# The Social Classroom:

## Integrating Social Network Use in Education

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# Chapter 9
# Facebook as an Educational Environment for Mathematics Learning

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## ABSTRACT

*In this chapter, the authors describe four successful experiments in using social networking sites (Facebook and Edmodo) in mathematics teaching and learning, where this use depended on populating the sites with historical mathematicians and/or mathematical phenomena. They describe two models of using social networking sites in mathematics education, as well as the phases of working mathematically with students when implementing each model. The authors emphasize the use of social talk as the first step to involve students with the learning of mathematics, as well as moving to cultural talk as a bridge between the social talk and the mathematical discourse. The experience in the four experiments indicates that social networking sites invite student collaboration, as well as encourage their learning actions and interactions. Teacher's or moderator's sensitivity is a very important factor for the success of the experiment, especially when young students are involved. Other factors which influenced the success of students' learning in social networking sites were the features of the social networking site, the properties of the inter-disciplinary phenomenon or the mathematics produced by the historical mathematicians, the background of the learners, and the activities of the moderator.*

## INTRODUCTION

Web 2.0 tools have been suggested for some years now for social life, communication, and work in various disciplines, especially in education (Alexander, 2006; Glogoff, 2005; Pempek, Yevdokiya & Calvert, 2009). Some of these tools are: Wikis, blogs, Facebook, Twitter, Second Life, Wiggio, etc. Researchers have studied the wikis' use in education more than any other Web 2.0 tool or social networking site (Daher, 2010; Daher, 2011; Forte & Bruckman, 2007; Grant, 2006). Here we

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are concerned with the use of social networking sites in education, and specifically Facebook and Edmodo in mathematics education.

Our concern with Facebook and Edmodo originates from the popularity of these sites among students and, at the same time, the beginning of their use as educational tools. This beginning indicates that these sites have the potential to motivate students to engage more actively in their learning through utilizing the sites' various technical options. The most important of these options are the sites' communication tools, for example, the chat, email, comments and 'likes' in Facebook. These options and potential meet the requirement of the National Science Teachers Association (2003) in the standards for science teacher preparation that science teachers should attempt to guide their students' learning by encouraging their conversations about scientific ideas. The communication tools of the social networking sites can help build a learning environment rich with students' conversation and discussions, and thus fruitful for building the scientific knowledge of students. Schroeder and Greenbowe (2009) say that one goal of the NSTA requirement is to help students articulate how they know, what they know, and how their knowledge connects to larger ideas, other domains, and the world beyond the classroom. These ideas were behind our intention to experience social networking sites, in our pre-service teachers' preparation. We intended that our pre-service teachers enrich their knowledge about mathematics, historical mathematicians and mathematical phenomena, concepts and procedures through conversing and discussing a phenomenon and the concepts and procedures associated with it, and through solving mathematical problems related to the phenomenon. This intention agrees with Smith and Peterson (2007) who describe knowledge as constructed not in the individual vacuum, but in the communication and exchanges enabled in social networks.

## BACKGROUND

Recently researchers attempted to use the Facebook environment to enable collaborative learning (English & Duncan-Howell, 2008), as well as to treat content knowledge in different disciplines (Schroeder and Greenbowe, 2009; Selwyn, 2007). English & Duncan-Howell (2008) reported that pre-service teachers used Facebook during their teaching practicum placements to facilitate mutual support, encouragement and the sharing of stories and anecdotes. Using Facebook enabled the pre-service teachers to direct their learning through creating, sharing and commenting on others' contributions, and by allowing them to choose from multiple forms of support. Further, Facebook environment enabled collaboration as the pre-service teachers assisted each other, shared digital artifacts and exchanged constructive feedback. These reports encouraged us to attempt using Facebook for mathematics education through students' collaboration and social work.

Schroeder and Greenbowe (2009) describe an experiment that involved using Facebook as an additional tool for their university students' learning. They point at the Facebook feature of enabling the upload of images to have an impact on their students' learning. Their students responded to comments, explanations, or observations with relevant diagrams, figures, or other graphics, while the instructors used the image uploading to draw chemical structures or step-by-step reaction mechanisms, as well as to post spectral data that could be used to discuss questions posted earlier. Another Facebook feature used was the 'Post Item' feature which was utilized mostly by the instructors to post Internet links of relevant Web sites.

Selwyn (2007) analyzed the content of Facebook pages of all undergraduate students who were studying at the School of Social Sciences in Coalsville University during the 2006/7 academic year. He found that when the education-related

postings were analyzed, five main themes emerged from the data: (1) recounting and reflecting on the university experience, (2) exchange of practical information, (3) exchange of academic information, (4) displays of supplication and/or disengagement, and (5) exchanges of humor and nonsense.

The previous initiatives that attempted to encourage collaborative learning and to treat elements of content knowledge in different subjects in the Facebook environment indicate that social networking environments can be a fertile land in which students are motivated to engage actively in their learning. Specifically for mathematics education, these environments can make the students enjoy the learning of mathematics and thus help them develop a positive image of it and raise their motivation to learn mathematics. This would expectedly increase the students' understanding of mathematical concepts and procedures and consequently might improve their achievement in mathematics. These conclusions made us want to experiment, together with our pre-service teachers, using Facebook for teaching and learning of mathematics. These experiments, we hoped, would open our eyes and those of our pre-service teachers, to the educational potentialities of social networking environments. Furthermore, it would make us and our pre-service teachers aware of the useful methods and strategies of utilizing these environments for their own needs and expectedly implement them with their pupils as teachers in the future. So, our main goal was to probe the potentialities of Facebook, as a representative of social networking environments, to enable the learning of mathematical concepts and processes, the hosting of historical mathematicians and the discussion of mathematical issues. More specifically we wanted to examine how we could move gradually from a social communication in Facebook to a more educational and content directed discourse. In addition we wanted to examine the actions needed to make this move smoother and more efficient.

