The Effect of Integrating Elements of History of Mathematics
On Students' Attitudes Towards Mathematics:
A Pilot Study

by

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June, 2005
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The Effect of Integrating Elements of History of Mathematics On Students’ Attitudes Towards Mathematics: A Pilot Study

by

NIAM ABDUL HAFIZ ETANY

A project submitted in partial fulfillment of the requirements for the degree of Master of Arts to the Department of Education and Social Science Division at the Lebanese American University

June, 2005

Beirut, Lebanon
DEDICATION

For all the people who bear the suffering
and rejoice at the pleasure of educating others...
ACKNOWLEDGEMENTS

All the gratitude goes to Dr. Iman Osta, for her patience and support. Had I known a better word to describe it, I would not have hesitated to use. All I know is thank you.
AN ABSTRACT OF THE PROJECT OF

Niam A. Etany for Master of Arts

Major: Education/Mathematics

Title: The Effect of Integrating Elements of History of Mathematics On Students' Attitudes Towards Mathematics: A pilot study

This pilot study is divided into two parts. The first is a qualitative action research that studies the effect of using mathematics history elements on students' attitudes towards mathematics in an eighth grade at a private school in Beirut. The participants are 14 female Lebanese students. The researcher coordinated with the teacher the use of historical anecdotes and problems, and general historical knowledge while explaining two new mathematics chapters. The researcher used observations, interviews, and test grades to detect any change in students' attitudes. The results of this action research show that there is a positive change in students' attitudes towards mathematics chapters when appended with mathematics history elements. Based on the results of this action research, the researcher developed two mathematics chapters: "Pythagoras' Theorem" and "Equations". The researcher depends on the Lebanese official curriculum and the official textbook Building Up Mathematics.
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PART ONE: ACTION RESEARCH

CHAPTER 1

INTRODUCTION

Background

Mathematics is an old human experience, almost as old as mankind. However, this experience has been transformed into an academic subject that scares students. The fear of mathematics has no rational background in most cases; it is rather the result of stereotypes and preconceived self conceptions. Nevertheless, the usage of mathematics as a contemporary science only in classrooms plays a role in dehumanizing this field of knowledge and transforming it into a mere collection of numbers, sketches and theories. Educators and researchers seek usually better achievement among students. Fewer of them aim to make mathematics a humane and lively experience, through spicing it with the spirit of the four thousand years or more it has spanned.

Purpose

The purpose of this project is to study the effect of introducing elements from the history of mathematics to the mathematics classroom, on students' attitudes towards mathematics. Based on this pilot study, the project aims to develop two prototypical mathematics chapters integrating historical elements.

Rationale and Significance of the Study

"The history of science is science itself" (Von Goethe, 1970, p. xliv).

This project is expected to achieve many goals on the cognitive, affective, and behavioral levels. The integration of elements from the history of mathematics in the mathematics classroom is expected to increase the attention and memory span of students regarding mathematical theories and concepts. It highlights the nature of mathematics as an evolutionary field of knowledge developed by people - just like the students studying it. It
also affects teachers' methods and attitudes towards mathematics and using its history in the classroom.

CHAPTER 2

LITERATURE REVIEW

What Affects Students' Attitudes towards Mathematics?

Attitudes towards mathematics may be a key factor in determining students' relation to the mathematics learning process. Although there is no scientific consensus on the positive correlation of attitude and achievement in mathematics, many research studies have found strong positive links between them (Ma, 1997; McLeod, 1992; Singh, Granville and Dika, 2002; House, 2003). Unfortunately though, and while many students enjoy mathematics, many others have negative attitudes towards this subject (Fennema and Sherman, 1978). These negative attitudes can be resistant to change (Tobias, 1995) and they may inhibit the learning process (Zeidner, 1991; Hembree, 1990). Worse yet, negative attitudes can be the road to math anxiety which can block out learning or slow down the learning process in a distorting manner (Martinez and Martinez, 1996). The positive aspect amongst all these effects of negative attitudes on mathematics learning is that attitudes are directional (Cardno, 1955; Aiken, 1970) and they can thus be changed. This is one of the reasons that keep researchers and educators persistent in their attempts to make mathematics an appealing experience.

Attitudes may be determined through examining three different aspects: the cognitive, the affective, and the behavioral aspects (Young, 1998). This implies that any attempt to change attitudes can be initiated and monitored also, through one of the cognitive, affective, or behavioral lenses. Researchers and mathematics educators have conducted studies and experiments that aim to improve students' attitudes toward mathematics, or improve the mathematics learning process. However, this issue of negative attitudes towards mathematics
seems to be rooted in a large socio-cognitive system that affects students' attitudes towards the subject, and draws certain discouraging stereotypes of their abilities in mathematics (Meece, Wigfield, and Eccles, 1990; Martinez and Martinez, 1996; Spencer, Steele, and Quinn, 1999). This socio-cognitive system greatly affects what Bandura (1997) terms "perceived self-efficacy", which predicts attitudes and achievement in specific and various areas (Schunk, 1989). Bandura's definition takes into consideration the circumstances that are present when accomplishing different tasks. He emphasizes that self-efficacy is concerned not "with the number of skills you have, but with what you believe you can do with what you have under a variety of circumstances" (Bandura, 1997, p. 37). The belief in self-efficacy regulates the relationship between mathematics anxiety and achievement (Meece, Wigfield, and Eccles, 1990). Moreover, this belief is the actual cause of mathematically disabling individuals who don't suffer from any deficiency in their mathematical abilities (Tobias, 1993; Martinez and Martinez, 1996). The same belief controls attitudes at the cognitive level, and is transmitted afterwards to the affective and behavioral levels (Young, 1998). All the above literature leads us to the conclusion that changing students' perceived self-efficacy in mathematics gradually changes their attitudes towards mathematics as a subject.

