	2	He studied geometry.	2
He studied geometry.	1	He studied algebra.	2
		He worked on Linear Algebra.	1
		He tried to construct non-Euclidean geometry.	1
		He worked on complex numbers.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He lost his sight. *	1	He is known as the prince of mathematicians.	2
		He is German.	2
		He studied at Göttingen University.	1
		He worked at Göttingen University.	1
Information on Fermat (1601-1665)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He is known for Fermat's Last Theorem.	9	He is known for Fermat's Last Theorem.	18
He worked on number sequences.	2	Fermat's Theorem was proved long after his death.	4
He studied analysis.	2	There is a theorem called Fermat's little theorem.	3
He studied probability.	1	He worked on the number theorem.	2
He studied algebra.	1	He studied probability.	1
He claimed that the 1 st derivative of a function is zero at the points where it goes from ascending to descending and vice versa.	1	Fermat's Last Theorem was proven by Andrew Wiles.	1
		He wrote a book where he developed and solved different problems.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
		He studied mathematics although he was a lawyer.	2
		He is a famous lawyer.	1
		He is a famous mathematician.	
Information on Fourier (1768-1830)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He worked on sequences.	9	He worked on sequences.	26
He studied algebra and analysis.	1	He studied analysis.	1
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-

*Inaccurate Information.

Table 4 shows that the most reported scientific contributions of Bernoulli, who lived in the 18th century, by the pre-service teachers before the course of HoM were that there is a random variable called a Bernoulli random variable, that he studied statistics and probability and that he found a method of solution for differential equations. After the

course, the pre-service teachers mostly stated that he studied probability, that he discovered Bernoulli's principles and that he found a method of solution for differential equations. It is remarkable that the pre-service teachers had more diversified information on Bernoulli after the course of HoM, compared to before the course. Regarding his personal characteristics, they reported that he is Swiss and from Bernoulli family. The most reported information on Gauss, who is one of the mathematicians of the 18th century, both before and after the course of HoM were that he developed Gaussian elimination method and that he found the formula for the sum of consecutive natural numbers. On the other hand, after the course of HoM, the pre-service teachers stated differently that he tried to construct non-Euclidean geometry and that he worked on complex numbers. The information on his personal characteristics provided by the pre-service teachers before the course were not accurate; yet, after the course, they correctly stated that Gauss is known as the prince of mathematicians, German, studied and worked at Göttingen University. The most reported information on Fermat, who lived in the 17th century, both before and after the course of HoM was that he is known for Fermat's Last Theorem. Also, differently from the information given before the course, the pre-service teachers reported after the course that Fermat's Theorem was proved long after his death, that it was proven by Andrew Wiles and that there is a theorem called Fermat's little theorem. The pre-service teachers failed to provide any information on the personal characteristics of Fermat before the course. However, after the course, they emphasized that he was a lawyer. The most reported information on the personal characteristics of Fourier both before and after the course of HoM was the fact that he worked on sequences. It is also notable that the pre-service teachers were not knowledgeable about the personal characteristics of Fourier. Table 5 presents the information of the pre-service teachers on Omar Khayyam, Descartes, Cauchy and Leibniz as well as the frequency distribution of these data.

Table 5: The Information Provided by the Pre-Service Teachers on Omar Khayyam, Descartes, Cauchy and Leibniz and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Omar Khayyam (1048-1131)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
He wrote the Rubaiyat poems.	2	He worked on astronomy.	3
He studied trigonometry.*	2	He studied mathematics.	3
He solved 2 nd order equations geometrically.*	2	He studied algebra.	3
He is the first person to develop the binomial expansion.	1	He wrote the Rubaiyat poems.	3
He is the first person to use the letter "X".	1	He was interested in literature.	2
He worked on number systems.	1	He is the first person to find the Pascal triangle.	2
He studied algebra.	1	He studied the number zero. *	2
He studied the number zero. *	1	He studied geometry.	1

