

## Chapter 18

# Building Multimedia and Web Resources for Teaching Mathematical Concepts through Their Historical Development

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### **ABSTRACT**

*This chapter describes how teachers can use technology to build learning materials and non-traditional lessons that incorporate heritage and history. Students are expected in these lessons to be engaged by a combination of mathematics, cultural heritage, and technological presentation. The chapter describes a project carried out in a teacher training college and presents the structure of the web-based learning environment. Preservice teachers who participated in the project developed the online materials and carried out the educational activities. The technological tools used to build learning materials were based on ICT pedagogical models and were integrated into the mathematical lessons. The chapter also describes various models and teaching settings in which heritage and technology can be utilized and integrated, followed by an example lesson plan which elaborates on the model. The chapter also describes the educational, pedagogical, technical, and logistical difficulties that the preservice teachers confronted during the project. They also struggled with reading historical material and relating it to mathematics. Semi structured interviews revealed that the preservice teachers overcame these difficulties by reflection and by communicating and collaborating with each other and with their lecturers. A questionnaire with yes-no items was used to collect data about attitudes and perceptions of the preservice teachers during the project. They viewed this technological project connected with their heritage as fun, benefiting them, making them proud of their mathematical heritage, and encouraging them to use such projects in their future teaching.*

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## **INTRODUCTION**

Educational researches point at the advantages of project based learning (Railsback, 2002; Boaler, 1998a, 1998b; Moore et al., 1996), technology based learning (Arroyo, 1992; Daher, 2009; Koller, Harvey, & Magnotta, 2006) and learning that emphasizes history (Arcavi et al., 1982; Daher, 2005; Kaye, 2008). This is true especially for mathematics education. In this chapter it is our aim to describe preservice teachers' experiences in developing project based, technology based and history based mathematics lessons for middle and elementary Arab schools in Israel. These preservice teachers, majoring in mathematics, computer science and information and communication technology (ICT) in Al-Qasemi teacher training college, built internet sites which include mathematics lessons that use historical materials and technological tools. We will describe the rich experiences of the preservice teachers in developing their projects: building internet sites, designing technology based and history based learning materials and writing mathematical lessons. As well, we will describe the preservice teachers' difficulties in developing their projects and the ways they used to overcome these difficulties.

### **Research Rationale**

Bitner and Bitner (2002) developed eight areas to look at when considering teachers' success to integrate technology into the curriculum: (1) fear of change (2) training in basics (3) personal use (4) teaching models (5) learning base (6) climate (7) motivation and (8) support. Thus, giving preservice teachers opportunities to develop projects that involve building technology based and history based mathematical materials will encourage the preservice teachers to use projects, technology and history of mathematics (which is related to their cultural heritage) in their future teaching. This encouragement will result from their experiences

which are expected to lessen their fear of change, provide them with personal training in successful methods which use technology to produce history based learning materials. At the same time, these experiences would give the preservice teachers alternative teaching models, motivate them to learn in a supportive climate of peers and lecturers, and thus qualify them to use these alternative teaching models as future teachers. Wang (2006) describes technology projects as influencing positively aspects of students' empowerment: autonomy, equality and skill building. This makes technology projects a tool for preparing preservice teachers for a teaching profession that empowers students and contributes to their autonomy, equality and skill building.

Fullan (1982, p. 107) stated that "educational change depends on what teachers do and think--it's as simple and complex as that." We believe that the preservice teachers, developing projects rich in technology and history, will adapt to these new methods and encourage their future students to learn by developing such projects. The adaptation to technology based projects will empower the preservice teachers as learners and future teachers (Keengwe et al., 2007), and thus empower the future generation of students.

### **The Research Goals**

1. To show how mathematical heritage could be utilized technologically and educationally to produce electronic mathematics lessons. This would help educators of other nations, for example, Greeks, Egyptians, Indians, etc. to develop mathematics (or other sciences) lessons and internet sites that are connected to their own history and heritage.
2. To describe the structure of the sites and lessons which the preservice teachers built.
3. To describe the sequences of action taken by the preservice teachers in carrying out their projects.

4. To describe models of lessons and teaching settings that the preservice teachers used to integrate heritage and technology.
5. To describe the types of learning materials that the preservice teachers developed.
6. To describe the technological tools and ICT pedagogical models which the preservice teachers used to develop the learning materials.
7. To describe the difficulties of the preservice teachers in building their sites and developing their learning materials and lessons, and how they overcame these difficulties.

## **BACKGROUND**

### **Project Based Learning**

Railsback (2002) pointed at the advantages of project-based instruction: (1) it prepares students for the workplace (2) it increases the motivation of students (3) it connects learning at school with reality (4) it provides collaborative opportunities to construct knowledge (5) it increases social and communication skills (6) it increases problem-solving skills (7) it enables students to make and see connections between disciplines (8) it provides students with opportunities to contribute to their school or community (9) it increases students' self-esteem (10) it allows students to use their individual learning strengths and apply diverse approaches to learning, and (11) it provides a practical and real-world way to learn how to use technology. Chang and Chang (2003) found that most of the junior college students participating in their research believed that their engagement in project based learning did improve their collaboration and communication skills. They also believed that it enhanced their thinking and problem-solving skills. Tan (2002) reported that secondary school boys thought that the project based learning had positive effects on teamwork and communication skills, problem-solving and thinking skills, as

well as self regulation skills, whilst Chua (2004) found that the students participating in project based learning had positive perceptions of their attainment in cooperation, knowledge application, communication and independent learning.

These advantages of project based learning were among our concerns when we chose to prepare our preservice teachers majoring in mathematics and computers to use projects and technology tools in their future teaching

### **Technology Based Learning**

Technology based learning, according to Koller, Harvey and Magnotta (2006) holds the promise of substantially transforming the way students learn because of its various advantages: (1) it fosters greater accessibility to learning by offering any-time and anywhere delivery (2) it is scalable to both large and small groups since it can accommodate larger numbers of learners at little extra cost and smaller groups of learners that otherwise would not be able to participate in traditional classroom training for lack of enrollments (3) the content of its courses, especially those that are delivered online, can be centrally developed and updated whenever the need arises (4) due to the previous property, the cost of replacing outdated course materials and retraining teachers and instructors drops significantly (5) it can be self-paced and matched to the learner's needs (6) it offers the prospect of promoting greater comprehension and retention, particularly for complex materials, because of its clear opportunities for the hands-on manipulation of course materials and the use of simulations and game-playing. The previous advantages of technology based learning encouraged us to choose technology as means by which the preservice teachers develop their projects.