Giving mathematics a meaningful purpose causes a change in students' attitudes and proficiency (Cornell, 1999). Mathematics is a human endeavor which "has spanned over four thousand years, it is part of every man's cultural heritage, and it is a very useful, beautiful, and prosperous subject" (Man Keung, 1998, p. 3). It is a pity that, nevertheless, mathematics classes "are too often dull and lifeless" (Posamentier and Stepelman, 1990).

The History of Mathematics in the Mathematics Classroom

Several educators and researchers recommend the use of mathematics history in teaching mathematics. Knowing the facts and understanding the evolution of mathematical theories and concepts give mathematics a meaningful purpose. They help in demystifying
mathematics, through showing that it is the outcome of human efforts, exerted by other people like the teachers and, more importantly, like the students themselves (Marshall and Rich, 2000).

Swetz (2000) claims that one of the first known attempts to incorporate the history of mathematics in mathematics education occurred in the late nineteenth century, when the Italian Mathematician and secondary school teacher Gaetano Fazzari started publishing a mathematical journal for his students, by the name of *Il Pitagora*. Fazzari's motive to take this step was students' dislike for mathematics, and his own notion that they have an inborn difficulty learning it. So Fazzari resorted to puzzles and history to arouse his students' interest in mathematics. It is widely possible that Fazzari achieved his goal, because his journal *Il Pitagora* remained in print from 1899 till 1918 when World War One forced many publications to stop.

After more than half a century, in 1977, McBride and Rollins conducted a study, where they introduced elements from the history of mathematics in an Algebra course for college students, and found that the inclusion of these elements causes a significant improvement in students' attitudes towards mathematics (McBride and Rollins, 1977). Many other research and non-research articles published later, suggest that including the history of mathematics in mathematics education enriches the learning and teaching of mathematics (Furinghetti, 1997; Jardine, 1997; Marshall and Rich, 2000). Some educators point to the effect of using elements from the history of mathematics on problem solving skills, and express their confidence in their positive influence in this area, and in providing the basis for a better understanding of mathematics (Bidwell, 1993; Wilson and Chauvot, 2000). Others highlight areas where the integration of elements from the history of mathematics positively affects the mathematics learning process. Among these positive effects are: inspiring students and raising their interest, forming links between the students and their culture or other
people's cultures, adding a touch of entertainment, creating a sense of respect for the creators of mathematics and appreciation of their theories, projecting the universal values of mathematics, and last but not least, motivating students (Eves, 1969; Edwards Jr., 1994; Michel-Pajus, 2000; Gellert, 2000; Wood & Sellers, 1996; Leitken & Zaslavsky, 1997; House, 1993).

CHAPTER 3

METHODODOLOGY

This project includes two parts: a qualitative action research that studies the effect of including elements from the history of mathematics in the mathematics classroom on students' attitudes towards mathematics, and the production of two mathematics chapters, by integrating elements from the history of mathematics in two chapters from the official Lebanese textbook for grade eight, *Building Up Mathematics*, based on the results of the action research. In our "Procedure" section, we deal with both parts as a whole to facilitate the description.

Participants

The setting of the action research is an eighth grade classroom at a private school in Beirut. The class consists of fourteen girls coming from middle class conservative Muslim families, with varying achievement levels in mathematics, aged between 12 and 13 years old. We chose this school because we had access to the administration, and were able to convince the supervisors to implement our study. The teacher herself, being a graduate student of Mathematics like the researcher, was very cooperative and understanding.

Procedure

*Collaboration with the Teacher*

The researcher worked closely with the mathematics teacher of grade eight throughout the action research. They started preparing one week ahead of making any
observations, and maintained the cooperation till the end of the study. The collaboration included sessions for rehearsing, where the teacher and the researcher decide on how the teacher will explain the chapters to the students. They also agreed on what elements from the history of mathematics the teacher will be using, and the researcher conveyed to the teacher the rationale behind each and every specific element being employed. After understanding the purpose and significance of including these specific elements, and the strategy to follow in introducing them, the teacher was able to use these elements without changing the style and method of teaching she usually adopts.

*Scenario of the Classes*

*Classical Scenarios*

This section describes the regular mathematics session as the teacher manages it. Each school session at this eighth grade is 50 minutes long. Mathematics is scheduled on the second period on Mondays and Wednesdays, the fourth on Tuesdays and Saturdays, and the fifth on Thursdays. The teaching strategy is mainly teacher-centered during the explanation of new chapters, but it takes a student-centered direction during problem-solving and application sessions.

The teacher usually lectures in the classroom, and uses the board frequently for illustrations. She does not use manipulatives or any outstanding motivation technique. When she explains a new chapter, the teacher follows the order of the sections as provided in the textbook. She writes important information and formulas on the board and asks students to copy them on their copybooks. Students' work and their understanding is later assessed through tests that are often administered after the completion of each chapter. Other exams that include more than two chapters are given monthly or every six weeks.
Modified Scenarios

This section describes the scenarios of two mathematics sessions that were modified after collaboration with the teacher. These sessions witnessed integration of elements from the history of mathematics to the chapters being explained. The researcher rehearsed with the teacher all the parts that include historical elements.

During the implementation sessions, the teacher maintained her teacher-centered method, and still wrote important information and formulas on the board. The only non-conventional techniques for the students during these sessions were starting with a story and using the map of Egypt as a visual aid. The pupils eventually showed verbal and non-verbal signs of appreciation for these techniques, signaling the success of the modified scenarios.

Tools

The major tools for data collection were observations and interviews. The use of two different tools is for the sake of triangulation and for increasing the reliability of this action research.