## MAIN FOCUS OF THE CHAPTER: EXPERIMENTING WITH MATHEMATICS LEARNING IN SOCIAL NETWORKING SITES

We intend to describe four of our experiments in using social networks in mathematics education. These experiments were conducted in the frame of our preparation of mathematics pre-service teachers who were in their third year of study. In this year the pre-service teachers carry out a personal project as part of the requirements of their practical training. Four pre-service teachers chose to carry out their personal project in experimenting with social networking sites as environments for teaching mathematics.

The pre-service teachers' experiments involved populating Facebook with historical mathematicians and with mathematical phenomena. In the first experiment, one pre-service teacher created a Facebook character of the great historical mathematician Mohammad Al-Khwarizmi. In the second experiment, another pre-service teacher initiated a fan group for the poet and mathematician Omar Al-Khayyam, while a third pre-service teacher created a page on the golden ratio (a mathematical phenomenon). In these three experiments the learning community consisted of adults and general friends without any limitations. In the fourth experiment, a pre-service teacher built the historical character: Fibonacci in an Edmodo environment, and discussed the Fibonacci sequence (a mathematical phenomenon) and its relation to the golden ratio, but this time the learning community consisted only of sixth graders. We will describe these experiments, mentioning the participants in each one of them, and analyzing the resulting data qualitatively. Doing so we will emphasize the following aspects: (1) using the social aspect of social networking sites and the cultural aspect of mathematical phenomena and mathematics history to encourage and facilitate mathematical discourse, (2) models for using social network-

ing sites in mathematics education, (3) preparing pre-service for teaching in social networking sites, and (4) involving school students in learning mathematics in social networking sites.

## A Facebook Character and a Facebook Fan Group

We carried out, together with our pre-service teachers, two experiments using Facebook to involve the users in mathematics history and concepts. One pre-service teacher created a Facebook character of the great historical mathematician Mohammad Al-Khwarizmi, while another pre-service teacher initiated a fan group for the poet and mathematician Omar Al-Khayyam. We directed and assisted the pre-service teachers to gradually move the communication with the friends from social talk to mathematical discourse that involved analysis of mathematical concepts and procedures.

We will describe the experiment regarding the Facebook character of Al-Khwarizmi. This experiment lasted for three months and attracted 335 friends. We will describe the various actions which the pre-service teacher performed in the Al-Khwarizmi Facebook character site. These actions are representative also of the major actions performed in the other site, i.e. the Al-Khayyam Facebook fan group.

To analyze the data in Al-Khwarizmi site we used the grounded theory (Strauss & Corbin, 1990) to categorize in themes the actions and interactions carried out by the moderator and friends of the site. The following themes emerged from our analysis.

### Initiating the Character

The pre-service teacher started an account under the name "Mohammad Al-Khwarizmi," and stated in the "info," basic information about Al-Khwarizmi. This information included: date of birth, gender, location of work and fields of scientific activity. She also uploaded a picture of Al-Khwarizmi in the profile section.

The pre-service teacher moderated the page under the name of Al-Khwarizmi and began the communication by sending messages to her friends from her real account, including the pre-service teachers in the practical training course, inviting them to be friends with Al-Khwarizmi. As a result, many friends accepted the invitation and became Al-Khwarizmi's friends. A special group of friends were students at An-Najah National University who were required by their instructor (the second author of this article) to friend with Al-Khwarizmi and participate in the interactions and activities occurring at the Facebook site.

### Socializing with the Friends and Getting to Know the New Modern World

The moderator played the role of Al-Khwarizmi and socialized with the friends: wished happy birthday to one of them; wondered about the language (Hebrew) of the name of another friend, a language he was not familiar with; and talked about ordinary daily activities. One of the friends wrote that he was going to give a lecture in economics to a group of women, and Al-Khwarizmi was amazed about the fact that modern women are interested in such advanced fields as economics.

### Moving to a Cultural Talk

Al-Khwarizmi, who was exposed to the culture of the friends through their social comments, inquired about the exact cultural characteristics of his successors. This led the friends and Al-Khwarizmi to argue about the present culture of Moslems and Arabs and to compare it to the culture of Al-Khwarizmi's era.

### Connecting the Past with the Present

Al-Khwarizmi wrote a status to the friends that he was looking through the time tunnel to see his past in their present time wondering about the

lifestyle and progress of his successors. He also expressed his pride in their friendship.

The number of friends at this stage exceeded already 100 friends. As for Al-Khwarizmi's wish, some of the friends (4) checked "like" and 34 commented. Most of the comments were social, welcoming Al-Khwarizmi and expressing their will to get to know him. Some asked about his mathematics. Others asked about his emotions regarding his period, and few wondered about meeting a person like Al-Khwarizmi in such a modern environment as Facebook.

## Connecting to the Home Town of Al-Khwarizmi

Al-Khwarizmi stated that he missed his home town of Khwarizm (Khiva) and asked to see its picture in the present time. Four of the friends responded with "like" and sixteen commented. Some comments were political ones, for some of the friends were refugees who also missed their home town and identified with Al-Khwarizmi. Others asked for more information about Al-Khwarizmi and expressed what little knowledge they had about his home town. One friend posted a link to a video about Khiva and hoped that Al-Khwarizmi would be happy to see it. This comment got four likes and sixty three comments, many of which were social, expressing their feelings about the video, while other comments expressed pride in the Islamic empire in the period of Al-Khwarizmi and hoped that the glorious period would return. Some friends wrote information about the life of Al-Khwarizmi and his scientific contributions. Others inquired about his mathematical work, writings and books.