Some factors support teachers and encourage them to use ICT in their classrooms. Cox, Preston and Cox (1999) found that the factors most important to teachers in their teaching, when

using ICT, were: ICT makes the lessons more interesting, easier, more fun for teachers and pupils, more diverse, more motivating for pupils and more enjoyable. Cox, Preston and Cox (1999) say that additional more personal factors could influence the teachers' use of ICT: ICT improves presentation of materials, allows greater access to computers for personal use, gives more power to the teacher in the school, gives the teacher more prestige, makes the teachers' administration more efficient and provides professional support through the Internet. Letting preservice teachers carry out build lessons based on technology is expected to give them means that support their future teaching and give them power as learners and future teachers.

Some factors may prevent teachers from using ICT in their classrooms. Pelgrum (2001) describe many of those obstacles, among which the following ten obstacles were the most mentioned by school principals and the technology experts in the schools (from the most influencing to the least influencing): Insufficient number of computers, teachers' lack of knowledge/skills, difficult to integrate in instruction, scheduling computer time, insufficient peripherals, not enough copies of software, insufficient teacher's time, not enough simultaneous access to WWW, not enough supervision staff, and lack of technical assistance. Jones, A. (2004) reported, depending on reviewing literature, that the teachers' level of confidence in using the technology is a very significant determinant of teachers' level of engagement in ICT; i.e. teachers who have little or no confidence in using computers in their work will try to avoid them altogether. In addition, there is a close relationship between levels of confidence and many other issues like the amount of personal access to ICT that a teacher has, the amount of technical support available, the amount and quality of training available, and the resistance to change. Requiring preservice teachers to carry out technology-based projects is supposed to increase their confidence in

using technology and thus increase their engagement in using it in schools.

### **Using History in Teaching Mathematics: Connecting the Preservice Teachers to Their Heritage**

An increasing number of researches point at the advantages of integrating mathematics history in the mathematics lessons, if to the mathematics student or teacher. These researches show that integrating the history of mathematics in mathematics lessons improve the awareness of the teachers of mathematics regarding this subject and regarding their approach to teaching mathematics (Arcavi et al., 1982; Fauvel, 1991; Furinghetti, 2000). Rose (2001) mentioned that integrating the history in mathematics lessons leads students to look at the history of mathematics as a factor which connects between the various fields of mathematics. This integration helps students, as well, to experience mathematics as it evolves and develops, so they look at mathematics as a human project. It also causes students to lessen their fear of mathematics (Marshall & Rich, 2000; Switz, 1984).

We chose that the preservice teachers projects involve Islamic history of mathematics, so, in our case, in addition to previous advantages, the preservice teachers were expected to connect to their cultural heritage and thus develop self confidence in mathematics, develop pride in their ancestors' accomplishments, and thus develop motivation to learn and teach mathematics.

## **RESEARCH METHODOLOGY**

### **Research Setting and Participants**

This chapter describes technological projects which were the final assignment in a pedagogic training course of third year preservice teachers

majoring in mathematics and computers. The number of participants in the course was 30 and they had different levels of mathematical content and pedagogic content knowledge. The authors of this chapter were the lecturers who gave the pedagogic training course.

The preservice teachers studied in a teacher training college in Israel called Al-Qasemi Academy; which includes Muslim preservice teachers and is surrounded by Arab schools whose most students are Muslims. It was intended that the preservice teachers' projects involve building internet sites that include materials for teaching and learning mathematics in middle and elementary Arab schools. These materials were required to be rich in historical resources and technological means. It was decided that the historical resources involve historical mathematics content that was developed and created in the Muslim era, so to connect the preservice teachers and the students to their mathematical heritage. We hoped that this connection would motivate the preservice teachers to be more involved in teaching and learning mathematics, and the students to be more involved in learning mathematics, due to their pride in their mathematical heritage.

Every internet site that the preservice teachers were required to develop had to include:

- The life history of a mathematician.
- The historical development of a mathematical concept or procedure.
- Learning materials developed based on various ICT pedagogical models using appropriate technological tools.
- A mathematics lesson that utilized all the learning materials developed.

### **Data Collecting Tools**

- *Interviews with the preservice teachers:* We interviewed the preservice teachers for almost thirty minutes each about their

experiences in carrying out the projects that involved writing mathematics lessons that integrated technology and history. The interviews were semi-structured and included questions such as: what sequences of action did you follow in carrying out the project? What ICT pedagogical models did you implement in the learning materials? What technology tools did you use to develop the learning materials? How did the lecturers' directions influence the carrying out of the project? Describe the difficulties you faced in carrying out the project and the solutions that you used to overcome these difficulties.

- *Questionnaire:* We required the participants to state their agreement or disagreement with 15 statements regarding their experiences in carrying out the project, and their perceptions of implementing such projects in teacher training and in the schools. The questionnaire included statements, such as: I enjoyed the process of carrying out the project, carrying out such project in my training encourages me to base my future teaching on such projects, the project benefits my future work as a mathematics teacher, the project makes me proud of my heritage, such projects motivate school students to learn mathematics.

### **Data Processing and Analysis**

We used the grounded theory approach (Strauss and Corbin, 1998) to identify the sequences of action taken by the preservice teachers in carrying out their projects, the models of lessons and teaching settings that the preservice teachers used to integrate heritage and technology, the types of learning materials that the preservice teachers developed, the technological tools and ICT pedagogical models which the preservice teachers used to develop the learning materials, the diffi-

culties that the preservice teachers encountered in carrying out their projects and to identify the solutions that they found for these difficulties. The grounded theory approach has three stages from which we used the first two:

- *Open coding*: Identification of repeated behavior that can be characterized. In this stage we divided each type of collected data into segments and examined the segments for similarities and differences. For example, at this stage, one of the objectives was to identify categories of difficulties and solutions that occur in carrying out the projects, place similar difficulties or solutions in the same category, and characterize each category.
- *Axial coding*: After identifying the categories and characterizing them, we examined the relations between the categories and their subcategories. For example, we characterized the difficulties and solutions according to the context in which they occurred and according to the conditions of their occurrence.