Observation Logs

The classroom contains 14 female students. A floor plan of the classroom with students' seats is available in Appendix B. The classroom is located on the last floor in a six-story building. The teacher usually does not sit during sessions. The observer sat in the middle back desk, which provides the best angle to observe almost all students. Two observation forms were used: the standard observation log and a timed form to record free notes (see Appendices C and D respectively). Each behavior included in the observation log was recorded using a tally system of record keeping.

The researcher attended all mathematics sessions during the study period of two months as a non-participant observer. This period was divided into three stages. In the first
stage, two mathematics sessions were attended, in order to get familiar with the setting, check the feasibility and ability of one observer to follow up with 14 students, and to check the applicable and non-applicable items on the observation logs. The original observation form was taken from Walker and Adelman’s *A Guide to Classroom Observation* (1990). In their guide, the authors list a long record of expressions and behaviors that indicate approval and disapproval of students in the classroom. Taking into consideration the existence of one observer and fourteen students, more than one behavior were deleted because they were impractical to be kept track of, such as smiling, raising eyebrows, frowning, or lowering eyebrows—among others. Other items were simply not applicable. The final observation form thus contains 17 (13 negative, 4 positive) behaviors (see Appendix C).

The list of behaviors that reflect negative attitudes on the tallied form includes: yawning, changing one’s seat or position, sighing, looking at the watch (or asking for the time), twiddling thumbs and/or biting nails, scratching the head or playing with hair or eyeglasses, asking for permission to go to the toilet, playing with pens or stationery or other objects, leaning on the wall, bag, desk or hand, tying or untying shoes, looking through the window or door or just staring nowhere, bringing up a non-mathematical topic, and talking to friends. The list of behaviors reflecting positive attitudes includes: speaking up enthusiastically; asking questions on topic; helping classmates solve problems on the board, and volunteering to answer questions.

After the two preliminary observation sessions ended, two additional phases of observation were carried out: a pre-implementation phase and an implementation phase. The pre-implementation phase included sixteen sessions, covering two chapters: "Plotting in a Coordinate Plane" and "Ares and Angles". This phase provided valuable input on the usual class setting, and helped the students get familiar with the observer's daily attendance.
The implementation phase lasted fourteen sessions, covering the two chapters previously prepared in cooperation between the teacher and the researcher: "Pythagoras' Theorem" and "Equations".

*Observation Notes*

The observation notes forms were used to write any specific incidents that may be of value to the research. The selection verbatim technique was used, whereby students' comments were written, especially those that pertain to the item "Speaks up enthusiastically", which is included in the observation log.

*Interviews*

The researcher conducted semi-structured interviews with the teacher of the classroom, and six selected students of varying achievement levels.

*Interview with the Teacher*

The interview with the teacher was a semi-structured interview. Questions were previously set for this interview (see interview questions in Appendix E). This interview occurred during the pre-implementation phase, and aimed at understanding the teacher's attitude towards mathematics and teaching in general, in addition to her expectations regarding the effectiveness of introducing elements from the history of mathematics in mathematics classes.

*Interviews with Students*

The interviews with students were semi-structured with pre-set questions (see interview questions in Appendix E). Two high-, two average-, and two low-achievers were selected with varying degrees of participation in class. The interviews were conducted individually after the end of the implementation phase. They aimed at investigating the effect of introducing elements from the history of mathematics on each student's attitude towards mathematics, and towards the specific topics involved, in addition to any other effects.
Post-Test

The students sat for a test in "Pythagoras' Theorem" after they completed this chapter, as they often do at the end of each chapter. This test was not co-prepared, it was administered by the teacher who chose the questions and graded the quizzes individually (see Appendices F and G for more details). It was therefore similar to all other quizzes the students had taken during the academic year. Unfortunately, the teacher was not able to administer a test after the end of the chapter on "Equations", because of time limits.

Students' scores on the Pythagoras post-test and their scores on all the tests they took previously after each chapter were obtained in order to draw any possible conclusions. The total tests amounted to seven tests in individual chapters.

CHAPTER 4

Results

Observation Logs

To analyze the observation logs, the negative behaviors and positive behaviors were added separately for each student per session. These two sums were cumulated for all the 16 sessions during the pre-implementation phase on one hand, and for the 14 sessions that constituted the implementation phase on the other. By the end of this calculation, each student was assigned four total numbers of positive and negative behaviors: two during the pre-implementation and two during the implementation phase. The first two scores were divided by 16 to obtain the average number of positive behaviors and the average number of negative behaviors during the pre-implementation phase. The second two scores were divided by 14 to obtain the average number of positive behaviors and the average number of negative behaviors during the implementation phase. Table 1 demonstrates these results.
## Table 1

**Numerical Representation of Observation Data**

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*Columns refer to the following data:

1) Average negative behavior during the pre-implementation phase (16 sessions).
2) Average positive behavior during the pre-implementation phase (16 sessions).
3) Average negative behavior during the implementation phase (14 sessions).
4) Average positive behavior during the implementation phase (14 sessions).
5) Total negative behaviors for each student during the explanation of "Pythagoras' Theorem".
6) Total positive behaviors for each student during the explanation of "Pythagoras' Theorem".
7) Total negative behaviors for each student during the explanation of "Equations".
8) Total positive behaviors for each student during the explanation of "Equations".

The observation logs provided data on the behavioral aspect of students' attitudes towards mathematics during the pre-implementation and implementation phases of the action research.

Data analysis of positive and negative behaviors showed a decrease in the average negative behavior for 13 out of 14 students during implementation. Positive behavior records, however, showed only minimal improvement in the session on Pythagoras' Theorem, and higher improvement in the session on equations. This indicates that integrating elements from the history of mathematics in the chapters has helped to keep students more attentive, and engage them more in the learning process.