Some friends stated that they did not know how to find information about Khiva and some did not know how to upload a picture or a video to Facebook. The friends helped each other overcome the obstacles, and as a result many pictures and links to sites about Khiva were uploaded to the site.

## Connecting to Countries Visited by Al-Khwarizmi

The moderator posted a status about the cities and countries visited by Al-Khwarizmi and stated that Al-Khwarizmi expected that some of the friends might belong to his nation.

The friends responded with three likes and six comments. Some friends mentioned some countries that Al-Khwarizmi visited in his life. Others stated that they were proud to be his successors and belong to the same nation. They related their pride at Al-Khwarizmi being a mathematical legend in the glorious past of the Islamic civilization. These comments were followed by other comments of the friends which led to the exchange of information about the countries visited by Al-Khwarizmi, especially old and new names of the countries. One of the friends indicated that Al-Khwarizmi wrote a book about the countries he visited. The friend added that the book also included a map of Al-Khwarizmi's trips and inquired what the friends knew about this book.

## Discussing Al-Khwarizmi's Contributions

Al-Khwarizmi asked the friends if they knew about the books written by him. The friends uploaded pictures and links to videos and sites related to Al-Khwarizmi's books and contributions. Other friends asked Al-Khwarizmi about his life, events in his period, books he wrote, fields of study and research, and problems he solved. The moderator answered some of the questions in the name of Al-Khwarizmi and directed the friends to related sites to search for answers to their questions.

## Discussing Al-Khwarizmi's Opinion of a Good Woman

One of the friends wrote a comment about how Al-Khwarizmi perceived the qualities of a good woman. He wrote that Al-Khwarizmi gave the

value of 1 for the ethics of the woman, then added a zero for her beauty to get 10, followed by other zero for her wealth to get 100 and an additional zero for her origin and affinity to get 1000, but if the woman lost her ethics she lost the 1 and stayed with the value of three zeros.

## Congratulating the Friends on the Al-Adha (sacrifice) Feast

The moderator posted a picture with congratulations to the friends on the occasion of the Al-Adha feast, and "poked" the friends. Five friends liked the picture, while thirteen wrote comments. Most of the comments were social, congratulating Al-Khwarizmi on the feast.

## Posting a Video About Al-Khwarizmi's Method for Solving a Quadratic Equation

The moderator posted a video that she prepared with one Facebook friend using the program MovieMaker. The video presented a conversation between two of Al-Khwarizmi's friends about the method he used to solve a quadratic equation.

It is important to note that the Arabic language used in the video and in all the comments on the video (and in all the communication in the site for that matter) was the spoken language. This was done through using Arabic letters in general and sometimes English letters. The moderator intended to use this type of language to avoid stepping out of the routine social interaction used regularly between Arab friends on Facebook. Using classical language could have discouraged some friends from participating in the discourse, considering it too sophisticated for them.

Some of the friends liked the video (10) and others (27) wrote comments. Most of the comments were social and educational indicating that the video was a cool teaching idea, especially learning through conversation between the two girls and using a video to explain a mathematical problem and its solution. An argument also was initiated, following this activity, about using Facebook to expose pupils to mathematicians such as Al-Khwarizmi and to mathematical concepts such as the "equation." Some wondered and even questioned if this was possible, and some encouraged this idea emphasizing the importance of using new technologies in the learning process. They claimed that this might add a lot of fun and joy to the learning environment and reminded the friends that this was actually the new regular daily environment of our children (i.e. Facebook, SMS, cellular phone, etc.).

## Asking Friends to Explain Al-Khwarizmi's Method

The moderator posted a picture presenting Al-Khwarizmi with a text stating the same mathematical problem solved by him in the video. In the picture, Al-Khwarizmi asked the friends to explain his method for solving the quadratic equation using Algebra and geometry.

Most of the comments at this stage were mathematical. Some friends attached to their comments a picture taken using a cellular phone of a handwritten geometrical explanation of Al-Khwarizmi's method for solving a quadratic equation. Other friends used the same way to present an algebraic explanation of the Al-Khwarizmi method. Some friends typed their work using a word processor, converted the document into a picture and attached it to their comment. Others prepared a presentation of their work, uploaded this presentation to a site and posted a link to the presentation in Facebook. This was necessary because Facebook does not allow uploading files to the site that are not pictures and videos.

### Asking the Friends to Find Other Methods for Solving a Quadratic Equation

After a week since posting the picture, the moderator posted a "note" that included a video presenting an explanation of the Al-Khwarizmi method and which was prepared by one of the friends. The moderator asked the friends at this stage to find other methods, especially modern ones, for solving quadratic equations.

It should be noted that the main mathematical part was done by the students of An-Najah National University, which implies that mathematical discourse would have been more successful and efficient had it been carried out in the framework of a real class.

## The Facebook Page on the Golden Ratio

In the previous experiments we populated Facebook with characters from the history of mathematics, where the goal of the populating was to encourage participants' mathematical talk and discovery. Here we intended to examine how populating Facebook with an inter-disciplinary phenomenon - the golden ratio, could encourage mathematical and scientific talk by Facebook participants. Specifically we looked at the conditions and consequences of such populating on the participants' learning, and aimed to answer two questions: what were the conditions needed for utilizing social networking sites like Facebook in mathematical and scientific talk and learning? And what were the consequences of such talk and learning?