## MAIN FOCUS OF THE CHAPTER

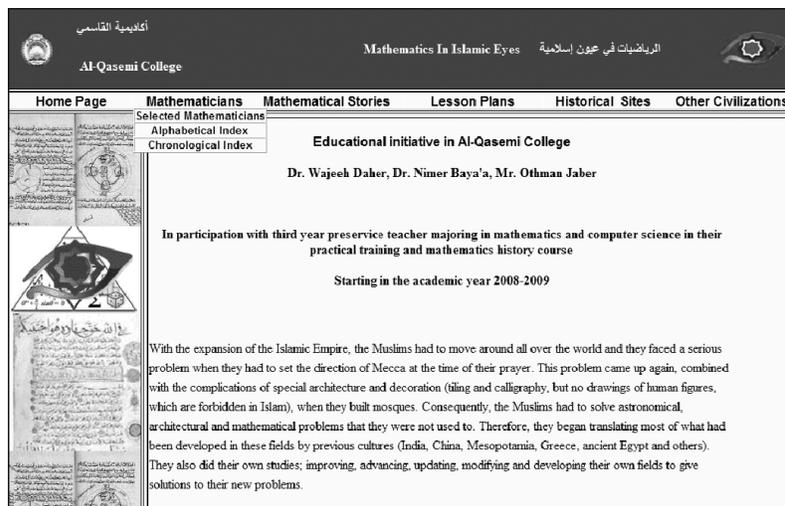
### Preservice Teachers' Projects, Internet Sites Developed, Mathematics Lessons Developed

#### The Structure of the Main Site and Its Sub-Sites

The **main site**<sup>1</sup> – Mathematics in Islamic Eyes – that was developed by the preservice teachers, is a web-based learning environment (as defined by Baya'a, Shehade & Baya'a, 2009) and contains the following sections: mathematicians, mathematical stories, lesson plans, historical sites and a section on other civilizations (yet to be constructed). Figure 1 represents screen shot of the main site.

The **mathematicians** section includes three sub-sections: selected mathematicians, alphabetical index and chronological index. The selected mathematicians sub-section contains sites about the life and contributions of the Muslim mathematicians whom the preservice teachers used at least one of their mathematical contributions to integrate in their lessons, while the indexes include all the Muslim mathematicians as found in MacTutor History of Mathematics ar-

Figure 1. A screen shot of the main site



hive<sup>2</sup>. The chronological index was arranged according to centuries, where each century includes the Muslim mathematicians who died in that century. Each mathematician name in the indexes is linked to a proper internet site.

The section of **mathematical stories** contains six sub-sections that include mathematical concept stories about functions, numbers, equations, circles, quadrilaterals and triangles. These concepts constitute most of the mathematics curriculum for the middle schools in Israel, as well as some of the mathematics curriculum for the elementary school.

The **lesson plans** section contains the same previous sub-sections and parts, because each mathematical concept story is used in a corresponding lesson plan. Each part includes the lesson plan for teaching a mathematical concept using its historical story and proper learning materials developed by the preservice teacher.

The **historical sites**' section contains two sub-sections: categorization according to language and categorization according to content. The categorization according to language sub-section has three parts: Arabic sites, Hebrew sites and English sites. The categorization according to content sub-section has also three parts: historical sites, educational sites and mathematical sites.

### Sequences of Action in Carrying Out the Projects

We found that the preservice teachers followed two main sequences of action in carrying out the projects:

#### Current to history

1. Deciding on a mathematical concept from the current mathematics curriculum.
2. Searching for historical resources and stories that could be related to the mathematical concept.

3. Planning the lesson based on the historical resources and stories.
4. Deciding on ICT pedagogical models (electronic presentation, video presentation, web-based learning environment, WebQuest activity, electronic worksheet, simulation) that could be used to illustrate, present or investigate the mathematical concept and the historical story.
5. Deciding on the technological tools needed to generate and develop the pedagogical models.
6. Building the learning materials according to the selected pedagogical models using the proper technological tools.
7. Writing the lesson plan and delivering it with the corresponding learning materials to the leading group.

#### History to current

1. Browsing internet historical sites and books involved with Muslim mathematician and their contributions to mathematics.
2. Searching for historical stories that describe the development of a mathematical concept or procedure developed by Muslim mathematicians and, at the same time, could be taught in the middle or elementary school.
3. Choosing such concept or procedure which is included in the current mathematics curriculum.
4. Deciding on ICT pedagogical models that could be used to illustrate, present or investigate the mathematical concept and the historical story.
5. Deciding on the technological tools needed to generate and develop the pedagogical models.
6. Building the learning materials according to the selected pedagogical models using the proper technological tools.

7. Writing the lesson plan and delivering it with the corresponding learning materials to the leading group.

### Technological Tools Used To Build Learning Materials Based On ICT Pedagogical Models

Table 1 describes the technological tools that the preservice teachers used, and the learning materials that they built using those tools according to a specific ICT pedagogical model.

### Models of Lessons That Integrate Technology and Heritage

The preservice teachers used different models to integrate technology and heritage in their lessons. We will describe below the main models of lessons that they used. Doing so, we will describe the ideational aspect of the model and the ICT pedagogical models used through it in the specific sequence of their occurrence.

