

# INTER-DISCIPLINARY PHENOMENA IN SOCIAL NETWORKING SITES: THE CASE OF THE GOLDEN RATIO IN THE FACEBOOK

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## Abstract

The recent years witnessed the emergence and growth of social networking sites as sites for social interaction, and gradually as educational sites. This emergence calls for research regarding the potentialities of social networking sites for the teaching and learning of various disciplines. This article describes an experiment in using the Facebook, as representative of social networking sites, for teaching and learning an inter-disciplinary phenomenon: the golden ratio. The current research used the grounded theory model to describe and explain the various factors associated with the teaching and learning of inter-disciplinary phenomena in a social networking site. Here we are specifically concerned with the conditions and consequences of such teaching and learning. We carried out, together with our pre-service teachers, three experiments using the Facebook to involve the users in mathematical and scientific phenomena, history, talk and concepts. One pre-service teacher initiated one of the experiments and created a page on the golden ratio. This page attracted 'friends' from different disciplines and places, and enabled them to exchange their experiences regarding the golden ratio among each other. The research findings show that teaching and learning an inter-disciplinary phenomenon in a social networking site as the Facebook is influenced by various conditions: the features of the social networking site, the properties of the inter-disciplinary phenomenon, the background of the learners and the strategies of the moderator. In our case, the learning included: justifying, exploring, experimenting, giving solutions, criticizing, connecting with real life, connecting with other disciplines, connecting with history and searching for information in 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, so we suggest these sites for engaging students with inter-disciplinary phenomena, and as a consequence of this engagement it is expected that these students exchange rich mathematical and scientific ideas and experiences as it happened in the experiment which we report.

Keywords: Inter-disciplinary, phenomena, social, networking, golden ratio, education

## 1 INTRODUCTION

Web 2.0 tools are being suggested for some years now for social life, communication, and work in various disciplines, especially in education ([1], [2], [3]). 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 network site ([4], [5], [6], [7]). Here we are concerned with the use of social networking sites in education, and specifically in mathematics and science education. In a previous research we studied the populating of the Facebook with characters from the history of mathematics ([8]), where the goal of the populating was to encourage participants' mathematical talk and discovery. Here we examine how populating the Facebook with an inter-disciplinary phenomenon - the golden ratio, encourages the mathematical and scientific talk of the Facebook participants; specifically we examine the conditions and consequences of such populating regarding the participants' learning.

## 2 RESEARCH BACKGROUND

School students use social networking sites to support their educational activities ([9]). The NSBA reports that nearly 60% of the respondents who use social networking sites discuss education-related topics online, and more than 50% specifically discuss schoolwork. The popularity of the social networking sites and the beginning of their use as educational tools indicate 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 the Facebook. These options and potential meet the requirement of Ref [10] in the standards for science teacher preparation, where the standards encourage science teachers to guide their students' learning by promoting their conversations about scientific ideas. The communication tools of the social networking sites can help build learning environment rich of students' conversation and discussions, and thus the environment becomes fruitful for building the scientific knowledge of students. Ref [11] says 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 utilize the social networking sites, in our case the Facebook, in our pre-service teachers' preparation. We intended that our pre-service teachers enrich their knowledge about mathematics, mathematical phenomena and mathematical concepts and procedures through conversing and discussing the phenomenon and the concepts and procedures associated with the phenomenon, and through solving mathematical problems related to the phenomenon. This intention agrees with Ref [12] who describe knowledge as constructed not in the individual vacuum, but in the communication and exchanges enabled in social networks.

Recently researchers attempted to use the Facebook environment to enable collaborative learning ([13]), as well as to treat content knowledge in different disciplines ([11], [14]). Ref [13] reported that pre-service teachers used the Facebook during their teaching practicum placements to facilitate mutual support, encouragement and the sharing of stories and anecdotes. Using the 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, the Facebook environment enabled collaboration as the pre-service teachers assisted each other, shared digital artifacts and exchanged constructive feedback.

Ref [11] describes an experiment that involved using the 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.

Ref [14] analyzed the content of the 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.