In this experiment, one of our pre-service teachers created a page on the golden ratio, which started as one involving a mathematical phenomenon. But soon Facebook friends widened it into an inter-disciplinary phenomenon, engaging various disciplines such as science, art and architecture. The experiment lasted for three months and attracted in total 575 friends.

After categorizing the themes of actions and interactions carried out by the moderator and friends of the site, according to the grounded theory (Strauss & Corbin, 1990), the following themes emerged from our analysis.

### Initiating the Golden Ratio Page

The pre-service teacher created a page in Facebook under the name "secrets and mysteries of the golden ratio." She began the communication by sending messages to friends from her private account, including her mates in the practical training course, inviting them to the page. She also suggested the page to her general friends on Facebook, especially those who were members in groups or pages dealing with the golden ratio on Facebook.

### Presenting the Golden Ratio Culturally

The pre-service teacher moderating the page posted a video, available on the internet, that included information about the golden ratio realization in real life. The friends commented on this video in two ways: some asked about the video and its real life content, while others asked about the phenomenon that was not known to them, and requested more information.

### Discussing the Golden Ratio Cultural Realization and Mathematical Definition

This time, the moderator created a video clip by herself trying to give answers to the friends' enquiries. She ended the video with a request to the friends, asking them to suggest a definition for the golden ratio concept. This post had many likes and over 65 comments, which included links to information available on the internet that the friends knew about, or files produced by the friends that present information about the golden ratio. The comments addressed various issues: examples of realizations of the golden ratio in

various real life aspects and phenomena, mathematical definitions of the concept, examples of uses of the golden ratio in different fields, examples of measurement tools based on the golden ratio, evidences of the holiness of this ratio in religion and ancient history and videos and presentations on the golden ratio created and produced by the friends. The moderator encouraged the friends to comment, and in turn commented on their comments. The moderator summarized the different issues raised by the friends as well as their comments, in a video posted to the page. This time too she got many likes and over 40 comments which concentrated on four main aspects: admiring the video, adding more information about the golden ratio phenomena, asking for permission to use the video outside the page and posting new questions and inquiries.

### Presenting a Mathematical Problem: Finding the Golden Section and its Value

To initiate a mathematical discourse, the moderator posted a link for an applet presenting a dynamic section of a segment (c) and asked the friends to use it in order to locate the golden section (given c=a+b, find the division point which satisfies the equality c/a=a/b) and to find the value of the ratio of this section. The friends replied with over 45 comments and many likes. This time the discourse took a more mathematical nature where the friends inquired about the moderator's request, discussed solutions of the problem, giving proper answers, and criticized the accuracy of the applets' measurements, emphasizing the importance of this accuracy in mathematics.

The moderator returned to the same problem, but this time asked the friends to solve it without the applet. She requested them to draw a line segment and to find a geometrical method that helped them locate the point of the golden section, then to explain this method on a piece of paper, to take a picture of it and post it to the page. Most of the friends could not solve the problem. Some found a solution on the internet, but did not understand why it was a correct one, so the moderator posted a video about the ancient mathematician Euclid and presented his method for solving the problem in a presentation that she prepared.

Here too, some friends expressed their difficulty in understanding the method and its steps. Some could apply it to locate the golden section, but could not prove it. So the moderator prepared an explanation and proof of the method on a piece of paper, referring the friends to the presentation describing the method. The moderator posted the scanned paper to the page, which made the friends express their admiration of the method and the moderator's clear explanation and proof of it. The friends worked on the problem, taking pictures of their work and posting them through their comments to the page. The moderator ended the activity with a video presenting some mathematical properties of the golden ratio, and, as a result, the friends thanked her for the video and presented links to sites and other videos on the internet that had answers and explanations related to the problems presented in the video.

## Fibonacci in Edmodo for Sixth Graders

In the previous experiments we targeted an adult population, where, at the beginning of each, the moderators invited to the sites their Facebook friends from the college as well as their regular Facebook friends. Afterwards they recruited friends from all over the world. In the Edmodo experiment, we, together with our pre-service teacher, wanted to involve elementary school students in learning mathematics on social networking sites. This would be done through the life and mathematics of the historical mathematician Fibonacci. The use of Edmodo goes side by side with the new policy of the Department of Education in Israel; not allowing the use of Facebook for student learning in the elementary school. This

network allows the teacher to create closed private groups, and thus prevents unwelcome intruders from entering the group, so the environment makes sure that the students are not exposed to the open and possibly dangerous world of social networks. Edmodo's privilege settings are such that the site allows the teacher and students to upload different kinds of files that are not allowed on Facebook, such as Power Point presentations.

The experiment involved sixth graders getting to know a historical mathematician and a mathematics phenomenon. Our pre-service teacher created an Edmodo character of Fibonacci. Here too the pre-service teacher started with social talks with the students, moved gradually, together with the students from social talk to cultural talk, and then to mathematical discourse about the Fibonacci sequence. The experiment lasted six months and included 19 six graders from one class in a private school in the city of Nazareth in Israel. The experiment utilized the two models experienced in the two previously described experiments: the historical mathematician and the mathematical phenomenon.

The following phases were identified as characterizing the proceeding of the experiment.

## Initiating the Character

The pre-service teacher started an account in Edmodo under the name "Leonardo Fibonacci," presenting only his name and picture. Then pre-service teacher created a private group with a secret code and met with the students in their class to give them the code. She told them that she would moderate the site by impersonating the character of the historical mathematician Fibonacci and then interact with them using the character.