A quick look at the average negative behavior columns during the pre-implementation phase and during the two rehearsed sessions that witnessed integrating historical elements reveals that these sessions were indeed special for the students. All negative behavior records for the 14 students during both sessions are less than the corresponding average negative behavior per session for each student.

The item "Speaks up enthusiastically" in the observation log showed an outstanding enhancement during implementation. The number of tallies for this item during the pre-implementation phase, or 16 sessions, was 86 with an average of 5.375 per session for the whole class. After the implementation, which lasted 14 sessions, the tallies on this item rose to 98, scoring an average of 7 per session for the whole class.
Observation Notes

The observation notes were used as complementary forms to record free notes. These notes often included some events that we deemed significant for our study. The notes were mostly elaborations on specific behaviors recorded on the tallied logs.

Observation notes associated with the behavior "Speaks up enthusiastically" which we analyzed above provide more insight into students' attitudes, specifically at the affective level. Students expressed their verbal appreciation of the two sessions on Pythagoras' theorem and equations. Many of them asked the teacher to begin every new chapter with a story. Two low achievers who usually don't pay attention during regular sessions were very enthusiastic. One of them declared that "Pythagoras' Theorem" was "a very easy chapter". Her low-achieving classmate sounded her agreement to this statement, to the teacher's surprise. One of the low achievers announced that she "should make a discovery so that teachers will later on tell my story to other students".

Observation notes corresponding to the behavior "Volunteers to answer questions" indicate that students were able to recall Pythagoras and Al Khowarizmi's stories in details. They also recalled the theorems of both lessons easily in an impressive and unprecedented way.

Most students enjoyed the session on equations. According to our observation notes, more than one student was surprised when the teacher announced that Arabs and Muslims taught foreigners many things, and this spread among the students a sense of pride and curiosity to know more. A student commented on this particular piece of information that this was the first time she knew something positive about Arabs. Another asked what other fields than mathematics did Arabs "teach the foreigners".
Interviews

Interview with the Teacher

The aim of the interview with the teacher was to investigate her attitude towards mathematics and towards teaching, to understand her stance with respect to integrating elements from the history of mathematics in mathematics education, and her perception of the effects this integration may have on students' attitudes towards mathematics.

The interview with the teacher was analyzed according to categories. The categories included the teacher's expectations concerning the possible effects of integrating mathematics history on students' attitudes at the cognitive and affective levels. They also included the teacher's own attitude towards mathematics and mathematics teaching, and towards using mathematics history in teaching mathematics.

Teacher's expectations

The teacher said she expects mathematics history to make students more interested and more attentive. She added that they may be able to remember the stories and the theorems better than previous sessions, and that the students may even exert more effort to understand and not give up easily. On another hand, the teacher claimed that she does not think the integration will affect students' attitudes towards mathematics as a subject. She stated that it may cause students to "like the individual lesson more, but not mathematics".

Teacher's attitudes

The teacher assured that she likes mathematics and likes teaching it. She said she is enthusiastic about trying to use the history of mathematics in her classes. The teacher added that her professor at the university narrated once the story of a mathematician's discovery of a certain theorem about 2 years before, and she still remembers the mathematician's theorem and his story in details. She pointed out that she enjoyed that experience of using mathematics history as a student.
**Interviews with Students**

The interviews with the students were conducted after the implementation phase. The aim is to study the effect of introducing history of mathematics on their attitudes towards mathematics. Six semi-structured interviews were conducted with 6 students individually. The researcher asked all students the same questions with a minimal degree of improvisation based on the different answers. Interview questions are available in Appendix E.

Table 2 illustrates students’ answers to the preset questions of the interviews.

<table>
<thead>
<tr>
<th>Question Topics*</th>
<th>NH</th>
<th>BD</th>
<th>SS</th>
<th>AR</th>
<th>NZ</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like/dislike?</td>
<td>like</td>
<td>like</td>
<td>dislike</td>
<td>so &amp; so</td>
<td>dislike</td>
<td>like</td>
</tr>
<tr>
<td>interesting?</td>
<td>yes</td>
<td>yes</td>
<td>not a lot</td>
<td>yes maybe</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>attitude change?</td>
<td>yes</td>
<td>yes</td>
<td>maybe</td>
<td>maybe</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Chapters differed?</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>Pyth, more</td>
<td>yes</td>
</tr>
<tr>
<td>Affected how?</td>
<td>nicer, liked more</td>
<td>understand</td>
<td>remember</td>
<td>easy</td>
<td>solving</td>
<td>solving</td>
</tr>
<tr>
<td>More attention?</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>I am used</td>
</tr>
<tr>
<td>Helped in what?</td>
<td>remember, understand</td>
<td>happy</td>
<td>remember</td>
<td>geography, final project</td>
<td>history, new info ratios of things</td>
<td></td>
</tr>
<tr>
<td>History in all?</td>
<td>yes</td>
<td>special</td>
<td>yes</td>
<td>yes</td>
<td>not algebra</td>
<td>yes</td>
</tr>
<tr>
<td>Math discovery?</td>
<td>maybe</td>
<td>yes</td>
<td>by chance</td>
<td>can</td>
<td>maybe</td>
<td>yes</td>
</tr>
</tbody>
</table>

* Complete interview questions are available in Appendix E.
The data obtained from the interviews were analyzed according to two categories and several subcategories. The two categories are the cognitive and the affective effects of integrating elements from the history of mathematics. The subcategories under cognitive include understanding, remembering, problem solving and discovery. The subcategories under affective include like, dislike and interest.