*Table 1. Learning materials built according to an ICT pedagogical model using technological tools*

Technological tools	ICT Pedagogical model	Learning materials
<ul style="list-style-type: none"> <li>• Presentation program</li> <li>• Picture editor</li> <li>• Voice recorder</li> </ul>	Electronic presentation	<ul style="list-style-type: none"> <li>• Animations illustrating mathematical concepts or procedures.</li> <li>• Animations describing historical mathematical stories.</li> <li>• Presentations describing the life and contributions of mathematicians.</li> <li>• Presentations giving summary of lessons.</li> </ul>
<ul style="list-style-type: none"> <li>• Digital video camera</li> <li>• Movie editor</li> <li>• Video format converter</li> <li>• Picture editor</li> <li>• Voice recorder</li> </ul>	Video presentation	<ul style="list-style-type: none"> <li>• Animations describing real world phenomena.</li> <li>• Movies describing the life histories of mathematicians.</li> </ul>
<ul style="list-style-type: none"> <li>• Web design editors</li> <li>• Web design programs and platforms</li> <li>• Web design script languages</li> <li>• Picture editor</li> <li>• Graphics editing program</li> </ul>	Web-based learning environment	<ul style="list-style-type: none"> <li>• Sites on the life, contributions and accomplishments of a mathematician.</li> <li>• Database of Islamic mathematicians in alphabetical and chronological order.</li> <li>• Database of internet sites that deal with mathematics history, according to the language of the site or according to the emphasize of the site (pedagogical, mathematical, historical).</li> <li>• Sites presenting the historical stories and the corresponding resources.</li> <li>• Sites presenting the lesson plan with the corresponding learning materials.</li> </ul>
<ul style="list-style-type: none"> <li>• Web design editors</li> <li>• Web design programs and platforms</li> </ul>	WebQuest activity	<ul style="list-style-type: none"> <li>• Web pages activities that direct students to explore the history development of mathematical concepts.</li> </ul>
<ul style="list-style-type: none"> <li>• Word processor</li> </ul>	Electronic worksheet	<ul style="list-style-type: none"> <li>• Electronic texts that require the students to Investigate and study mathematical concepts or procedures.</li> <li>• Electronic texts that require the students to solve exercises in order to evaluate their understanding.</li> </ul>
<ul style="list-style-type: none"> <li>• Web applets</li> <li>• Spreadsheet program</li> </ul>	Simulation	<ul style="list-style-type: none"> <li>• Mathematical web applets available in the internet.</li> <li>• Dynamic maps available in the internet.</li> <li>• Dynamic text constructed using a spreadsheet program.</li> </ul>

### Lesson Model I

Presenting the life history of a mathematician like Al-Khwarizmi, presenting a specified mathematical contribution of that mathematician, for example how Al-Khwarizmi solved specified types of the quadratic equation, giving the students quadratic equations to solve following the Al-Khwarizmi method, connecting the historical method to the current method, evaluating the understanding of the students and giving a summary for the lesson.

The sequence of the pedagogical models:

- An electronic presentation – using a presentation program - describing the life history of the mathematician and one of his contributions to mathematics.
- A couple of electronic worksheets for the investigation part using a word processor.
- An electronic worksheet for the evaluation part using a word processor.
- An electronic presentation for the summary part using a presentation program.

### Lesson Model II

Presenting current mathematical procedure; for example multiplication, presenting the Muslim way of performing multiplication, giving the students numbers to multiply in the Muslim way, connecting the Muslim way to the current procedure, evaluating the understanding of the students and giving a summary for the lesson.

The sequence of the pedagogical models:

- An electronic presentation – using a presentation program - describing the current procedure of multiplication.
- An electronic presentation – using a presentation program - describing the Muslim way of multiplication.

- An electronic worksheet for the investigation part using a word processor.
- An electronic worksheet for the evaluation part using a word processor.
- An electronic presentation for the summary part using a presentation program.

### Lesson Model III

Presenting real world aspects of a mathematical phenomenon like the golden section, linking the mathematical phenomenon to mathematical heritage, for example the use of the golden section in the great mosque of Kairouan in Tunisia and which was founded around the year 670 A.D., investigating the golden section phenomenon, evaluating the understanding of the students and giving a summary for the lesson.

The sequence of the pedagogical models:

- A video presentation describing the golden section phenomenon in the nature, and in the Islam period - the preservice teacher used a movie editor and a voice recorder to make the description in Arabic.
- A WebQuest activity for the investigation part using a web design editor.
- An electronic worksheet for the evaluation part using a word processor.
- An electronic presentation for the summary part using a presentation program.

### Lesson Model IV

Requiring the students to work with an applet to discover a mathematical phenomenon; for example addition of fractions, linking the mathematical phenomenon to history and heritage; for example showing how Al-Kashi added fractions, giving the students fractions to add following the

Al-Kashi method, evaluating the understanding of the students and giving a summary for the lesson.

The sequence of the pedagogical models:

- A simulation on addition of fractions using an applet from the internet.
- An electronic presentation – using a presentation program - describing the method of Al-Kashi for adding fractions.
- An electronic worksheet for the investigation part using a word processor.
- An electronic worksheet for the evaluation part using a word processor.
- An electronic presentation for the summary part using a presentation program.

### Models of Teaching Settings That Integrate Technology and Heritage

We will describe now the two teaching settings that the preservice teachers suggested to be used when integrating heritage and technology in teaching mathematics. The two teaching settings suggested were: (1) online teaching in a regular class (2) online teaching in a computer laboratory. These settings are described below.

**Online teaching in a regular class:** In this setting, the teacher uses a computer connected to the internet and to overhead projector, and a regular screen or smart board (interactive board) connected to the teacher's computer screen. The teacher in this setting presents the teaching/learning materials to the students, and manages the investigation and discovery through discussions with the students.

**Online teaching in a computer laboratory:** In this setting, the teacher uses a computer connected to the internet and to overhead projector, and a regular screen or smart board connected to the teacher's computer screen. The students have access to computers individually or in pairs, where all the computers are connected to the

internet. The teacher in this setting presents the teaching/learning materials to the students, and guides them while they perform individually (or in pairs) the investigation and discovery activities given to them. In this setting, the students are given the chance to discover mathematical relations, concepts and procedures independently while working with technology.

### An Example of a Lesson Plan for Teaching the Circumference of a Circle

The lesson plan is intended to be applied in a double lesson for a period of almost 90 minutes for ninth graders in the middle school. The lesson is divided into four parts: introduction, investigation and discovery, summary and evaluation. The teaching is suggested to be done in one of the two models of teaching settings: online teaching in a regular class or online teaching in a computer laboratory.

We describe now the teaching/learning materials and processes that the preservice teacher prepared and planned for the four parts of the double lesson.

#### Introduction

The teacher starts the lesson with a video presentation prepared from a video clip taken from a TV episode about the Muslim Abbasid Caliph Al-Ma'mun who is the son of the great Caliph Harun Al-Rashid and is known for the prosperity of sciences in his era.

