RELATIONSHIP BETWEEN PRE-SERVICE MATHEMATICS TEACHERS' KNOWLEDGE OF HISTORY OF MATHEMATICS AND THEIR ATTITUDES AND BELIEFS TOWARDS THE USE OF HISTORY OF MATHEMATICS IN MATHEMATICS EDUCATION

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ABSTRACT

The purpose of this study was to investigate the relationship between pre-service mathematics teachers' knowledge of history of mathematics and their attitudes and beliefs towards the use of history of mathematics in mathematics education. Data were obtained from 1593 pre-service elementary mathematics teachers during the fall semester of 2010-2011 academic year by Attitudes and Beliefs towards the Use of History of Mathematics in Mathematics Education (ABHME) Questionnaire and Knowledge of History of Mathematics (KHM) Test. The main correlation between ABHME and KHM mean scores was found to be positive and statistically significant ($r=.18$, $p<.01$) which meant that the pre-service teachers who were more knowledgeable in history of mathematics topics had more positive attitudes and beliefs towards the use of history of mathematics in mathematics education. Furthermore, all of the seven correlations between the mean scores from each of the seven sub topics of ABHME Questionnaire and the original form of KHM Test were also positive and statistically significant at the .01 level, which were presented in details in the results. The findings were discussed with the relevant existing literature followed by implications for teacher education programs and policy makers, and suggestions for future research were addressed.

Keywords: History of mathematics, Attitudes and beliefs, Knowledge of history of mathematics, Mathematics education, Pre-service mathematics teachers

1 Introduction and Theoretical Framework

Teachers may enhance the standards and the quality of mathematics teaching by including various methods into their instruction through meeting varied learning goals (Hiebert & Grouws, 2007). Be-

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fore entering upon the professional career, they undergo the formal pre-service education process which gives opportunities to improve their knowledge and skills in their field. Having knowledge of history of mathematics (HM), being able to use HM and displaying a demand for this usage as a rooted special method for mathematics education may be pointed as important components of such knowledge and skills (McBride & Rollins, 1977) as HM illuminates the relationship among mathematical concepts, it introduces different perspectives to the learning of mathematics subjects and it clarifies the nature of mathematics and mathematical knowledge (Freudenthal, 1981; Furinghetti & Radford, 2002; Gulikers & Blom, 2002; Siu, 2000).

Mathematics teachers' knowledge and their attitudes and beliefs regarding the teaching and learning of mathematics have been foci of interest and frequently investigated on the grounds that both of them influence the quality of mathematics instruction (Alexander & Dochy, 1995). Apart from this common point, research in education indicates a natural interaction between individuals' knowledge of an issue (as a component of cognitive domain) and their related attitudes and beliefs (as a component of affective domain) (Maker, 1982; Thompson, 1992). Gilbert (1991) claimed that one must initially have some knowledge and experience on a topic before stating attitudes and beliefs related to that topic. In other words, attitudes and beliefs form the subjective form of one's objective knowledge of a topic (Pehkonen & Pietila, 2003). Thompson (1992) also stated that "disputability is associated with beliefs; truth and certainty is associated with knowledge" (p. 129).

The knowledge of HM is likely to present credible information about the mathematics topics at first hand (Freudenthal, 1981). The great part of the responsibility here may probably be on the pre-service education (Hill, Sleep, Lewis, & Ball, 2007). In order to practice upon HM in ME effectively in the future, pre-service mathematics teachers should firstly master the historical information of the mathematical concepts that they are going to teach (Fried, 2001) by taking curricula and textbooks into consideration. Yet, having enough HM background may not be adequate on its own for the pre-service teachers. If they do not hold positive attitudes and beliefs towards the use of HM in mathematics education, then they may not utilize it in the mathematics classrooms (Li, 1999).