Ref [8] examined the use of the Facebook as an environment in which students articulate what they know about the history of mathematics, about mathematics, and about mathematical concepts and procedures like the solution of quadratic equations in their case. They found that various reasons met to make the experiment a successful one: choosing an important mathematician from the friends' history; starting the Facebook site with social talk; advancing to the mathematical discourse through cultural discourse; juggling between the social, the cultural, and the mathematical talks; connecting the past to the present; giving friends the opportunity and encouraging them to act and interact; and using the various option of the Facebook.

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 and science education, these environments can make the students enjoy the learning of these disciplines and thus help them develop positive image of the disciplines and raise their motivation to learn them. This would expectedly increase the students' understanding of mathematical and scientific concepts and procedures and consequently might improve their achievement in mathematics and science.

### **3 RESEARCH RATIONALE AND GOALS**

Ref [15] concluded from a study of how effectively university students may be using Facebook to support their learning that using Facebook as part of learning and teaching is as much of a challenge for many students as it may be for most educators. This made us want to experiment, together with our pre-service teachers, using the Facebook for teaching and learning of mathematics. This experiment would open our eyes and those of our pre-service teachers to the educational potentialities of social networking environments. Further 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 students as teachers in the future. So, our main goal was to probe the potentialities of the Facebook, as representative of social networking environments, to enable mathematical and scientific talk and learning of mathematical and scientific concepts and processes.

### **4 RESEARCH QUESTIONS**

- (1) What are the conditions of utilizing social networking sites like the Facebook in mathematical and scientific talk and learning?
- (2) What are the consequences of such talk and learning?

### **5 METHODOLOGY**

The research followed the grounded theory model to explain the various factors associated with the learning of inter-disciplinary phenomena in social networking sites. Here we are specifically concerned with the conditions and consequences of such learning in the case of the golden ratio phenomenon in the Facebook social network. Our concern with educational factors such as conditions and consequences makes the grounded theory model appropriate as a methodology for our research.

#### **5.1 Research Setting**

We carried out, together with our pre-service teachers, three experiments using the Facebook to involve the users in mathematical and scientific phenomena, history, talk and concepts. One pre-service teacher created a page on the golden ratio, another preservice teacher created a fan group for the poet and mathematician Omar Al-Khayyam. A third pre-service teacher created a Facebook character of the great historical mathematician Mohammad Al-Khwarizmi. In this article we will describe only the experiment regarding the Facebook page on the golden ratio, where this experiment started as one involving a mathematical phenomenon, but soon the 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. Specifically, we will describe the various conditions and the consequences of populating the Facebook with the golden ratio phenomenon regarding the participants' learning.

#### **5.2 Data collection means and tools**

To collect data about the non-formal learning of mathematical-scientific phenomena in the Facebook environment, we followed the discourse development between the moderator and the friends in the page of the golden ratio during the three months of the experiment. This discourse included likes, comments and notes posted by both sides. We also examined the materials posted by the moderator and the friends, such as texts, pictures, videos and links.

#### **5.3 Data processing and analysis**

We used the grounded theory approach ([16]) to identify mathematics learning causal, contextual and intervening conditions, to categorize the moderator and friends' behavior during the experiment and to detect the consequences of educational involvement in the Facebook environment (and relations between these conditions, behaviors and consequences). The grounded theory approach has three stages:

Open coding: Identification of repeated behavior that can be put into categories. In this stage we divided each type of collected data into segments and examined the segments for similarities and differences. Here, the objective is to identify categories of behavior that occur within the community of participants, place similar behaviors in the same category and characterize each category.

**Axial coding:** After identifying the categories and characterizing them, we examined the relations between the categories and their subcategories. We characterized the behaviors according to the context in which they occurred and according to the conditions of their occurrence.