Two out of the six interviewed students said they dislike mathematics. Another said she likes only geometry. The other three said they like mathematics. All students thought that "changing something" in the way the teacher explains the lesson might make mathematics more interesting. Four out of six said this could positively change their attitudes towards mathematics. The two who dislike mathematics said that it would not affect their attitude. All six agreed that the chapters on Pythagoras' theorem and equations were different and better than other chapters, that these chapters had a positive effect on them, and that they encouraged them to solve more problems or solve problems better.

The students also declared that they would like the teacher to include mathematics history in every chapter she explains. When asked if they could make a mathematical discovery themselves, all students claimed that it is possible, whether on purpose or by chance.

On the cognitive level, students mentioned several effects that the inclusion of mathematics history elements had on their experience. These effects included improving their understanding and retention of the theorem and the story, increasing their will to solve more problems and their ability to solve problems better, helping them recognize the practical use of mathematics in everyday life, paying more attention in class, and getting introduced to new information in other fields such as history and geography.

On the affective level, five of the six interviewees acknowledged that the use of the history of mathematics made mathematics more interesting to them. All of them said they
would like the teacher to include stories in every new chapter she explains. Two who had mentioned that they don't like mathematics, claimed they liked the chapters that included historical episodes, and wanted the teacher to use such episodes more often. One of them said this may change her attitude towards mathematics on the long run and that she may like it more.

Students' interviews yielded positive effects on the cognitive and affective levels of their attitudes. Many of what researchers and educators expected from the usage of the history of mathematics in the mathematics learning experience proved to be true to varying extents. The use of mathematics history elements motivates students and encourages them, it affects their attitude toward problem solving regardless of their skills, and it also helps them to understand and retain theorems better. The students' mere recognition and awareness of these effects enhances their perceived self efficacy. Perceived self-efficacy, as mentioned earlier in this study, directly relates and correlates to attitudes (Bandura, 1997). This was shown vividly when the interviewees admitted the existence of a greater possibility of liking mathematics more. The use of elements from the history of mathematics also has an effect on students' general knowledge, as more than one interviewee pointed to the fact that they acquired new geographical and historical information. This can be studied from a multi-academic subject angle, as students were supposed to have studied the geography of North-Eastern Africa and the Nile River at the beginning of this same academic year in their geography curriculum. The integration of Al Khowarizmi's story to the chapter on equations assisted the students in developing a sense of association and common roots with the Arab and Muslim Scholar. One student said she was very happy to know his story because of these common qualities. When asked about their abilities to make mathematical discoveries, the students declared it was very comforting to know the people who found these theories, and claimed that they can discover similar theories because they are just like them. One student
mentioned during her interview that she is already trying "to calculate ratios of things around me, maybe I can discover something like Pythagoras".

Post-test

The students' mean score on the test in "Pythagoras' Theorem" was 4.04 on a scale of 5. Their mean score on the other 7 quizzes they had taken in previous chapters was 2.44 on a scale of 5 (See Appendix G for details). This reflects a positive improvement in students' grades after mathematics history was employed in the classroom. Unfortunately and as previously indicated, the students were not tested on the "Equations" chapter individually. This made it hard to check the consistency of the grade raise. Nevertheless, the grades on "Pythagoras" stood out amongst all other grades, and this indicates that the learning experience of this chapter stood out amongst other chapters.

CHAPTER 6

CONCLUSION

Limitations

The action research was conducted in a class of 14 female students, who are all Arabs and Muslims. The number and the gender of the students constitute limitations of the research because they make a very small sample. Moreover, the Arab and Muslim identity of the students put them at an advantage in both chapters, because they can relate easily with Egypt in the first chapter and with Al Khowarizmi as an Arab Muslim scholar in the second. Although this has positive consequences in our research as a specific case, this may not be the case when and if the research or the chapters are given in a different cultural setting.

The small sample also imposed restrictions on the quantitative analysis and use of statistical data pertaining to the observation logs and scores on tests. The methodology could have also been enhanced with a more balanced number of positive to negative behavior ratio than 4:13.
The schedule which the teacher had to abide by for finishing each chapter imposes another limitation. The existence of one observer is a drawback, but is partially compensated through the interviews. The main obstacle remains, of course, that 14 sessions in less than one month's time constitute a very short period for students' attitudes to show change.

Future Implications

The findings of this study and the developed chapters can be used in mathematics classes, in order to present mathematics in its universal and historical context. These chapters, and many other chapters that can be developed using similar methods, will assist in improving students' behavior in mathematics classes and can positively affect their attitude towards mathematics. They also constitute a sample for teachers who can use history of mathematics in their teaching methods and strategies.

This pilot study opens a perspective for further research in the field of using history of mathematics in mathematics teaching and its effects on various aspects of the learning process. Moreover, it opens a perspective for further development of additional chapters in the Lebanese textbooks specifically using the same methods used in this study.
PART TWO: DEVELOPMENT OF THE CHAPTERS

DEVELOPED CHAPTERS

Selection of the Chapters

The study started with a review of the scope and sequence of the mathematics curriculum at the middle school. Grade eight was chosen as a context, since the mathematics curriculum for this grade includes many topics that can easily append elements from the history of mathematics. In coordination with the teacher, two consecutive chapters were selected to be developed: "Pythagoras' Theorem" and "Equations".

The content of these two chapters is the primary reason for their selection, as both are relevant for the integration of elements from the history of mathematics. Moreover, the second chapter can directly be related to the students' Arab and Muslim heritage through Al Khowarizmi. We also chose consecutive chapters in order to use our time and the teacher's time efficiently. The scheduled dates for explaining these two chapters were also convenient for the timeline of the study.