In addition, the preservice teacher prepared in the introduction a 5 minutes electronic presentation, which illustrates the story of measuring the circumference of the globe in the time of Al-Ma'mun. The story tells that Al-Ma'mun informed the mathematicians known as 'Sons of Mousa Ben Shaker' that he had read about the possibility to set a point on the globe and go around it passing through the earth poles holding a rope. Arriving back at the same point with the same rope would

give us a length of 24,000 miles. Al-Ma'mun ordered the mathematicians to investigate this fact and to bring him a proof or to do the measurements by themselves. The sons of Mousa chose to do the measurements by themselves. The first step they did was to pick a straight land in the desert of Sinjar (in northwestern Iraq of today). Then, they set a point and took the direction of the North Pole, using a compass, and started stretching a rope. They continued connecting ropes and measuring the change in the angle of their location relative to the North Pole using the tool of Astrolabe. They stopped when the change in the angle was one degree. Then they did the same thing going south to check if they get the same rope length for one degree change south. The distance they measured in both directions was 66 and 2/3 miles. They computed 360 times that distance to get a complete circle and found the circumference of the globe to be 24,000 miles, which is close to the measurements that we have today (almost 40,000 km which is almost 25,000 miles).

### Investigation and Discovery

In this part the preservice teacher prepared three activities for the students. The first activity uses

Google Earth, where the students are required to find the town of Sinjar in northwestern Iraq of today and present the grid (in the View list in the main menu) of the longitude and latitude lines. The students are directed then to use the Ruler in the Tools list in the main menu, and to use the Line tool to measure the distance between two points on the same longitude line that are one degree far from each other on the latitude line in the area of Sinjar. Then the students are asked to multiply their measurements (which should be around 69 miles) by 360, and to compare it with the result that the Muslims got in the time of Al-Ma'mun almost 1200 years ago, and the measurement of today as they can find in the internet. Figure 2 describes a screen shot of the result that Google Earth gives for the distance between two points that are one degree far from each other on the latitude line in the area of Sinjar, on condition that the two points are on the same longitude line.

In the second activity, the students are asked to open the applet of computing  $\pi^3$  in order to build a circle of diameter one and measure its circumference using the applet. To do so, they are required to build two regular polygons, one that is inscribed in the circle and one that circumscribes it, and then measure their circumference using

*Figure 2. A screen shot of the result that Google Earth gives for the distance between two points on the same longitude line that are one degree far from each other on the latitude line in the area of Sinjar*

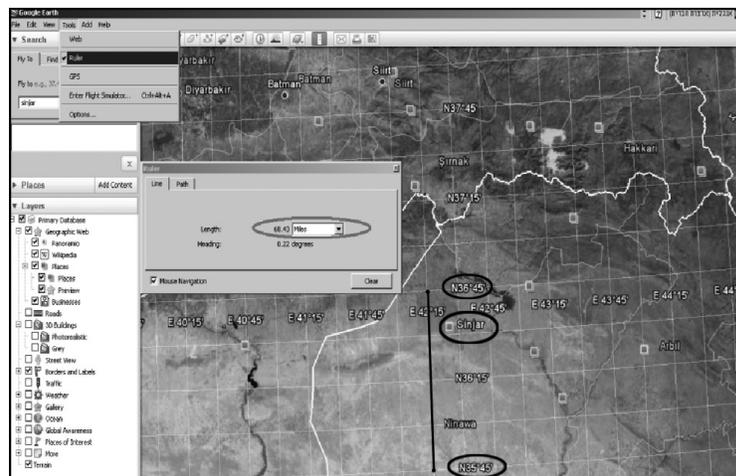
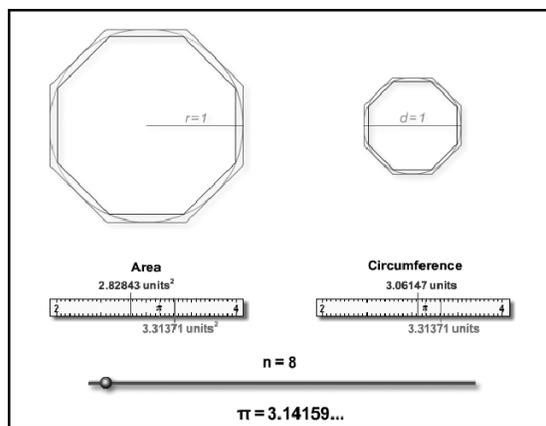


Figure 3. A screen shot of the applet when the number of sides is 8

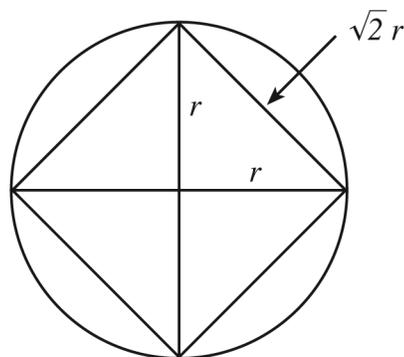


the applet. They are asked to start from a square, repeat the same operations with a regular polygon of 8 sides, 16 sides and 32 sides. Then, the students are asked to compare the circumferences of the polygons with the circumference of the circle and draw proper conclusions. Finally the students are guided to notice the relation between the number of sides of the polygons to the accuracy in the estimation of the value of Pi. Figure 3 describes a screen shot of the applet when the number of sides is 8.

In the third activity, the students are encouraged to investigate the Pi value algebraically; i.e. to investigate the relation between the circumference of a circle, estimated by an inscribed regular polygon, and its radius, and consequently get an approximation of the value of Pi. The students are given the following directions:

1. Approximate the circumference of the circle by the circumferences of regular polygons inscribed in the circle, starting with a square and each time doubling up the number of the polygon sides. The following figure represents the beginning stage (Let us call it Figure 4 in this chapter).