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He proved the Pythagorean theorem with his own method. *	1	He solved 3 rd order equations.	1
		He correctly calculated the trigonometric measure of a 1 degree angle until the 6 th digit after the decimal point.*	1
		He solved 2 nd order equations with algebra tiles. *	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Turkish-Islamic mathematician.	2	He is a Turkish-Islamic mathematician.	2
		He is Iranian.	1
Information on Descartes (1596-1650)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He developed the Cartesian coordinate system.	3	He developed the Cartesian coordinate system.	3
He studied philosophy.	3	He studied mathematics.	2
He studied mathematics.	1	He contributed to studies on probability. *	2
		He studied philosophy.	1
		He studied algebra.	1
		He studied geometry.	1
		He has a work titled La Geometry.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a philosopher.	1	He is a philosopher.	3
He is French.	1	He died of pneumonia.	1
His famous statement is "I think, therefore I am."	1	He lived in Ancient Greece. *	1
		He is French.	1
Information on Cauchy (1789-1857)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He developed the Cauchy-Schwarz theorem.	6	He developed the Cauchy-Schwarz theorem.	6
He studied linear algebra.	4	He studied linear algebra.	2
He proposed a problem solution method in analysis.	2	There is a sequence named after Cauchy.	1
He developed error theory.	1	He designed a test for the convergence and divergence of the series.	1
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-
Information on Leibniz (1646-1716)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He studied analysis.	3	He studied analysis.	8
He worked on differential equations.	3	There is a law called after Leibniz.	4
There is a theorem called Leibniz's theorem.	3	He worked on differential equations.	3
He found a theorem in analytics.	1	He developed some theorems simultaneously with Newton.	2
		He studied algebra.	1

		He studied sequences.	1
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-

*Inaccurate Information.

As seen in Table 5, before the course of HoM, the pre-service teachers mostly stated on Omar Khayyam, who lived between 1048-1131, that he wrote the Rubaiyat poems in the field of literature, that he found the binomial expansion and that he is the first to use the letter X for the unknown. After the course, the most reported information on Omar Khayyam were that he studied astronomy, mathematics and algebra and that he wrote the Rubaiyat poems. It is notable that the pre-service teachers did not know much on the personal characteristics of Omar Khayyam, but some stated that he is a Turkish-Islamic mathematician. Also, the pre-service teachers may have mistaken Omar Khayyam for Al Khwarizmi, as some information provided by them belonged to Al Khwarizmi, not Omar Khayyam. An example for this is the statement that Khayyam studied the number zero. The most reported scientific contribution of Descartes, who lived in the 17th century, both before and after the course of HoM was that he developed the Cartesian coordinate system. As for his personal characteristics, the pre-service teachers emphasized that he is a philosopher. The pre-service teachers may have considered Descartes more like a philosopher rather than a mathematician because of his popular phrase "I think, therefore I am." The statement that he contributed to studies on probability is not accurate. As for Cauchy, the most reported information on Cauchy, one of the foremost mathematicians, by the pre-service teachers both before and after the course of HoM were that he developed the Cauchy-Schwarz theorem and that he studied linear algebra. It is notable that they did not have any information on his personal characteristics. The most reported information on Leibniz, who lived between 1646-1716, before the course of HoM were that he studied analysis, that he worked on differential equations and that there is a theorem called Leibniz's theorem. Following the course of HoM, the pre-service teachers highlighted that he studied analysis, that there is a law called after Leibniz and that he worked on differential equations. It should be noted that the pre-service teachers did not have any information on his personal characteristics. Table 6 presents the information of the pre-service teachers on Euler, Al-Khwarizmi, Hilbert and Ramanujan as well as the frequency distribution of these data.

Table 6: The Information Provided by the Pre-Service Teachers on Euler, Al-Khwarizmi, Hilbert and Ramanujan and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Euler (1707-1783)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
There is a theorem named after Euler.	3	There is a theorem named after Euler.	6
There is a constant named after Euler.	1	He developed Euler's formula.	4
He developed Euler's formula.	1	There is a constant named after Euler.	3

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He developed a solution method for differential equations.	1	He calculated the series expansion of trigonometric functions.	2
He worked on sequences and series.	1	He studied sequences.	2
He studied analysis.	1	He studied complex numbers.	1
He studied trigonometric functions.	1	He studied differential equations.	1
		He studied analysis.	1
		He worked on logarithm.	1
Information on his Personal Characteristics	-	Information on his Personal Characteristics	
		He was studying at St. Petersburg Academy in 1724.	1
Information on Al-Khwarizmi (790-850)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He studied algebra.	2	He discovered the number zero.	9
He discovered the number zero.	2	He studied astronomy.	
He brought the zero to Europe.	1	He studied algebra.	8
He studied the distance between two meridian arcs.	1	He developed a solution method for 2 nd order equations by completing the square.	3
		He has a work titled Hisab Al jabr wal muqabalah.	2
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Turkish-Islamic mathematician known as Algorithm in Europe.	1	He is known as the father of algebra.	7
He is known as the father of algebra.	1	He is one of the most famous mathematicians in the Middle East.	2
		He is a Turkish-Islamic mathematician.	2
		He served in Bayt al-Hikma.	1
Information on Hilbert (1862-1943)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He has works known as Hilbert plane works. *	1	He studied analysis.	2
He developed the infinity theory.	1	There is a space named after Hilbert.	2
He studied physics.	1	He worked on axiomatizations.	1
He worked on axiomatizations.	1	He developed the infinity theory.	1
		He has works known as Hilbert plane works. *	1
		He was interested in geometry.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a mathematician.	1	His name is David.	2
		He is a Mathematics Philosopher.	1
Information on Ramanujan (1887-1920)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He studied analysis.	1	He worked on number patterns.	2