Before illuminating the significance of these attitude and belief constructs in conjunction with the HM integration, it is necessary to primarily identify them. In respect of Philipp's (2007) metaanalysis on affective domain research, attitudes are defined as "manners of acting, feeling, or thinking that show one's disposition or opinion" where beliefs are the "lenses that affect one's view of some aspect of the world" (p.259). Correspondingly, attitude and belief are actually two different, but strongly engaged affective constructs (Ajzen, 2001; Goldin, Rösken, & Törner, 2009). More specifically, attitudes are related to senses such as "liking, disliking, being curious, being bored" (McLeod, 1992, p.581), whereas beliefs are more related to one's cognition as "psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p. 103) which also form basis for the related attitudes (Koballa & Glynn, 2007). In comparison with beliefs, attitudes may change more easily and thus less permanent (McLeod, 1992). Indeed, the common point of these constructs, which is also the driving force for considering them together in this study, is that humans generally reflect their attitudes and beliefs towards an object, a situation, or another person into their related feelings and behaviors such as interest, demand for learning, and utilization (Koballa & Crawley, 1985). Considering these definitions, pre-service mathematics teachers' beliefs regarding the use of HM in mathematics education can be identified as their professed viewpoints for this usage, and their related attitudes are feelings and thoughts displaying these beliefs. Both of them are likely to

influence the concern, excitement, trust, and knowledge related to this notable method, and thus also to affect the relevant choices and usages in future mathematics teaching.

As for the research pertinent to the relationship investigated in this study, Goodwin (2007) studied mathematics teachers' knowledge of HM together with their images of the mathematics discipline. In his study, knowledgeable teachers thought that learners of mathematics could discover mathematical ideas again, mathematics could be done even one was not a professional mathematician, and mathematics was a continuously developed subject by several cultures in the history (Goodwin, 2007). The parallelism of these thoughts with the essential arguments of history in mathematics education was notable. However, the relationship between pre- or in-service mathematics teachers' HM knowledge and their attitudes and beliefs about integrating HM in mathematics education has not been investigated in the accessible literature, indicating a gap in the mathematics teacher education. This limitation and the presented arguments in favour of the interplay between knowledge and attitude-belief leaded to the following research question examined in this study:

- Are there statistically significant correlations between pre-service elementary mathematics teachers' knowledge of HM and their attitudes and beliefs towards the use of HM in ME?

This study aimed to fill the addressed gap in the literature by finding a response to the above research question via data collected from Turkish pre-service elementary mathematics teachers.

2 Methodology

This study intended to raise a claim, which was the existence of a link between pre-service mathematics teachers' knowledge of HM and their attitudes and beliefs about using it in mathematics education, via generalizing from a large and representative sample to the population of interest considering the more general literature on the relationship between individuals' knowledge and their associated attitudes and beliefs. Therefore, it was based on quantitative methodology.

2.1 Context and Sample

The Elementary Mathematics Education (EME) programs in Turkey are four years teacher education programs which train future mathematics teachers for grades 4 to 8. These programs are similar in terms of courses as higher education is loosely centralized through a governing Council of Higher Education (CHE) in Turkey. CHE suggests that "History of Science", "History of Mathematics", and "Philosophy of Mathematics" should be considered as elective courses in EME programs and compulsory pedagogical courses such as "Methods of Teaching Mathematics" should include HM and its integration into mathematics education (CHE, 2007).

A total of 1593 pre-service elementary mathematics teachers (478 freshmen, 432 sophomores, 409 juniors, and 274 seniors; 1064 females and 529 males) from nine universities located in each of seven geographical regions of Turkey were the sample of the study. Clustered random sampling method was used in order to attain a representative sample of target population (Fraenkel & Wallen, 2006) who were all Turkish pre-service elementary mathematics teachers. Twenty per cent of the universities from all the regions were initially selected randomly, and the pre-service teachers enrolled in four years teacher education programs were reached as many as possible in the fall semester of 2010–2011 academic year.