## Socializing with the Friends

The Moderator played the role of Fibonacci, beginning the socialization with the friends by writing a welcome post. The students started with social talk among themselves and with uploading of their pictures. They felt safe to do so because Edmodo allowed the creation of a closed group and each member had to register and remember the secret group code.

## Moving to a Cultural Talk

The moderator engaged the students in cultural talk, asking about the life of Fibonacci, especially his hometown and his contribution to modern mathematics. The students responded to the moderator's request, uploading to the site pictures, video clips and presentations related to the life of the mathematician. The moderator proceeded to ask more specific questions about Fibonacci, such as presenting a picture of his statue and asking about its location. The students gave answers to these questions and added more information about the life of Fibonacci and his contributions, such as uploading pictures of his hometown Pisa and its famous tower, as well as a counting instrument which he built based on his sequence.

## Discussing Fibonacci Mathematical Contributions

The moderator posted some mathematical contributions by Fibonacci, such as a copy of a page from one of his books. This was done to shift the direction of the cultural talk gradually to mathematical talk.

## Posting Mathematical Problems Raised by Fibonacci and Discussing Different Solution Methods for Them

The moderator directed the discourse to mathematical problems presented by Fibonacci, and to historical solutions suggested by him, comparing them with modern mathematical solutions. One special problem engaged the students with mathematical discourse more than the others: the rabbits' problem. This discourse led the students to the construction of the Fibonacci sequence. The

moderator presented the problem using a video and asked the students to suggest answers and a pattern to find the number of rabbit pairs when given the number of the months in which the rabbits bred. After getting several answers from the students, showing that they had misunderstood the problem, the moderator presented the problem textually and visually.

At this stage, the moderator was more involved in directing the mathematical discourse, giving hints and directions aiming to lead the students to more mathematical understanding. One student presented her answer on a piece of paper which she scanned and uploaded as a file. The answer was not complete, but opened interesting mathematical discourse that led another student to present an answer to the rabbit problem using a Power Point presentation. The moderator prepared a clear answer with proper animations and posted it to the site, which helped the students to understand the problem and its solution.

### Connecting between Various Mathematical Concepts

After understanding the Fibonacci sequence, the moderator connected the sequence to the concept of the golden ratio, through a spreadsheets activity. The students carried out the activity and were excited with its results. They wondered about the new concept at which they arrived – the golden ratio, which was not known to them.

### Connecting Mathematical Concepts to Real Life Phenomena

The moderator directed the students to sites that demonstrated the realization of the golden ratio in real life. The students were impressed with this realizations and found several examples by themselves, especially in the human body. Some students even conducted measurements with their parents to check the realization of the golden ratio in the human body.

### Congratulating the Friends on a Holiday

At some stage, the moderator noticed that most of the students stopped interacting with her because of the Easter holiday, so she congratulated them and asked them about the special rituals of this holiday in their community. This talk led the students to an interesting investigation about the religion of Fibonacci and the diverse holiday rituals of different religions. This social/cultural talk raised several social and cultural questions and attracted the students back to the social networking site.

The above acts (moving between social, cultural and mathematical talks) kept the students interested and involved in the experiment, and proved once again that these transitions are an important factor to the success of the use of social networking sites in mathematics learning among students at various school stages.

## Reflecting on the Experiment through an Interview

At the end of the experiment we conducted an interview with the pre-service teacher, the students who participated in the experiment, one member of the school administration and the director of the practical training in our college. When asked to reflect about learning mathematics in a social networking environment, one student confessed that at the beginning he worried about his ability to use the Edmodo networking site, but soon after getting involved with it he learned to engage in dialogue with his mates. Doing so, he developed different dialogue techniques.

Another student stated that the experiment taught her how to answer mathematical questions or any problems she faced. To do so (she elaborated), one should wait and think properly, which helped get at the solution, whatever it was. She elaborated that when solving the rabbits' problem, she had a hard time at the beginning but she believed she could solve it. Although making some

mistakes at the beginning, she learned from these mistakes to arrive at the right solution.

More than one student declared that they were excited about the experiment and joined it because of its novelty. They also acknowledged that they were introduced to a very interesting mathematician some of whom had no knowledge of before. In addition, they were intrigued by his mathematical contributions. Doing so, they learned about new mathematical concepts such as the Fibonacci sequence and the golden ratio. Moreover, they got to know about the origins of these concepts in mathematics history and the problems that led to their appearance. They were amazed by the mathematical relations between the concepts and their realization in real life phenomena. They emphasized the importance of the role of the moderator and her relation with them, especially her patience in responding to their many questions, and they thanked her for that. One student emphasized also the importance of the collaboration among the students, claiming that this collaboration developed naturally in the social networking site. She stated that when things got complicated she collaborated with her mates in the group through Edmodo and in school, an act that she had hesitated to do before. She was happy that her relation with her classmates got better because of the experiment. She also pointed out the continuation from the virtual discussions in the Fibonacci group in Edmodo to real life dialogue with her friends. This collaboration in Edmodo, as well as in Face-to-Face meetings, improved her social life, besides her mathematics.

The school administrator declared proudly that the school policy encourages the use of advanced technologies in the educational environment and welcomed experiments that introduce innovative pedagogies based on new technologies, especially those that engage the students in collaborative learning activities. This was why their students have advanced CIL (Computer Information Literacy) abilities and were acquainted with modern technologies and tools. This was the reason, he declared, for the success of the Edmodo experiment.