**Selective coding:** After refining the categories, subcategories, and their characteristics and relations, we attempted to identify one or two main or core categories that could be used to connect the rest of the categories and to build a conceptual framework for the studied phenomenon, that is, engaging in mathematical and scientific learning in the Facebook environment. Within the conceptual framework, the categories and subcategories were described from several points of view: (1) the phenomenon, that is, the central idea, event, or happening that a set of actions/interactions attempts to manage or handle; (2) causal conditions, which are the set of categories or properties that have led to the occurrence of other categories or properties; (3) contextual conditions, namely the specific set of properties that pertain to the phenomenon and constitute its setting; (4) intervening or broader conditions pertaining to the phenomenon and acting as either facilitators or constrainers of the action/interaction strategies pursued within a specific context; (5) strategic action/interaction aims for managing, handling, carrying out, and responding to a phenomenon as it exists within a context or under a specific set of perceived conditions; (6) consequences of the strategic actions/interactions performed in the course of a specific phenomenon and within a context, given a set of conditions.

Our use of the grounded theory approach to identify characteristics of the non-formal mathematical-scientific learning in the Facebook environment is supported by the use of this theory by the authors themselves when they studied middle school student learning of mathematics using the features and qualities of the mobile phone ([17]), and by other researchers who studied educational processes that can be related to ours, for example, Ref [18] collected and analyzed data of applied research about using modern and new technologies in education. The authors used grounded theory to study e-facilitation in face-to-face and distributed electronic meetings. In another study, Ref [19] described the complex decisions and actions taken regarding the use of ICT in a primary school in the UK.

## 6 FINDINGS

During the open and axial coding phases of building a grounded theory about learning mathematics and science in the social networking environment, we identified several categories and subcategories. These categories and subcategories are presented below with description of their characteristics. During the selective coding phase we developed a conceptual framework of relations among the various categories and subcategories. The framework is presented in Figure 1:

Causal conditions:

- Opening a social network site for an inter-disciplinary phenomenon:

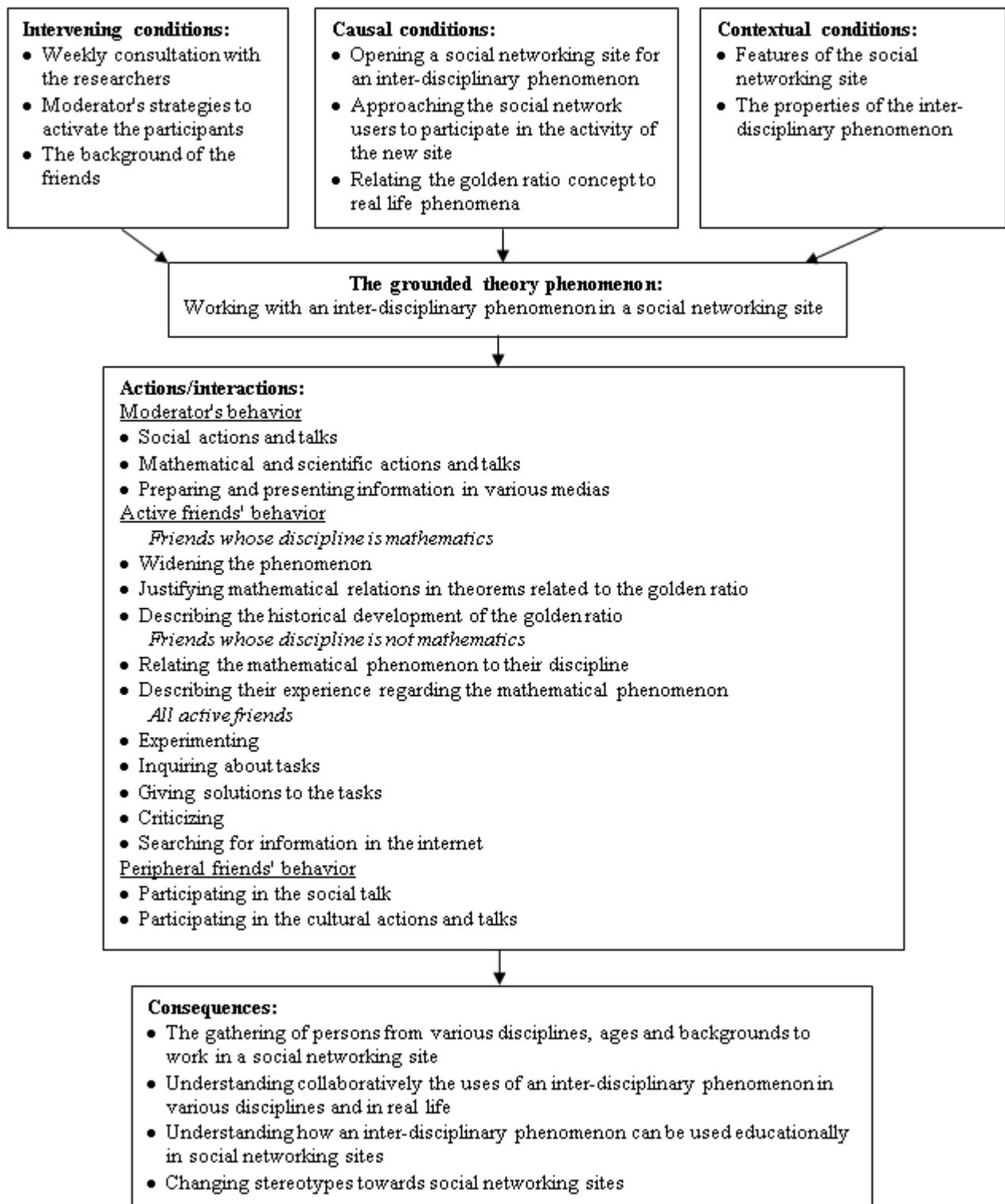
Opening the golden ratio site.