Figure 4. Investigating the Pi value: Beginning stage

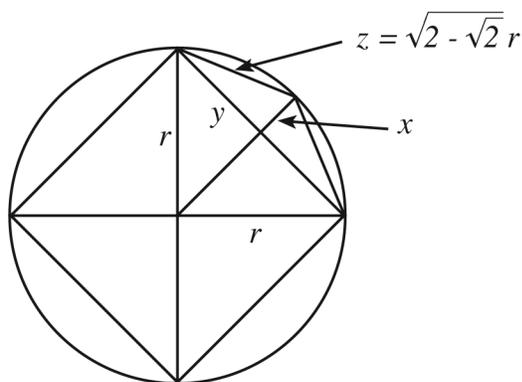


2. Express the length of the polygon side in terms of  $r$ .
3. Express the value of the polygon circumference in terms of  $r$ , and divide it by  $2r$  to get an approximating expression for Pi.
4. Divide each side equally and draw a perpendicular to the side from its midpoint until it meets the circumference of the circle.
5. Draw a new regular polygon that connects all the new and old points on the circumference of the circle.
6. Use algebra and the Pythagorean Theorem to express the length of the side of the new polygon in terms of  $r$  - the length of  $z$  in the following figure (Let us call it Figure 5 in this chapter).
7. Go back to step 3 and repeat the process again for the cases of 16 sided regular polygon, and 32 sided regular polygon.
8. Do you see a pattern of an algebraic expression that approximates the value of Pi?

## Summary

In this part the preservice teacher prepared another electronic presentation that summarizes all the conclusions and results that the students were supposed to arrive to.

Figure 5. Using the Pythagorean Theorem to find the side length of the new polygon



## Evaluation

In this part the preservice teacher prepared a WebQuest activity that requires the students to search the internet for another stories about the calculation of the circumference of the globe in other cultures. Then the students are asked to find various approximations of Pi through the history until the expansion of Taylor:

$$\Pi = 4 * (1 - 1/3 + 1/5 - 1/7 + \dots)$$

## Preservice Teachers' Perceptions of Carrying Out Projects Connected With Heritage and Technology

The preservice teachers perceived their work with the technological projects connected with their heritage as fun, making them proud of their heritage, benefiting them, encouraging them to use such projects in their future teaching and increasing the school students' motivation to learn mathematics.

## Difficulties and Solutions

Tables 2 and 3 in the Appendix describe the difficulties which the preservice teachers confronted while carrying out the projects and the solutions

they used to overcome these difficulties. Table 2 concentrates on the difficulties of the preservice teachers who developed the learning materials – the regular groups (The preservice teachers worked in 8 regular groups of 3-5 members each, where each regular group constructed a site about a selected Muslim mathematician), and Table 3 emphasizes the difficulties of the preservice teachers who built the main site – the leading group (the leading group consisted of 3 members who constructed the main site and arranged links to the mathematicians' sites. Furthermore, the leading group built the two indexes of the mathematicians).

We will elaborate on these difficulties and their solutions in the discussion section below.

## DISCUSSION

### Utilizing Mathematical Heritage and Technology

Muslim mathematical heritage was utilized educationally to build internet sites that include the life histories of mathematicians and the historical development of mathematical concepts and procedures. In addition, the Muslim mathematical heritage together with technological tools, were used to develop learning materials to be used in mathematics lessons. Every lesson, used learning materials based on ICT pedagogical models and utilized the mathematical heritage. Searching for specific stories of mathematical heritage to fit into a lesson was of particular importance, as well as choosing ICT pedagogical models and technological tools that fit the presentation and/or examination of the chosen story of mathematical heritage. This successful utilization of heritage in writing mathematical lessons would encourage the preservice teachers from one side and inservice teachers from the other side (who would be introduced to the sites and lessons) to use the sites and the lessons in their teaching, which may motivate students to increase their engagement in

mathematics learning (Glevey, 2007), especially when this learning is done through exciting technological means and related to their own culture and heritage.

### **Models of Integrating Heritage and Technology in Mathematics Lessons**

The preservice teachers had the freedom to choose the ICT pedagogical models and the historical materials that could be integrated in their lesson plans. They also had the freedom to use any technological tool or learning material connected to their heritage in each part of the lesson they prepared. This freedom made them build non-traditional lessons that differed in structure, type of heritage material, way of presentation and tools that the students would use to explore and investigate mathematical concepts and procedures.

Generally the preservice teachers wrote the lessons in two sequences: (1) starting from the historical material and advancing to the current learning material (2) starting from the current learning material and returning to the historical material.

Regarding the first part of the lesson, some preservice teachers used mainly electronic presentations, or video presentations or simulations to present the mathematical concept, procedure or the life history of the Muslim mathematician. Then they utilized electronic worksheets, Web-Quest activities or simulations to let the students discover and investigate mathematical concepts or procedures. Electronic presentations were also used in the summary part which means that (1) it was easy for the preservice teachers to work with electronic presentations (2) the preservice teachers considered the electronic presentations an educational tool that the teacher can utilize during various parts of the lesson. Another ICT pedagogical model which was used intensively by the preservice teachers is the video presentation which empowered the preservice teachers because it allowed them to present every day phenomena

or life histories of Muslim mathematicians from their own perspectives. They did that using various technological tools, especially movie editors, to change components of the video, removing some of them, adding others and recording their own comments. This empowering influence of technology is mentioned by Heafner (2004) who says that technology empowers students by engaging them in the learning process, in our case the teaching training process. He adds that technology gives flexibility to diversify tasks, and this is supported by what technology allowed the preservice teachers in our case, where they used various technological tools, ICT pedagogical models and heritage resources to build mathematical lessons.

### **Perceptions of Carrying Out Technological Projects Connected With Heritage**

The preservice teachers perceived their work with the technological projects connected with their heritage as fun, benefiting them, making them proud of their heritage, and encouraging them to use such projects in their future teaching. Igbaria, Schiffman, Wieckowski (1994) examined whether users are motivated to accept a new technology due to its usefulness or fun and found that the perceived usefulness is more influential than the perceived fun in determining whether to accept or reject microcomputer technology. We have not compared between the relative influence of each factor, but it seems that the two factors influenced the preservice teachers' perception of the technological projects connected to technology. An important factor that influenced the preservice teachers' perception is the heritage connection, where the historical mathematical performances of the Moslems made the students proud of their heritage and eager to carry out the projects. The preservice teachers also perceived learning of school students, based on carrying out or implementing similar projects, as increasing motivation to learn mathematics. This perception agrees with

Blumenfeld et al. (1991) who described project-based learning as a comprehensive approach to classroom teaching and learning that sustains motivation and thought.