The director of the practical training at the college was impressed by the social talk in the experiment, especially the social values and messages passed by the moderator to the students who come from various backgrounds and different religions. He was also impressed by the students' ability to express their emotions and reflections about the experiment clearly in the interview. Moreover, he was overwhelmed by the students' emphasis on the development of their dialogue and collaboration abilities, which the college encourages also among the pre-service teachers, and wants these pre-service teachers to encourage school students to do the same. He emphasized that the Edmodo experiment actualized the college's vision of the need for innovative pedagogy based on advanced and modern technologies, especially in the practical training and hoped that other schools would cooperate with the preservice teachers in this endeavor.

## Solutions and Recommendations: What We Learned from Our Experiments

Carrying out our experiments, we got to recognize the possibilities inherent in the use of social networking sites, especially Facebook and Edmodo, as educational environments for mathematics teaching and learning. We categorized these into four categories: (1) models for using social networking sites in mathematics education: historical mathematicians and mathematical phenomena, (2) using the social potentiality of the sites, as well as the cultural aspect of mathematical phenomena and mathematics history, to encourage, facilitate and move towards mathematical discourse, (3) the need for preparing pre-service and in-service teachers for teaching using social networking sites, and (4) the importance of involving school students in learning mathematics on social networking

sites. We will clarify these aspects and explain how they can affect positively the use of social networking sites as educational environments in the teaching/learning processes in general and in teaching/learning mathematics specifically.

## From Social Talk to Mathematical Discourse through Cultural Talk

Iiyoshi and Richardson (2008) say that "the personal, contextual, and accretive nature of knowledge of teaching and learning, with its complex interaction of people, tools, and resources, makes it difficult and time-consuming to capture and examine, either in verbal or other modes" (p. 339). We intended to capture and examine in written text the complex interactions occurring in Facebook and which involved the mathematical history of great mathematicians and the realization of mathematical phenomena and concepts in authentic real life situations.

Looking at the interactions occurring during the experiments that attempted to capture mathematical history, phenomena and concepts on Facebook, we found that three main interactions occurred: social, cultural and mathematical. The cultural interactions were the steering component which moved the friends from the social into the mathematical, while the social was the glue which hooked the friends together in the social networking environment. The social interaction spread through the whole discourse and attracted the friends again and again. This importance of the social talk is emphasized in other studies, for example, DeAnda (2007) found that developing a sense of comfort with group members was often perceived by the members as a precursor to progressing in mathematical work. Here, the social made the friends comfortable and ready for the transition to the cultural and afterwards to the mathematical.

What made the friends feel comfortable with the move from social issues to mathematical content knowledge was the smoothness of the transition through the cultural interests of the friends. To move from the cultural to the mathematical, the moderators shifted the focus of the conversation to the contributions of the historical mathematicians (especially their books), then they presented some of their main contributions – solving quadratic equations or solving the rabbits' problem and introducing a new sequence. In the case of mathematical concepts or mathematical phenomena, the moderators used the realization of the concept or the phenomena in real life to move from cultural talk to mathematical discourse. After getting admiring comments, the moderators posted more mathematically oriented requests for the friends, such as explaining the solution method presented by a historical mathematician using modern mathematics and found other methods or explaining mathematically the realization of mathematical phenomena or concept in real life. This was a successful move which was usually followed by many comments, pictures and links to presentations that involved mathematical talk and work done by the friends.

Various actions were carried out to arrive at mathematical content knowledge: socializing with friends, connecting the past to the present, connecting to places: the mathematician's hometown and the countries visited by him, connecting to the mathematician's contributions, etc. So, the transition to the mathematical was not all of a sudden, but through different actions most of which were not related to mathematics, but to social, historical, cultural elements, and to real life. The finding of the ability of Facebook to attract the participants to learn content knowledge was reported in the literature, but for other subject matter (Schroeder and Greenbowe, 2009; Selwyn, 2007).

Another strategy that the moderators used, which attracted and motivated the friends, was a cultural strategy: connecting the friends' knowledge of ancient history to their present. For example, in the case of Al-Khwarizmi, of whose culture the friends considered themselves descendants, they felt proud of him and of his

contribution to mathematics and humanity, and thus they were motivated to act and interact. The same result was achieved by the sixth graders when they searched for the religion of Fibonacci and discovered that they belonged to the same religion. These connections to the students' own life and feelings are known to better the teaching and learning of mathematics (Lin, 2005).

Utilizing Facebook and Edmodo environments to represent a famous mathematician who relates to the friends, motivated them and was an important reason for them to feel proud and identify with the Facebook character and his mathematics. This implies that the choice of great mathematicians who lived in glorious periods relating to the friends' history, added nostalgia and pride, which were often present in their comments.

The presentation of the life and contributions of a great mathematician was done through utilizing the various technological options available in Facebook. The friends mostly used the 'comment' option, maybe because they were mostly engaged in commenting on Al-Khwarizmi and on each other. The high number of comments indicates that the friends' interactions prevailed in the historical mathematical Facebook environment. The second option mostly used by the friends was the text posts, which enabled the friends to ask Al-Khwarizmi questions about his home town, cities that he visited or his mathematics. The posts also enabled the friends to describe various issues associated with Al-Khwarizmi, for example his contributions to mathematics, his solution of mathematical equations and his importance as a mathematician.

The above discussion implies that social networking sites, such as Facebook and Edmodo, can be used for mathematical study and discourse, but need social talk to help learners with mathematical content. Therefore, the moderator, whose goal is to keep the mathematical discourse as his objective, should remember that persistence on this discourse without break might pull some of the friends out of continuous study mode. To avoid that, the moderator should always integrate social and cultural talk into the mathematical one, so the friends might be interested further and motivated to keep engaged also in mathematics learning.