- Approaching the social network users to participate in the activity of the new site:

First, the preservice teacher approached all her Facebook friends asking them to join the new page, and then she went to other Facebook pages and to Facebook groups and put an invitation for them to join the golden ratio page.

- Relating the golden ratio concept to real life phenomena:

The preservice teacher started her work in the golden ratio page by asking the friends about the representations of the golden ratio in real life. The goal of this act was to raise the interest of the friends in the golden ratio and make them active participants in the new page.



**Figure 1: A grounded theory model for working with an inter-disciplinary phenomenon in a social networking site**

Intervening conditions:

- Weekly consultation with the researchers:

The moderator used to meet the researchers on a weekly basis to discuss issues related to the Facebook page. Examples on these issues are: strategies to activate the Facebook page friends, the optimal continuum of learning actions that would not burden the friends' schedule, the multimodal means that suits best a specific educational goal, etc.

- Moderator's strategies to activate the participants:

The moderator used diverse multimodal presentations enabled in the Facebook. The goal of this multimodal use was to make the mathematical-scientific learning more exciting for the friends.

- The background of the friends:

The backgrounds of the friends were varied. This fact is connected to the nature of the phenomenon being treated by the Facebook page. This is explained further below.

Contextual conditions:

- Features of the social networking site:

The features of the social networking site influenced the types of media used by the moderator to present learning materials related to golden ration, or ask the friend to present or discuss such materials. The moderator used the following media in the golden ratio page: text, pictures, videos, PowerPoint and Movie Maker presentations and web pages.

The moderator utilized the Facebook options to make the learning in the Facebook diverse and interesting. For example, she added notes to remind the friends of some tasks. In addition, she created a discussion group about the use of the golden ratio in the mathematics and scientific classroom. Further, the moderator added a link to an applet to investigate the golden section, as a step towards arriving at the golden ratio.

The friends utilized the 'like' and 'comment' options in the Facebook, and usually responded with many likes and comments and added pictures which mostly consisted of photos taken by cellular phone or digital cameras of written mathematical solutions of a mathematical problem posted by the moderator or the friends themselves. The friends added videos and internet links as well. One of the friends asked the moderator to add a discussion group to discuss the importance of the golden ratio in the different sciences.

- The properties of the inter-disciplinary phenomenon:

The golden ratio, being a phenomenon which is used in the different sciences and in art, drew to the Facebook site friends from various geographic areas and from various disciplines.