2.2 Data Collection Tools

The data were gathered via Knowledge of History of Mathematics (KHM) Test (Alpaslan, Işıksal, & Haser, 2011b) and Attitudes and Beliefs towards the Use of History of Mathematics in Mathematics Education (ABHME) Questionnaire (Alpaslan, Işıksal, & Haser, 2011a) whose validity and reliablity procedures were completed. KHM Test was formed of 11 questions comprising 13 multiple choice, short answer, and true-false items which were determined with reference to mathematics teacher competencies suggested by Turkish Ministry of National Education (MoNE, 2011), Turkish elementary mathematics curricula (MoNE, 2009), and formal elementary mathematics textbooks (Durmuş, 2010a, 2010b, 2010c). ABHME Questionnaire was a Likert type scale containing 35 items in which the pre-service mathematics teachers could state their attitudes and beliefs concerning the use of HM in the context of its practicality, didactical and motivational contributions to mathematics education, importance for their future teaching (Alpaslan, Işıksal, & Haser, 2011a). In order to examine the correlation between knowledge of history of mathematics and the related attitudes and beliefs under discussion in details, the items of ABHME Questionnaire were grouped into seven sub topics. Considering the relevant literature, these subtopics were determined as *self-efficacy* (SE) beliefs towards the method (the use of history of mathematics in mathematics education) (items 11, 12, 17, and 29), attitudes and beliefs towards the *personal development* (PD) on the method (items 6, 7, 28, and 32) and *usability* (US) of the method (items 1, 15, 18, 21, 23, and 33), the method's contributions to *revealing the meta-issues* (RM) of mathematics (items 2, 5, 10, 13, 19, 24, and 30), to *motivations for learning* (ML) mathematics (items 4, 20, and 25), to *learning* (LE) mathematics directly (items 3, 8, 9, 14, 22, 26, 31, and 34). There were also items addressing *very general* (VG) attitudes and beliefs towards the method (items 16, 27, and 35). The items of KHM Test was not grouped as ABHME Questionnaire on the gorunds that it was designed for measuring the knowledge of the history of elementary mathematics topics in Turkish elementary mathematics curricula (MoNE, 2009) as a whole and thus it had a unity in itself. One sample question from KHM Test and seven sample items for each sub topic of ABHME Questionnaire were illustrated respectively in Table-1 on the following page.

3 Results

Pearson product-moment correlation analysis was run through PASW Statistics 18 software program with the intent of examining the possible relationship. Before conducting this parametric statistical method, its five assumptions which were *level of measurement, related pairs, independence of observations, normal distribution, linearity,* and *homoscedasticity* were checked in order to see whether the data is appropriate for this analysis (Pallant, 2007). Since all of the variables produced from pre-service elementary mathematics teachers' knowledge of HM and their attitudes and beliefs towards the use of HM in mathematics education were continuous at interval level, the *level of measurement* assumption was ensured. In the final form of the data, there was not any missing datum in the *related pairs* of scores on the two variables. The participants were presumed to have no interaction during the data collection addressed *independence of observations*. In addition, their mean scores on each of the variables were observed to be *normally distributed*. As for the *linearity* assumption, the scatterplots revealed a linear relationship for each of the examined correlations, which referred a trend of increase in one variable accompanied with the increase in the other variable, or the reverse. The scatterplots also clarified that the data pairs (e.g., ABHME mean scores-KHM mean scores, ABHME/SE mean

Table-1: Sample Items from KHM Test and ABHME Questionnaire

Instrument	Sub Topic	Item
KHM Test		**1.** – They have one of the known oldest number systems. - They developed a number system up to millions before approximately 5000 years ago. - Numerals in their mathematics are formed by juxtaposing some certain symbols. - 7 different symbols constituting their numeration system was given below:  Which antique civilization has the above mentioned characteristics? **A)** Mesopotamian Civilization **B)** Roman Civilization **C)** Egyptian Civilization **D)** Babylon Civilization
ABHME Questionnaire	SE	**11.** I <u>do not</u> have an idea about how to use history-based didactical materials (e.g., pantograph, tangram).
	PD	**7.** Prospective teachers must be given courses about how to use history of mathematics in mathematics education.
	US	**1.** It is <u>difficult</u> to integrate history of mathematics in mathematics education.
	RM	**2.** Having knowledge about history of mathematics gives an idea about why humans felt the need for mathematics.
	ML	**4.** Using history of mathematics in mathematics education causes students to <u>lose</u> their enthusiasm for learning mathematics.
	LE	**3.** The use of history of mathematics in mathematics education makes positive contribution to the learning of mathematics by providing a different standpoint and mode of presentation.
	VG	**16.** History of mathematics should be integrated into mathematics education.

scores-KHM mean scores) concentrated around the linear correlation line provided the last assumption called homoscedasticity (Pallant, 2007). These implied meeting all the required assumptions of Pearson product-moment correlation analysis.