We can also conclude that successful actions to utilize social networking sites are: Connecting to the friends' identity and lives, encouraging the friends to act and interact, sometimes requesting them explicitly to do so; utilizing the different options of the social networking site, especially text posts, comments and video link; beginning with the social and using it throughout the experiment to keep the harmony of the community; and moving to those cultural aspects that relate to the mathematics. The gradual and smooth transition to the mathematical topics ensures the continuing involvement of the friends.

## Models for Using Social Networking Sites in Mathematics Education

In our experiments we presented two models for using social networking sites in mathematics education. One model was based on populating Facebook with characters from the history of mathematics, where the goal of the population was to encourage participants' mathematical talk and discovery through smooth transitions between social, cultural and mathematical talk. The other model involved the population of Facebook with mathematical phenomenon or concepts, where we aimed to encourage the mathematical and scientific talk of the participants; specifically we looked at the conditions and consequences of such population regarding the participants' learning, and intended to answer two questions: what are the conditions of utilizing social networking sites like Facebook in mathematical and scientific talk, and learning? And what are the consequences of such talk and learning? In the previous section we discussed primarily the first model. Here we will analyze the second model, discussing the conditions and consequences of mathematical learning in social networking sites using mathematical phe-

nomena. We experimented with two phenomena: the golden ratio and the Fibonacci sequence. We will concentrate in our discussion on the golden ratio experiment, most of which also applies to the Fibonacci sequence experiment.

The enthusiasm of the moderator of the Facebook page to make more Facebook participants friends of the golden ratio page made her look for friends in different gatherings: her friends, other Facebook groups and other Facebook pages. This enthusiasm to attract more participants to the golden ratio page made the moderator emphasize the relation of the golden ratio to real life phenomena. This enthusiasm made the necessary difference in promotion. This is supported by Metcalfe and Game (2008) who reported that teachers' enthusiasm inspired their students, ignited something in them and made the difference in turning them onto the subject matter. The moderator strategy to relate the golden ratio to real life was successful, as connecting learning to real life phenomena is known and suggested as a strategy to provide a stimulus for student learning and which creates greater motivation and excitement for the learning (Quitadamo & Brown, 2001). This strategy was also used successfully with the sixth graders in the Fibonacci experiment, in which the students were amazed by the realizations of the incidence of the golden ratio in real life, especially in the human body.

The weekly consultations with the researchers made the moderator reflect on her strategies to motivate the learning of the friends and at the same time discuss her strategies for their future learning. The variety of the media used by the moderator motivated the friends to participate in the page activities and tasks. This influence of the various media on student learning is described elsewhere, for example by Abdullah et al. (2006), who refer to the combination of various media attributes of computer capability of enhancing instructional outcomes. Furthermore, Zengin (2007, as reported in Ilter, 2009) and Mayora (2006), point out multi-media and technology as the factors behind the interest and motivation of students in their lessons.

Other conditions which influenced student learning were the features themselves of the social networking sites and the properties of the scientific phenomena at the base of the learning environment. The moderator and the friends utilized the technical options of the social networking site, uploading pictures, videos and texts, sharing links, and communicating through Facebook communication channels: likes, comments, notes and groups. The site's features were, in our case, the features of the learning environment which influenced various educational constructs, including the students' learning approaches (Mayya, Rao & Ramnarayan, 2004). In our case they influenced the moderator and the friends' actions and interactions.

The actions and interactions of the moderator and friends consequently influenced the consequences of working in a social networking site, giving the adult participants (in-service and pre-service teachers) insights into two main issues: how to use mathematical phenomenon in various disciplines and in real life and how an inter-disciplinary phenomenon can be used educationally on social networking sites. This enriched the educational experience of the adult participants and contributed to their professional development as learners and/or teachers in present day, technology rich society. They also gave students a new aspect of mathematics that they did not usually experience in the school environment. This applied aspect of mathematics was exciting for them, motivating them to experiment with mathematical concepts in a more realistic and authentic way.

## Preparing Teachers for Teaching in Social Networking Sites

To understand the process of preparing and mentoring pre-service teachers for teaching on social networking sites, we will look at the reflections that our pre-service teachers wrote to conclude the experiments.

Two pre-service teachers moderated the Al-Khwarizmi Facebook character and Al-Khayyam Facebook fan group. They wrote their reflection together stating that they had a mixture of feelings and sometimes even contradicting ones that prevailed almost a year throughout the experiments. These feelings included: joy, confusion, anxiety, sadness, insistence, frustration, pride and enthusiasm.

The two pre-service teachers declared that when the idea of using Facebook in education was suggested to them by their lectures, they were very enthusiastic but immediately felt anxious, raising different questions, such as: What guaranties the success of the experiment? How can what is essentially a fun and social environment be used as a mathematical learning site? How can we encourage friends to interact with them on the site, especially when posting mathematical problems? How can we adapt the mathematical content to the diverse backgrounds of the friends?

At the same time they felt a certain joy impersonating Al-Khwarizmi, but also frustration when difficult questions were raised regarding the life of Al-Khwarizmi and they could not answer them. To get out of this situation they directed the questions back to the friends and, at the same time, consulted their lecturers. Both strategies increased their confidence and encouraged them to raise new questions. Sometimes they felt frustrated, especially when the friends did not cooperate with them, or the friends did not understand the given task. But they also felt pleasure and pride, especially when they got admiring comments, or they had extensive cooperation from the friends, or when the friends expressed their pride about the accomplishments and contributions of Al-Khwarizmi.