Regarding the various disciplines of the golden ratio page's friends, these disciplines were: mathematics, science, art, religion and architecture. These friends described the various uses of the golden ratio in their disciplines. Doing so, they showed computation and photos or drawings, and invited the friends to specific web pages to see what they actually do.

Actions and interactions:

Moderator's behavior

- Social actions and talks:

These actions and talks included: (1) Showing much appreciation for the friends and thanking them for their contributions; (2) Congratulating some friends on their birthday days; (3) Posting social comments, pictures, videos and links to web sites, especially at the feasts. Also, posting cards that included the number of days, minutes, and seconds to the arrival of the feast.

On the holiday day of the end of the Islamic calendar year, the moderator wanted to post authentic piece of her life experience, so she went to a visit to Jerusalem, took pictures of her trip and posted them on the page.

- Mathematical and scientific actions and talks:

These actions and talks included: (1) Posting YouTube links to videos related to representations of the golden ratio in real life; (2) Giving explanations and clarifications regarding the information presented in the videos; (3) Uploading learning materials with the intention to advance the participants into the following levels of mathematical and scientific learning: recognizing mathematical relations, perceiving these relations intuitively, realizing them in real life, describing and explaining these relations verbally, defining them mathematically, exploring them historically, experimenting with them, drawing them, analyzing them geometrically and calculating the relations using algebraic methods; (4) Posting assignments and tasks; and (5) Encouraging the friends to do the mathematical work.

- Preparing and presenting information in various medias:

When the moderator used new media, this resulted in an increased participation of the friends. This happened for example when the moderator uploaded a video which she prepared herself and when she required the friends to upload images of phenomena in which the golden ratio is realized.

Active friends' behavior

Friends whose discipline is mathematics:

- Widening the phenomenon:

The moderator started the golden ratio topic with the golden ratio as realized in a straight line. The friends widened the phenomenon to other geometric shapes, talking about the golden triangle and the golden rectangle.

- Justifying mathematical relation in theorems related to the golden ratio:

Generally this happened as a consequence of the moderator's requirement from the friends to show the correctness of mathematical relations or methods related to the golden ratio. For example some friends proved geometrically the correctness of the Euclid's method for locating the point of the golden section.

- Describing the historical development of the golden ratio:

Some friends gave historical information about the first mathematical problems which led to the golden section and golden ratio investigation, and described the historical methods of that investigation.

Friends whose discipline is not mathematics:

- Relating the mathematical phenomenon to their discipline

Some architectures and artists told the moderator and the friends that they come from disciplines in which the golden ratio has significant influence on what they do.

- Describing their experience regarding the mathematical phenomenon

Friends who are architectures and artists noted that they had encountered the golden ratio concept in their learning or work. Some of the architectures and artists described how they use the golden ratio in their discipline. To describe how they use the golden ratio in their disciplines, the architectures and artists uploaded images and directed the friends to web pages which describe this use.

All active friends:

- Experimenting:

The friends worked with an applet which treated the golden ratio. They moved a point on a segment presented in the applet until the values of the ratio between the longer part of the segment and the shorter part equaled the ratio between the whole segment and the longer part.

The friends worked with a piece of paper using only a ruler to find a point on a segment which realizes the golden ratio as above.

- Inquiring about tasks:

Some of the friends' comments included inquiry about the task and request to explain it more thoroughly.

- Giving solutions to the tasks:

Some friends wrote the solution of a task with explanation on a paper, then took a picture of the paper using a digital camera or a cellular phone and uploaded the picture to the golden ratio site.

- Criticizing:

Some friends criticized the accuracy of the measurements given by the applet suggested by the moderator.

- Searching for information in the internet:

Some friends searched the internet to find answers for the moderator's questions and gathered rich information about the golden ratio, such as detailed mathematical information, detailed historical information, proofs to theorems related to the golden ratio and examples of the realization of the

golden ratio in real life, such as in the perfect human body (the ratio between the person's height and the height of the navel).