Development of the Two Chapters

References

The researcher started developing the chapters by reviewing their contents, then conducted a research in the history of mathematics to find elements that can be integrated with these chapters. The research led to a wealthy body of information on Pythagoras and on equations. As for "Pythagoras' Theorem", the choice was made not to confuse the students with the proof of his theorem, and to concentrate on his story in Egypt and the way he came up with the theorem. Thus, the proof of Pythagoras' theorem is not included. In the second chapter, the focus is on Al Khowarizmi. In addition to the original source Al Jabr Wal Muqabala, several other references on the history of mathematics were used (Cooke, 1997; Boyer & Merzbach, 1989; Katz, 1997; Fauvel & Gray, 1987).
Selections for the Development

Chapter One: Pythagoras’ Theorem

After studying the historical episodes, the researcher decided to mention the existence of many proofs and discoveries related to Pythagoras’ theorem without specific emphasis. Sections from Pythagoras’ life story that relate directly to the content of the chapter were chosen. These sections are: his birth in 570 B.C. and a brief statement about schooling in that era, Thales being his teacher, his travel to Egypt, a brief introduction to the geography of Egypt and specifically the Nile River, the annual flood of the Nile and the way the farmers had to re-measure their lands each year, and finally Pythagoras’ discovery of the relation between the side measures and diagonal measures of the rectangular lands.

Chapter Two: Equations

The second chapter starts with a brief introduction on the contributions of Arabs and Muslims to sciences in general, and then addresses Al-Khowarizmi’s contributions to mathematics and to algebra in specific. A word problem and its solution from his book Al Jabr Wal Muqabala is added to the chapter as quoted in the original Arabic version of the book. The same problem is then represented and solved in symbols.

Rationale of the Selections

Chapter One: Pythagoras’ Theorem

The inclusion of Pythagoras’ date of birth informs the students about the era during which he lived. Then the chapter briefly describes tutoring during that era. This remark on the difficulty of schooling in that period touches on the students’ affective level of thinking about the schooling process today. When students know that in the past one had to learn about all existing sciences and arts from one person knowledgeable in all those fields, they may sense the relative ease with which present-day students attain high degrees. The teacher may also hint this to students. It is important to include Thales since he is one of the most prominent
figures in mathematics history, and because the students will be studying his theorem in grade nine. Pythagoras' journey to Egypt and the geography of Egypt and the Nile River is a must-know information for the students, as part of the story and the geography of the Arab world. It can also be regarded as an entry to cultural exchange.

The issue of the farmers who re-measure their lands each year after the flood of the Nile, adds a dramatic touch to the story. Pythagoras' induction of the theorem constitutes the glamorous "end" of the story, whereby he arrives at a universal solution for the farmers' exhaustion. If the teacher is able to bestow Pythagoras a heroic status due to his discovery, students are likely to develop an admiration towards the main character, who is our scholar in this case. Consequently, Pythagoras' works, including his famous theorem, will have more significance to the students.

Chapter Two: Equations

The chapter on equations starts with an introduction about the contributions of Arabs and Muslims to sciences in general. This is expected to instill a sense of pride and curiosity among the students, and to arouse their interest to know more about these contributions. Then the specific and universally acclaimed contribution of Al Khowarizmi is addressed, because it serves as a distinguished example. The main historical element is a word problem quoted with its solution from *Al-Jabr Wal Muqabala*. Only the word problem and solution are included, and these *seem* to be complicated at first glance that no student may be able to know that the solution is included. Students can then see that solving this word problem after transforming it into a first degree equation is simple. Solving the same problem written in words and then using mathematical symbols provides a platform for the students to compare the two approaches.
Style and Content of the Chapters

Both chapters "Pythagoras' Theorem" and "Equations" are produced with specific choices for the format, style and content of both chapters. It is important to note, though, that all mathematical content and theorems or properties are not different from those in the adopted textbook.

Regarding the style, theorems or properties of both chapters are included in yellow boxes, in order to distinguish them from activity boxes. The font used to write the theorems and properties is also larger. The theme color changes from one chapter to the other, to add variety and to break monotony. The activity boxes were overlaid with shades from the theme color for each chapter: green for "Pythagoras' Theorem", blue for "Equations".

Chapter One: Pythagoras' Theorem

The chapter starts with a long background section, which includes the historical anecdote relevant to this topic. Photographs and graphics that assist in making the concepts more concrete and contribute to students' knowledge regarding the specific topics are used on the left margin of the page. Beneath each photograph, a short comment gives the specific figure additional meaning and relevance. Small boxes appear on the other side of the page in the chapter. These boxes carry minor interesting information, intriguing questions, home or class secondary tasks, and sometimes motivating expressions. The story at the beginning of the chapter leads students to the main mathematical idea which is Pythagoras' theorem. After that, the chapter continues with the mathematical content, whereas the graphics, pictures, and boxes maintain the historical touch. The mathematical content of the chapter including all theorems and properties are the same as in the original textbook. Only the format and the general historic mood of the chapter are modified.

The figures in "Pythagoras' Theorem" include a photograph of Pythagoras' statue and a portrait of James Garfield, the American president who found an original proof for the
theorem. The track of the Nile River in Egypt is demonstrated in a small map. Teachers can use bigger maps of Egypt or Eastern Africa in the classroom to show the path of the river. One photo of the science in Ancient Egypt pinpoints the importance of the Pharaonic civilization. The second photograph from Egypt shows Luxor Temple, with a note mentioning that Pythagoras was inspired by the geometric dimensions in the old great temples. Students may get curious to investigate the topic more on their own. Two photographs on the last page show signs of greatness of the Ancient Greek civilization.