### **Difficulties of Carrying Out the Technological Projects Which Utilize Heritage in Building Learning Materials**

The preservice teachers who developed the learning materials had several difficulties which could be categorized as:

1. Difficulties due the absence of a clear plan for the project or specific examples on the various leaning materials that should be developed. This absence resulted in:
  - a. Difficulties to choose proper models of integrating heritage and technology in the lessons.
  - b. Difficulties in designing educational settings and choosing proper ICT pedagogical models for their lessons.
2. Difficulties of finding Muslim mathematicians and mathematical stories that could be integrated in mathematics lessons. These difficulties are of two types:
  - a. Difficulties of finding mathematician who developed mathematical concepts which could be integrated in middle or elementary schools mathematics lessons.
  - b. After finding several contributions of a mathematician, there was the difficulty of choosing one that can be integrated in the lesson more successfully than the rest.
3. Difficulties of verifying the real mathematician who developed a certain concept or procedure.
4. The difficulty to understand the mathematics of historical materials.
5. The difficulty to use a technological tool.

6. Logistic difficulties to manage the selection of the materials.

The first difficulty that the preservice teachers faced at the beginning of the project occurred because the lecturers had an idea of the whole project and its aim, but they did not have a detailed plan, models and examples of what they intended to develop with the preservice teachers. This difficulty was resolved through continuous discussion between the preservice teachers and the lecturers. Through collaborative work they developed an outline plan and refined it throughout the actual work. In addition, the collaboration between the preservice teachers and the lecturers resulted in good examples of lesson plans which the preservice teachers then followed. The lesson models and the lesson example presented in this chapter would help other educators develop similar projects and lessons with their students. The second difficulty happened because it was the first time that the preservice teachers integrate heritage stories in their lessons, so it was difficult for them to know how to choose an appropriate story or mathematical contribution in order to integrate it in their lessons. Coping with this difficulty led the preservice teachers to two sequences of action in carrying out their projects (current to history, history to current). The third difficulty could be explained by the fact that sometimes a mathematical concept could be related to more than one mathematician or one nation, for example, finding the circumference of the earth could be related to the Muslims or Greeks, i.e. there is a story how each of them discovered or re-discovered a way to compute the circumference of the earth. The fourth difficulty could be explained by the different representations and terms used nowadays and in the heritage texts to represent or name the same mathematical concepts. The fifth difficulty is expected because, though the preservice teachers majored in computers, they had not been acquainted with every new technological tool. The sixth difficulty occurred

when the preservice teachers started selecting contributions of mathematicians and historical stories without coordinating the selection among them. Using a forum that included announcements of the preservice teachers regarding their selections overcame this difficulty.

The preservice teachers' leading group, who built the main site, faced several difficulties which could be characterized as: (1) design difficulties (2) maintenance difficulties (3) communication difficulties (4) technological difficulties (5) logistic difficulties. The first and third types of difficulties could be explained by the preservice teachers being new to site design, so they did not know how to choose between different site structures and did not understand that design issues could not be decided in one meeting or two, or that views and decisions may change from one meeting to another. The second type of difficulties could be explained by the innovation of the project which influenced the pace of the preservice teachers' work. This innovation involved blending heritage and technology and made the building of learning materials more difficult and challenging, and thus it slowed it. Maintaining all the developed materials and organizing it efficiently urged the leading group to be creative in finding successful ways of data organization and data storage efficiency, thus we can say that the leading group demonstrated administrative effectiveness (Raudenbush, 2003). The fourth type of difficulties was due to the fact that the leading preservice teachers were new to the construction of internet sites, so they did not know which technological tools they should use to fulfill their goals. They started with tools that they knew, and cooperated with experts to decide upon tools that fulfill their special needs. They also learned special techniques and new tools that they did not know before. The fifth type of difficulties was inevitable because of the massive amount of learning materials and the large number of participants who carry out their final projects.

Regarding the solutions that the preservice teachers used to overcome their difficulties in carrying out the projects, the preservice teachers who developed the learning materials used the following solution types: (1) reflection (2) consulting and collaborating with the lecturers, each other or the computer lab experts (3) searching and consulting the web or history mathematics books (4) using a technological tool (forum). The preservice teachers who built the sites used the following solution types: (1) discussion and collaboration with the lecturers (2) consulting the lecturers and the computer lab experts (3) self learning and hard working (3) communicating with the preservice teachers who developed the learning materials (4) using data organization and storage efficiency. But overall, discourse with the lecturers and with peers was the main method to overcome the preservice teachers' difficulties. This role of discourse is known in the literature, for example Cobb, Boufi, McClain, and Whitenack (1997) found that discourse increased conceptual development, Latham (1997) found that discourse increased knowledge of a domain area, while Menke and Pressley (1994) found that discourse resulted in the improvement of task-related knowledge. The lecturers were always available for the preservice teachers to discuss any issue of the project and this facilitated the preservice teachers work in carrying out their project successfully. The importance of the lecturers' role is supported by Usma & Frodden who emphasize the role of the facilitator in educational innovations.

## **FUTURE RESEARCH DIRECTIONS**

In this chapter we described how heritage and technology could be utilized to build mathematics lessons. Future research can examine how teachers and students use these lessons to teach and learn mathematics, how lessons based on heritage and technology influence the learning of students, their

performances, their self esteem and pride, their attitudes towards and enjoyment of learning and their perceptions of mathematics.

## CONCLUSION

This chapter showed how heritage and history can be utilized using technological means to build learning materials and non-traditional lessons which students are expected to learn enthusiastically due to the link of the mathematics to their own heritage and to its special representation in an exciting technological way. This expectation depends on previous researches that describe the enthusiasm of students when learning in a novel technological environment (see for example Baya'a & Daher, 2009).