The correlation analysis results revealed that all of the correlations tested for the pairs between ABHME mean scores and KHM mean scores were positive and statistically significant, whose coefficients (r values) were presented in Table-2 below:

Table-1: Sample Items from KHM Test and ABHME Questionnaire

	ABHME Mean Scores							
	ABHME Mean Scores	ABHME/SE Mean Scores	ABHME/PD Mean Scores	ABHME/US Mean Scores	ABHME/RM Mean Scores	ABHME/ML Mean Scores	ABHME/LE Mean Scores	ABHME/VG Mean Scores
KHM Mean Scores	.18*	.19*	.12*	.10*	.12*	.18*	.12*	.08*

*. Correlation is significant at the 0.01 level (2-tailed).

Considering the table above, the result that all of the positive correlations were also statistically significant could lead to the idea that pre-service teachers' higher scores on KHM Test accompanied with their higher scores on ABHME Questionnaire. Additionally, the relatively higher correlation coefficients between the three pairs of KHM mean scores-ABHME mean scores, KHM mean scores-ABHME/SE mean scores, and KHM mean scores-ABHME/ML mean scores were remarkable which were discussed in the next part. The coefficients of determination (r^2) were ranged between .01 and .04 referred that the different kinds of the attitudes and beliefs shared 1 through 4 per cent of their variance with the knowledge, or vice versa.

4 Discussion and Implications

The results of the study suggested a relationship between pre-service elementary mathematics teachers' knowledge of HM and their attitudes and beliefs towards the use of HM in mathematics education which supported the claims in the literature for the interplay between knowledge, attitudes, and beliefs (Gilbert, 1991; Maker, 1982; Thompson, 1992). It was also coherent with the relevant specific studies on the relationship between knowledge of HM and HM related attitudes and beliefs (Goodwin, 2007). It might be the case that better knowledge on the HM would be a key factor in the preferences for employing it in the classroom for mathematics teachers of the future. On the contrary, the reversibility of the correlation also pointed out that positive attitudes and beliefs about using HM seemed to lead the pre-service teachers to enrich the knowledge of HM. The positive attitudes and beliefs might have encouraged them to learn HM and this situation maybe resulted in an increase in the achievement got from the KHM Test.

In private, the relatively higher positive relationship between *self-efficacy* beliefs towards the use of history of mathematics in mathematics education and knowledge of history of mathematics pointed out the importance of mastering the history of mathematics before employing it for teaching mathematics. The pre-service teachers' decidedness for the future use of the method may be broken down due to poor knowledge of history of mathematics, and hence lower self-efficacy beliefs towards using it. The other relatively higher positive relationship between knowledge of history of mathematics and attitudes and beliefs towards the method's contributions to *motivations for learning* mathematics may

be a result of that the Turkish pre-service teachers' attitudes and beliefs were a product of their self-perceiving the method as only a tool servicing the motivational purposes of learning mathematics (Alpaslan & Haser, 2012). As a result of this, the pre-service teachers who were more knowledgeable on the history of mathematics might have much displayed that they could use this knowledge for motivational aims. As for the relatively lower positive relationships, they might be an outcome of that the pre-service teachers were not raised awareness of the addressed sub topics (*personal development* on the method, *usability* of the method, the method's contributions to revealing the meta-issues of mathematics, *learning* mathematics directly, and the method in *general*) (Alpaslan & Haser, 2012). If they were adequately informed about the use of history of mathematics in mathematics education and were gained more positive attitudes and beliefs on this method, this might have directed them to enrich their knowledge of history of mathematics.

The dual relationship found here could guide teacher educators for presenting HM knowledge in order to train mathematics teachers who feel themselves familiar with and even competent in using this alternative method. Teacher education policy makers may also design undergraduate courses on HM addressing both the HM knowledge and the relevant attitudes and beliefs. Further studies should explore this relationship through other research designs in different contexts such as those directly seeking for a cause and effect relationship between knowledge of HM and different components of affective domain. In these studies, qualitative methodology also can be included to see the existing reality more vividly.

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