He studied differential equations.	1	He worked on equations.	1
He worked on number patterns.	1		
He developed his own theorems.	1		
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is Indian.	3	He is Indian.	3
He is a mathematician with no formal training.	2	He is a mathematician with no formal training.	3
		He is French*	

*Inaccurate Information

Table 6 shows that three pre-service teachers mentioned on the scientific contributions of Euler before the course of HoM that there is a theorem named after Euler. Also, the facts that there is a constant named after Euler, that he developed a solution method for differential equations and that he worked on sequences and series were reported by only one pre-service teacher. After the course of HoM, the most reported scientific contribution of Euler by the pre-service teachers was Euler's theorem, Euler's formula, Euler's constant and his works on series expansion. The only information given regarding his personal characteristics, which was the fact that he was studying at St. Petersburg Academy in 1724, was provided after the course. The most reported scientific contribution of Al Khwarizmi, who lived in the 9th century, by the pre-service teachers before the course was that he studied algebra and discovered the number zero. After attending the course, the pre-service teachers mentioned that he discovered the number zero, studied astronomy, developed a solution method for 2nd order equations by completing the square and has a work titled Hisab Al jabr wal muqabalah. Also, on his personal characteristics, they reported that Al Khwarizmi is known as the father of algebra, is one of the most famous mathematicians in the Middle East and is a Turkish-Islamic mathematician. It is notable that the information of the pre-service teachers on the personal characteristics and scientific contributions of Al Khwarizmi increased after the course. As for Hilbert, who lived between 1862-1943, the most emphasized information before the course of HoM was that Hilbert studied analysis and spaces. Some pre-service teachers mentioned that he is a mathematics philosopher. Remarkably, the pre-service teachers had more information on the personal characteristics of Ramanujan, who is another prominent mathematician. The most notable information on him both before and after the course of HoM was that he did not receive formal training and he is Indian. Further, one of his highlighted scientific contributions was that he worked on number patterns. Table 7 presents the information of the pre-service teachers on Liu-Hui, Heron, Abel, Eratosthenes and Diophantus as well as the frequency distribution of these data.

Table 7: The Information Provided by the Pre-Service Teachers on Hui, Heron, Abel, Eratosthenes and Diophantus and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Liu Hui (220-280)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
He proposed the Chinese Remainder Theorem.	2	He proposed the Chinese Remainder Theorem.	2
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Chinese mathematician.	2	He is a Chinese mathematician.	5
Information on Heron (10-75)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He has a method to calculate the square root.	2	He has a method to calculate the square root.	9
		He developed the formula to find the area of a triangle.	3
		He discovered the area of quadrilaterals.	1
		He studied triangles.	
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is a Greek mathematician.	1	He is a Greek mathematician.	1
Information on Abel (1802-1829)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He studied algebra.	3	He studied algebra.	4
He worked on the number theory.	1		
Information on his Personal Characteristics		Information on his Personal Characteristics	
He died at a young age.	1	He is a mathematician who was disregarded by Gauss.	1
		His work was recognized after his death.	1
Information on Eratosthenes (MÖ 276-194)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
There is a sieve named after Eratosthenes to find prime numbers.	2	There is a sieve named after Eratosthenes to find prime numbers.	4
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-
Information on Diophantus (200-284)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He worked on the root of 1 st order equations with one unknown.	1	He worked on the root of 1 st order equations with one unknown.	3
He has a work titled Aritmetica.	1	There are equations named after Diophantus.	2

There are equations named after Diophantus.	1	He has a work titled Aritmetica.	1
		He studied algebra.	1
Information on his Personal Characteristics	-	Information on his Personal Characteristics	-