The chapter described the difficulties that preservice teachers confronted in carrying out the project. These difficulties were mainly of educational, pedagogical, technical, and logistical types, added to the difficulties in reading historical material and relating it to teaching mathematics. They overcame these difficulties mainly by reflecting on the difficulty, communicating and collaborating with each other and with their lecturers. These means of overcoming difficulties confronted in carrying out the described technological projects were used by preservice teachers who carried out other technological projects for the first time, for example Daher and Baya'a (2008) reported that preservice teachers who managed online courses for the first time used communication as a means for overcoming their difficulties in managing the online courses. Confronting difficulties and overcoming them, the preservice teachers became more powerful in general and in working with educational innovations in particular. It could be said that the empowerment of the preservice teachers became possible because of the autonomy that they had in carrying out their projects (Usma & Frodden, 2003).

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## KEY TERMS AND DEFINITIONS

**Heritage of Muslim Mathematicians:** The life history and contributions of mathematicians from the Islamic empire era.

**ICT Pedagogical Model:** A pedagogical model constructed using ICT tools which also apply these tools in the learning/teaching process. Examples on ICT pedagogical models are: electronic presentation, video representation, web-based learning environment, WebQuest activity, electronic worksheet and simulation.

**Mathematics History:** History of the development of mathematical concepts and procedures.

**Project Based Learning:** Learning which is based projects. These projects could be carried out in the classroom or out of the classroom. It is intended as an alternative learning method where the student is active and engaged in deep learning.

**Technological Tool:** An electronic, digital or physical tool that can expand the human ability for performing tasks or generating products. For example: word processor, presentation program, spreadsheet program, graphics editing program, picture editor, movie editor, video format converter, web design editors, web design programs and platforms, web design script languages, web applets, voice recorder, digital video camera, etc.

**Technology Based Learning:** Learning which is based on technology. This technology could be electronic, digital or physical. It is introduced to make the student work on the learning topic

individually or collaboratively to discover the phenomenon associated with the learning topic.

**Web-Based Learning Environment:** Any educational web site constructed by educators (preservice, inservice teachers or other educational experts) who attempt to wrap together knowledge in specific content areas and technological features in pursuit of learning goals.

## ENDNOTES

- <sup>1</sup> At <http://users.qsm.ac.il/islamath>.
- <sup>2</sup> At <http://www-history.mcs.st-and.ac.uk/>.
- <sup>3</sup> At <http://illuminations.nctm.org/ActivityDetail.aspx?ID=16>.

**APPENDIX**

*Table 2. Difficulties and solution during the carrying out of the projects, regarding the regular groups*

<b>Difficulties</b>	<b>Solutions</b>
There was no outline plan for what the preservice teachers were supposed to do.	The preservice teachers inquired from the lecturers about this difficulty and collaborated with them to put such a plan.
The lecturers did not provide a lesson model or a good lesson example of what the preservice teachers should do.	The preservice teachers inquired from the lecturers about this difficulty and discussed with them the various models of integrating heritage and technology in mathematics lessons.
The preservice teachers gathered massive material about Muslim mathematicians, and did not know what to do with it.	The preservice teachers reflected on the gathered material and selected with the lecturers the important mathematicians that their life history and contribution should be written in detail under the sub-section of selected mathematicians, while the other mathematicians were described in general under the sub-sections of the indexes.
The preservice teachers found many historical stories of Muslim mathematicians' contributions, but faced the difficulty of selecting appropriate stories for their projects.	The preservice teachers reflected on the gathered stories and inquired about this difficulty from the lecturers who suggested that they should find a historical story of a concept or procedure which could be related to the current mathematics curriculum of middle schools.
The preservice teachers faced another difficulty with the historical stories. They did not know how to use it; just to tell it, or to present its historical mathematical concepts and procedures.	The preservice teachers Inquired from the lecturers how to utilize the historical stories and discussed the issue with them. They agreed to present the historical mathematical concepts and procedures involved in the story, relate them to current concepts and procedures and investigate their correctness with current mathematical techniques.
Some of the preservice teachers faced difficulties with some of the technological tools.	The preservice teachers supported each other and, in few cases, asked for support from experts in the computer lab in the college. In most cases, they found one among them who is specialized in the technological tool that they had difficulties with, or they cooperated together to get acquainted with the tool by reading its menu or trying it by themselves.
Sometimes the preservice teachers selected the same materials and argued among them on who selected the materials first.	The lecturers and the leading group started a forum which included the announcements of the preservice teachers regarding the materials that they selected, and the one who had the first dated announcement had the right on the selected materials.
Making sure that the contribution (concept or procedure) is actually for the mathematician to whom it is related to.	The preservice teachers browsed the internet and searched in mathematics history books for evidence of the mathematician who actually developed the concept or procedure. In some cases they found contradicting data on who was the first to introduce the concept or procedure.
Some preservice teachers had difficulty in understanding some of the historical mathematical materials.	The preservice teachers discussed the materials with each other and in some cases they consulted the lecturers.

**Building Multimedia and Web Resources for Teaching Mathematical Concepts**

*Table 3. Difficulties and solution during the carrying out of the projects, regarding the leading group*

Difficulties	Solutions
Choosing between different structures for the main internet site.	The choice was made by an agreed decision between the leading group and the lecturers. They did not arrive at an agreed site structure from the beginning, but developed the structure over and over again, and through different attempts.
Deciding on technological tools for constructing the main site.	The preservice teachers used technological tools that they had known and mastered already from other computer courses in which they participated. Sometimes they worked with the tools without prior knowledge to examine their fitness for their specific needs. In some cases they had to consult experts in the computer lab in the college and graphical experts that they knew.
Keeping the time schedule of the project and making their fellow preservice teachers deliver the learning materials on time.	They urged their fellow preservice teachers to deliver the learning material on time, and then they worked day and night to upload these materials to the main site. Sometimes, they had to involve the lecturers sometimes to make a formal request from their fellow preservice teachers and set deadlines.
Putting in the right place every page of the internet sites delivered to them by their fellow preservice teachers, and deleting the junk material that was forgotten by those fellow preservice teachers.	They worked day and night to clean the sites from junk materials, and set a structure of directories and file naming that all the preservice teachers had to follow.
The lecturers were not consistent and sometimes changed their views and remarks.	Discussing modeling issues with the lecturers made the leading group understand why the lecturers sometimes changed their views, so it was easy for them to comply with the lecturers' new suggestions.