Chapter Two: Equations

The same techniques are used for the chapter on equations. The introductory story is shorter than that of Pythagoras, because the chapter includes a full problem from Al Khowarizmi's mathematical masterpiece Al Jabr Wal Muqabala. The problem is chosen so that students can solve it easily when it is written using mathematical symbols, but not when it is written in words. The goal is to let students understand the importance of using mathematical symbols, and appreciate the relative easiness of the format which they use to solve equations, no matter how hard they seem.

The figures in this chapter include one of Abu Raihan Al Bairuni, a famous Arab scholar. The picture is included in the context of an "E-Search" for the students to find out more about this scholar. After that there is a portrait of Al Khowarizmi, and a photograph of his statue at Amirkabir University of Technology in Iran. The statues of scholars in both chapters are expected to encourage the students to make discoveries. For that sake, the words under one of them in "Pythagoras' Theorem" say: "Statues of great figures, like Pythagoras, remind the people of their great contributions."

A photograph of the first page of "Al Jabr Wal Muqabala" in the handwriting of Al Khowarizmi is included in the chapter "Equations". Teachers may mention that printing was not invented when Arab scientists flourished, or leave it out for the students to notice on their
own. On the last page of "Equations" is a photograph of the Louvre Museum in Paris. The Louvre resembles an important international site that contains many Arab and Islamic masterpieces.
REFERENCES


CHAPTER 7

PYTHAGORAS' THEOREM
Pythagoras was born about 570 B.C. on the Greek island of Samos. He was well educated, and the most important among his teachers was Thales. Thales introduced Pythagoras to mathematical ideas and astronomy.

When Pythagoras showed signs of ingenuity, Thales sent him to Egypt, to learn from the pharaohs. Pharaonic Egypt was very distinguished in sciences like astronomy, medicine, and mathematics.

The Nile River crosses agricultural lands in Egypt. It flooded each year, leaving farmers in need to measure their lands annually, to mark their boundaries. The lands were shaped as rectangles on both sides of the Nile. Farmers did not have any formula to measure the perimeter and area of lands, or to restore the right angles at their corners. So they used triangle shaped ropes, with 3, 4, and 5 as side measures.

**CLASSWORK**

Use a measuring ruler to measure side lengths of any three right triangles you draw. Record the measure of each side in all triangles. Can you think of any mathematical relation between the sides of a right triangle?
Pythagoras discovered that there is a special mathematical relation between the lengths of the sides of lands, and he decided to check if this relation works for any right triangle.

Chinese, Babylonian, Egyptian, Roman, and Indian mathematicians also found proofs for this relation which is known around the world now as "Pythagoras Theorem".

**PYTHAGORAS' THEOREM**

In a right triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides.

Check with Pythagoras if his theorem applies to the right triangles in the following figure.

Conversely...

Check if Pythagoras' theorem applies to triangle ACE. Is this triangle right?

**RECALL**

In an isosceles triangle, two sides are congruent.
Apply Pythagoras Theorem to a right isosceles triangle with a hypotenuse "c" and side "a".

Complete the following property:

APPLICATION
In a right isosceles triangle with hypotenuse "c" and side "a", we have:

\[ c = \ldots \ldots \ldots \ldots \ldots \ldots \]

RECALL
In a semi-equilateral triangle, the shorter side is equal to half the hypotenuse.

Apply Pythagoras Theorem to a semi-equilateral triangle with a hypotenuse of length "c" and longer side of length "a". Find a relationship between "a" and "c".

APPLICATION
In a semi-equilateral triangle with hypotenuse "c" and longer side of length "a", we have:

\[ c = \ldots \ldots \ldots \ldots \ldots \ldots \]

HOMEWORK
Imagine that you are Pythagoras, and your teacher Thales sent you to Egypt. Tell your story.
Credits

Sources of figures and photographs in this chapter:

- Portrait of Pythagoras
  http://www.livius.org/a/1/greeks/pythagoras.jpg

- Pharaonic Civilization
  http://showcase.netins.net/web/ankh/

- Map of Egypt
  http://www.lib.utexas.edu/maps/atlas_middle_east/egypt.jpg

- Lands by the Nile
  Computer Generated by Researcher

- Luxor Temple
  http://www.lts-orient.ch/lts-franz/nilkreuzfahrt/karnak/tempelkarnak.htm

- James Garfield
  http://www.exploredc.org/images/presidents/20_01.gif

- Greek Statue

- Ancient Greek medicine
When Europe was suffering through its darkest era, Arab and Muslim scientists and scholars, between the years 750 and 1100 A.D., provided the most powerful inspiration for people's quest for knowledge.

Of these scholars, Al-Khowarizmi lived during the rule of Al Mamun in Baghdad. He is one of the greatest mathematicians who ever lived, and he is the founder of several branches and basic concepts of mathematics.

Here is a historical problem solved by Al Khowarizmi:

Mathematically, the problem above can be simply written as: $\frac{10a+5}{x} = 4$.
Muhammad Ibn Mussa Al Khowarizmi is the founder of "Al Jabr" (Algebra). He is the one who explained the use of zero, a numeral of vital importance developed by the Arabs.

Thanks to Al Khowarizmi, Arabs got introduced to algebra, which was later translated to Latin so that the Europeans can benefit from it.

SOLVE...
Can you find the value of \(x\) so that \((x + 2)(x - 1) = 0\)?

We know that if the product of two factors is zero, then at least one of them is zero.