*Inaccurate Information

As seen in Table 7, the only information provided by the pre-service teachers on the scientific contributions of Liu Hui that he developed the Chinese Remainder Theorem and on his personal characteristics that he is Chinese. Although there was no new information provided by them after the course of HoM, the number of the pre-service teachers that mentioned these facts increased. As for Heron, two pre-service teachers mentioned about his method to calculate the square root before the course of HoM and mentioned about his method to calculate the square root as well as formula to find the area of a triangle after the course. Regarding his personal characteristics, they only reported that he is Greek. On Abel, the pre-service teachers stated that he studied algebra. Yet, it is notable that they did not have much information on the scientific contributions of Abel, who died at a young age. Likewise, the pre-service teachers reported on Eratosthenes both before and after the course of HoM that there is a sieve named after Eratosthenes to find prime numbers. The number of those who learnt about this fact increased after the course. The information that the pre-service teachers had on Diophantus, who lived between 200-284, were of similar nature; yet, after the course of HoM, the number of those who were knowledgeable increased. Indeed, they mentioned that Diophantus worked on the root of 1st order equations with one unknown, that there are equations named after him and that he has a work titled Aritmetica. One finding that stands out is that the pre-service teachers did not know anything on the personal characteristics of Diophantus. Table 8 presents the information of the pre-service teachers on Brahmagupta, Ptolemy, Cardano, Napier and Lobachevsky as well as the frequency distribution of these data.

Table 8: The Information Provided by the Pre-Service Teachers on Brahmagupta, Ptolemy, Cardano, Napier and Lobachevsky and the Frequency Distributions

Information on Mathematicians Before the Course of HoM		Information on Mathematicians After the Course of HoM	
Information on Brahmagupta (598-670)			
Information on his Scientific Contributions	f	Information on his Scientific Contributions	f
He established the rules for dealing with zero.	1	He calculated the area of quadrilaterals.	3
He worked on numbers.	1	He offered a different proof of the Pythagorean theorem.*	1
		He contributed to the development of the number zero.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
He is Indian.	2	He is Indian.	5

Information on Ptolemy (85-165)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
He wrote a book titled Algebra.*	1	He wrote a book titled the Algebra.*	1
		He has a work named the Almagest.	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
	-		-
Information on Cardano (1501-1576)			
Information on His Scientific Contributions		Information on His Scientific Contributions	
		He studied probability.	4
He solved 4 th order equations.*	1	He solved 3 rd order equations.	2
		He discovered 4 th and 5 th order equations.*	1
Information on his Personal Characteristics		Information on his Personal Characteristics	
		He played games of chance and gambled.	1
He is Italian.	1	He has a book named Games of Chance.	1
Information on Napier (1550-1617)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
		There is a multiplication method with Napier's bones.	5
Information on his Personal Characteristics		Information on his Personal Characteristics	
	-		-
Information on Lobachevsky (1792-1856)			
Information on his Scientific Contributions		Information on his Scientific Contributions	
	-		-
Information on his Personal Characteristics		Information on his Personal Characteristics	
	-		-
		He lived in Russia.	1

*Inaccurate Information

Table 8 shows that the pre-service teachers reported on Brahmagupta, who lived between 598-670, before the course of HoM that he established the rules for dealing with zero and he worked on numbers; after the course, they stated that he calculated the area of quadrilaterals and that he contributed to the development of the number zero. Regarding his personal characteristics, the pre-service teachers only mentioned that he is Indian. One pre-service teacher incorrectly stated that Brahmagupta offered a different proof of the Pythagorean theorem. As for Ptolemy, the information of the pre-service teachers before the course of HoM were inaccurate and only one pre-service teacher provided accurate information on him after the course of HoM by stating that he has a work named the Almagest. Also, one pre-service teacher expressed that Ptolemy has a work named the Algebra, but this was not accurate. The pre-service teachers did not have accurate information on Cardano before the course of HoM; on the other hand, they mentioned that he studied probability and that he solved 3rd order equations. Regarding his personal characteristics, they expressed that he is Italian and interested in games of chance. Yet, the information that Cardano discovered 4th and 5th order equations was inaccurate. The

pre-service teachers did not have any information on Napier before the course of HoM. However, five pre-service teachers reported after the course that there is a multiplication method with Napier's bones. As for Lobachevsky, only one pre-service teacher stated after the course of HoM that he lived in Russia. No information was provided by the pre-service teachers on his scientific contributions.