The pre-service teachers felt thankful to their lecturers for their support, ideas, consultations, encouragement and appreciation for their work. They emphasized their pride at experiencing a unique and innovative experiment and the importance of this kind of experience for their future. They benefited from it personally and professionally, and invested in it much more time than any other project they had in their study period. The nature of working in a social network environment such as Facebook demanded continuous and consistent work on a daily basis. They developed social skills, especially in interaction with friends from different backgrounds and scientific levels. Furthermore, they became more patient and tolerant when interacting with friends. Professionally, they were exposed to new teaching methods, including adapting mathematical content to target group, and harnessing technological tools to the educational goals.

The pre-service teacher who moderated the golden ratio page had similar anxieties, frustrations and also pleasures. She highlighted the following points as milestones for all those who want to moderate social networking sites for education: (1) the moderator should use electronic materials about the subject matter available on the internet, (2) the moderator should prepare activities suitable for the objectives of the educational experiment, (3) the moderator needs to accept with patience and tolerance the opinions, suggestions and criticisms of others and, at the same time, prepare proper and profound answers when responding to the participants' questions and demands.

The pre-service teacher who moderated the Fibonacci site emphasized the advantages of having a private closed group in Edmodo. This influenced open discussions with the participants positively, but pointed out that to remind students to interact in the Edmodo group, sometimes she had to contact them also through Facebook, which they used frequently. The pre-service teacher stated that she was surprised by the effort invested by the students in writing their comments and in preparing and uploading files that contained their solutions to the different tasks. Furthermore, the pre-service teacher gave special credit to the students' mathematics teacher and the administration of the school for helping her in organizing the group and keeping it functioning.

## Involving School Students in Learning Mathematics on Social Networking Sites

The Fibonacci experiment indicates that two models can be combined to enrich mathematics teaching and learning on social networking sites: populating the sites with historical mathematicians and populating them with mathematical phenomena. We can say that it would be better to introduce the historical mathematician first, because this facilitates engaging students with cultural talk that is a step towards engaging them with mathematical discourse. Furthermore, solutions and recommendations described above can be applied here too, starting with social talk, moving to cultural talk and proceeding to mathematical discourse. Teachers should prepare activities that are related to school student culture and life, where this relation motivates the students to act and interact actively in order to arrive at the mathematics.

What should distinguish the social climate on social networking sites where school students are involved, is the sensitivity of the teacher to students' needs and questions. This is one of three components associated with the mathematics teacher's work in the classroom (Jaworski, 1992) and was emphasized by the participating school students as a motivating and encouraging factor for the learning of mathematical phenomena and relations.

## FUTURE RESEARCH DIRECTIONS

Additional attempts should be made to look for other utilization models for social networking sites. Involving other student populations, for example middle school students, high school students and university students, could also prove useful. In addition, attempts should be made to involve students with regular mathematical topics on social networking sites, for example the exploration of equations and functions. Social networking sites could also be used to teach disciplines other than mathematics.

## CONCLUSION

Various factors came together to make the experiments described in this chapter successful. Choosing an important mathematician from the friends' own culture (associated with the students' history or/and religion), starting the activity on the social networking site with social talk, transiting to the mathematical discourse through cultural discourse, juggling the social, the cultural and the mathematical, connecting the past to the present, giving the friends the opportunity and encouraging them to act and interact, and utilizing the various options of the social networking site. These experiments imply that social networking sites not originally intended as teaching vehicles, can be adopted for education in general and for mathematics education in particular.

In addition, the learning achieved through social networking sites is influenced by various conditions: the site's features, the properties of the inter-disciplinary phenomenon or the mathematics produced by the historical mathematicians, the background of the learners and the strategies of the moderator. In our case, the learning included: justifying, exploring, experimenting, giving solutions, criticizing, connecting to real life, connecting with other disciplines, connecting with history and searching for information on the internet. These varied learning actions point at the great potentialities of social networking sites with multimodal options for teaching and learning mathematics and science.

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## KEY TERMS AND DEFINITIONS

**Cultural Talk:** In this chapter, social talk refers to talk related to cultural issues, like the history and geography of countries and towns, books in general and mathematical books in particular, art and the manifestation of mathematical phenomena in real life and the sciences.

**History of Mathematics:** The history of mathematics involves talking about past mathematicians' work and contribution. In the mathematics classroom history can benefit teachers by exposing students to the life of the mathematicians, and thus to ways of doing mathematics, as well as to how mathematicians developed mathematical concepts and procedures. Teachers can also relate and compare historical ways of doing mathematics with modern ways.

**Interdisciplinary Phenomenon:** This is a phenomenon that can be related to at least two fields or subjects. For example the golden ratio can be related to subjects such as: mathematics, science, architecture, and art.

**Mathematical Discourse:** In this chapter, mathematical discourse refers to the interaction among the participants on social networking sites regarding mathematical issues, concepts, procedures, relations, problem solving and phenomena. The interaction can be initiated or/and directed by a moderator as well as by the friends themselves.

**Pre-Service Teachers' Preparation:** Teachers' colleges differ in the programmes or/and policies of preparing pre-service teachers to be ready for teaching in schools. In Al-Qasemi Academic College of Education, this preparation takes four years.

**Social Networking Sites:** In this chapter, the social networking sites used are Facebook and Edmodo, where Facebook is an social networking site open for all Facebook participants, while Edmodo is a social networking site which was meant from the beginning to be educational. At the same time, to participate in a course in Edmodo, students have to register to a closed group started by the teacher.

**Social Talk:** In this chapter, social talk refers to the regular talk that occurs generally in social networking sites such as Facebook. Examples of this talk are: greetings, congratulations, announcement of social events, and inquiring about somebody's absence.