So, if \((x + 2)(x - 1) = 0\), then

\[x + 2 = 0, \text{ and } x = -2\]
\[x - 1 = 0, \text{ and } x = 1\]

APPLICATION
The roots of any equation of the form: \((ax + b)(cx + d) = 0\), are:
\[-\frac{b}{a} \text{ and } -\frac{d}{c}\]

RECALL:
Equations of the form \(x^2 - p = 0\), can be written as equations with a product of factors.
RECALL
To factorize equations, search for common factors, or recall standard formulas

When an equation is not a product equation, you need to factorize it before finding its roots.
For example,

$$3x^2 - 12 = 0$$ is not a product equation,

Factorize:

$$3(x^2 - 4) = 0$$
$$3[(x - 2)(x + 2)] = 0$$

2 and -2 are roots of the equation:
$$3x^2 - 12 = 0$$

COMPLETE THE FORMULAS...

\[
\begin{align*}
(a + b)^2 &= \ldots \\
(a - b)^2 &= \ldots \\
(a + b)(a - b) &= \ldots
\end{align*}
\]
Credits

Sources of figures and photographs in this chapter:

- Abu Raihan Al Bairuni
  

- Portrait of Mohammad Ibn Mussa Al Khowarizmi
  
  http://engr.smu.edu/~saad/courses/cse3358/

- Statue of Al Khowarizmi
  

- Cover page of Al Jabr Wal Muqabala
  

- Louvre Museum
  
  http://www.globalperspectives.net/france/images/louvre.jpg
APPENDIX B

FLOOR PLAN & STUDENTS' SEATS
FLOOR PLAN SHOWING STUDENTS SEATS AND OBSERVER'S SEAT

- Door
- Board
- Teacher's desk

Students' seats:
- AR
- HS
- FI
- NZ
- DN
- AM
- SA
- NH
- SS
- BD
- SH
- MA
- MH
- FG
- Observer

Windows on the right side.
<table>
<thead>
<tr>
<th>Date:</th>
<th>Behavior/Student Names</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Helps student on board | Asks questions related to the topic | Talks to friends | Volunters to answer definitions | Speaks up enthusiastically | Laugh | Look out of subject window | Snatch bag | Play with head | Scratch head | Pay with hair or eyeglasses | Bite nails | Bite thumb | Ask permission for toilet | Ask for the time | Look at watch | Look around | Lean on wall/brush/sdesk | Sigh, complain | Yawn | Change setting position |
|-----------------------|------------------------------------|-----------------|-------------------------------|---------------------------|------|--------------------------|----------|-----------------|--------------|------------------------|-----------|-------------|--------------------------|-----------------|-------------|----------------------|
APPENDIX D

OBSERVATION NOTES
<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1'</td>
<td></td>
</tr>
<tr>
<td>2'</td>
<td></td>
</tr>
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<td>3'</td>
<td></td>
</tr>
<tr>
<td>4'</td>
<td></td>
</tr>
<tr>
<td>5'</td>
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</tr>
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</tr>
<tr>
<td>10'</td>
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</tr>
<tr>
<td>11'</td>
<td></td>
</tr>
<tr>
<td>12'</td>
<td></td>
</tr>
<tr>
<td>13'</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E

QUESTIONS OF THE INTERVIEWS
Interviewer: Niam A. Etany
Interviewee: Hala Hajj Shehadeh.
Place: Al-Iman Pilot School.
Date: Wednesday, April 21st 2004, 10.05 a.m.

Would you introduce yourself please?

Did you choose to be a mathematics teacher?

Why?

Do you regret this decision now?

In your opinion, what would change in a mathematics session if we use episodes from the history of mathematics?

Like what?

So you think they will remember the theorem better?

Do you think that using mathematics history will affect students' attitudes towards mathematics? And in what way?

Do you think using the history of mathematics will affect the way they understand and learn mathematics? And in what ways?

Its practicality maybe?

So you think it is not going to affect their understanding of mathematics?

Ok, Thank you.
Interviewer: Niam A. Etany
Interviewees: Six students
Place: Al-Iman Pilot School
Date: Saturday, June 12th 2004

What is your attitude towards Mathematics as a subject. Do you like mathematics? Why or why not?

Do you think that if the teacher changed something in the way she explains the lesson, mathematics may become more interesting?

Can this change your attitude towards mathematics?

Do you think that the chapters on Pythagoras Theorem and Equations were different from other chapters? Why or why not?

How did these chapters affect you?

Did this effect encourage you to pay more attention and solve the problems better?

How else did the story and the old problems help you?

Would you like the teacher to include mathematics history in every chapter she explains?

Do you think you can make a mathematics discovery?
APPENDIX F

QUESTIONS OF THE POST-TEST ON PYTHAGORAS' THEOREM
Post-test Questions

I) State Pythagoras Theorem in a triangle PFS with hypotenuse FS.
   Calculate PS if FS = 5 cm and PF = 3 cm.
   Draw the figure.

II) In a triangle MOH right angled at M, we have: angle MHO = 60.
    Draw the figure.
    Find the measure of MH, knowing that OH = 8 cm.

III) In an isosceles triangle LPD right angled at L, we have:
     N is the midpoint of PD.
     LN = 2 cm.
     Draw the figure. Find the measure of LD.
<table>
<thead>
<tr>
<th>Names</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8*</th>
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</thead>
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<tr>
<td>AM</td>
<td>1.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5</td>
<td>3.5</td>
<td>6</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>AR</td>
<td>7</td>
<td>5.5</td>
<td>7</td>
<td>3</td>
<td>1.5</td>
<td>5.5</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>BD</td>
<td>7</td>
<td>8.5</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>HS</td>
<td>6.5</td>
<td>9.5</td>
<td>9</td>
<td>5</td>
<td>3.5</td>
<td>9.5</td>
<td>19.5</td>
<td>5</td>
</tr>
<tr>
<td>DN</td>
<td>8.5</td>
<td>6.5</td>
<td>7.5</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>16.5</td>
<td>5</td>
</tr>
<tr>
<td>SS</td>
<td>1</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2.5</td>
<td>12</td>
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*Q8 refers to the post-test on Pythagoras' Theorem.