4. Discussion and Conclusion

This study seeks to analyse the change in the informational awareness of primary school mathematics teachers on famous mathematicians. Accordingly, it reveals that the pre-service teachers were most knowledgeable about Euclid, Pythagoras, Pascal, Thales, Newton, Bernoulli, Gauss, Fermat and Fourier and least knowledgeable about Ptolemy, Cardano, Napier and Lobachevsky before the course of HoM. Also, 50 percent or more of pre-service teachers were knowledgeable about 7 out of 27 famous mathematicians (Euclid, Pythagoras, Pascal, Thales, Newton, Bernoulli, Gauss) before the course of HoM. After they attended the course of HoM, more than half of the pre-service teachers were knowledgeable about 13 famous mathematicians (Euclid, Pythagoras, Pascal, Newton, Bernoulli, Fermat, Fourier, Al-Khwarizmi, Thales, Gauss, Euler, Omar Khayyam, Leibniz). The mathematicians that they were least knowledgeable about after the course of HoM were Ptolemy and Lobachevsky, similar to before the course of HoM. Başbüyük and Şahin (2019) reported that Al-Khwarizmi, Omar Khayyam, Euclid, Pythagoras and Thales were the famous mathematicians most remembered by mathematics teachers. Gençkaya (2018) stated that the most reported famous mathematicians by pre-service teachers were Pythagoras, Cahit Arf, Euclid, Ali Kuşçu, Al-Khwarizmi, Thales and Omar Khayyam. The study by Yazlık and Erdoğan (2018) found out that the famous mathematicians most known by pre-service teachers were Cahit Arf, Pythagoras, Ali Kuşçu, Al-Khwarizmi, Omar Khayyam, Euler and Euclid. The findings of these studies are congruent with the findings of this present study.

This study further concludes that before the course of HoM, the pre-service teachers were more knowledgeable about the famous mathematicians, who have theorems, principles, axioms, formulas or concepts named after them and mentioned in the content of the courses such as analysis, differential equations, linear algebra and geometry. Examples of these content are Euclidean correlation, Pythagorean Theorem, Pascal's triangle, Cauchy-Schwarz Theorem as well as sieve of Eratosthenes. It is notable that the pre-service teachers had more diverse information on famous mathematicians, yet the number of the pre-service teachers that had such information is not sufficient. Moreover, the information provided before the course of HoM were also mentioned and at a higher frequency after the course.

It is remarkable that the pre-service teachers were more knowledgeable about European mathematicians compared to the two best known Turkish-Islamic mathematicians (Al-Khwarizmi, Omar Khayyam). It is certainly important that pre-service teachers are knowledgeable about mathematicians from different cultures so that

they can understand that mathematics is a universal and common value. However, it is believed that if they are knowledgeable about the characteristics and contributions of mathematicians from their own cultures to recognize the place of their own countries in the history of culture and civilization and to love mathematics more by taking inspiration from the contribution of mathematicians from their own cultures to science.

Another remarkable finding of this study is that the pre-service teachers had inaccurate information on the scientific contributions and personal characteristics of famous mathematicians. The pre-service teachers mistook Euclid for Euler due to name similarity and Al Khwarizmi for Omar Khayyam as they are both Turkish-Islamic mathematicians who lived in similar times. Likewise, Bozdoğan et al. (2015) determined that pre-service teachers had inaccurate information on the scientific contributions of scientists.

This study significantly pointed out that the pre-service teachers provided information on famous mathematicians by mentioning their contributions not only to mathematics but also to other disciplines. For example, they reported the works of Pascal and Newton in physics, the contribution of Omar Khayyam to literature and the works of Al Khwarizmi to astronomy.

It can be argued that considering the information of the pre-service teachers on famous mathematicians, their awareness on famous mathematicians increased after the course of HoM and the course of HoM was effective in this increase, yet their awareness did not increase at the desired level. Discussion on various information on the lives of famous mathematicians as part of the course of HoM would be useful in increasing the diversity and amount of information of the pre-service teachers on famous mathematicians. Also, introductory guides that present the work areas, inventions of famous mathematicians and the milestones in their lives can be prepared for pre-service teachers to increase their awareness on famous mathematicians. Furthermore, more detailed information about the resources and ways to benefit from the life of famous mathematicians can be provided to pre-service teachers, and practical exercises can be carried out. In the course of HoM, emphasis can be given to the gamification of the life stories of mathematicians.

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