Peripheral friends' behavior:

- Participating in the social talk

Many comments consisted only of admiration remarks, such as expressing admiration for the self-prepared videos that the moderator uploaded. Some comments consisted of putting 'likes' on mathematical or social talk or action. In addition, some friends thanked the moderator for introducing an applet which is easy and enjoyable to work with. Further, Some friends congratulated the moderator on her birthday.

- Participating in the cultural actions and talks

Some friends emphasized the holiness of the golden ratio and its realization in Islamic designs and constructions and in the holy Quran. A friend posted a link to a video on the YouTube that describes how the location of Mecca in relation to the South Pole and to the North Pole realizes the golden ratio.

Consequences:

- The gathering of persons from various disciplines, ages and backgrounds to work in a social networking site:

The page had 575 participants which can be categorized as: (1) friends interested in mathematical knowledge, such as teachers, university and college students, (2) engineers and architectures, and (3) photographers. All the participants focused on the realization of the golden ratios in real life and the various disciplines.

- Understand collaboratively the uses of an inter-disciplinary phenomenon in various disciplines and in real life:

A group of a lecturer and his students from a Yemen university shared with the friends their experience of using the golden ratio in architecture. One lecturer from an Egyptian university shared with the friends the representations of the golden ratio in Quran. The friends, with the guidance of the moderator, discussed the realization of the golden ratio in real life, especially in human body, animals, plants and in inanimate objects. One friend introduced a special geometrical tool that looks like the compass to the friends, calling it the golden ratio tool. Further, some friends got interested in the tool and inquired about the way and fields it is used. The friend explained its operation and mentioned some of the fields in which it is used: dentistry, construction engineering, photography, drawing, and sculpture.

- Understanding how an inter-disciplinary phenomenon can be used educationally in social networking sites.

Some teachers asked for permission to use the materials posted on the page in teaching their students. The moderator encouraged them to do so stating that this was one of the goals of building the page. She also asked them to motivate their students to participate in the page, and consequently some of these students became actually active friends.

Some teachers presented some of the authentic work of their students in real life activities based on the learning materials posted on the page. They emphasized that mathematics based on real life phenomena had a positive effect on students' interest to learn mathematics.

Some friends raised an educational argument regarding the use of the golden ratio in the mathematics and the science curriculums. Others raised an argument regarding the use of social networking sites in education and their advantages and disadvantage.

- Changing stereotypes towards social networking sites:

Some friends changed their perceptions and stereotypes about the Facebook, stating that they looked at it as a chat only site, but when they experienced it in their learning they changed their minds.

## **7 DISCUSSION**

Causal conditions:

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 which are expected to attract the attention of the friends. This enthusiasm of the moderator made the difference in promoting participation in the golden ratio page. This analysis is supported by Ref [20] who reported that teachers' enthusiasm inspired their students, ignited something in them and made the difference in turning them into 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 students' learning and which creates greater motivation and excitement for this learning [21].

Intervening conditions:

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 the future learning of the friends. These strategies intervened to attract the friends to participate in the assignments posted on the page. 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 students' learning is described elsewhere, for example Ref [22] refers to the combination of various media attributes of the computer to have the capability of enhancing instructional outcomes. Further, [23], as reported in [24] and [25] points at multi-media and technology as the factors behind the interest and motivation of students in their lessons.

Contextual conditions:

The contextual conditions are composed of the features of the social networking site and the properties of the scientific phenomena in which the learning environment is involved. The features of the social networking site had the main effects on the moderator's presentations, the friends' presentations and the interactions occurring in the golden ratio page. The moderator and the friends utilized the technical options of the Facebook environment, uploading pictures, videos and texts, giving links, and communicating through the Facebook communication channels: likes, comments, notes and groups. The features of the social networking site are, in our case, features of the learning environment which influence various educational constructs including students' learning approaches [26]. In our case they influenced the moderator and the friends' actions and interactions.

The properties of the inter-disciplinary phenomenon treated in the Facebook page influenced the texture of the community of learners interested in the page. Being an inter-disciplinary phenomenon it attracted diverse friends who exchanged their domain-specific experiences and enriched the experience and the learning of each other. Inter-disciplinary phenomena and topics are recommended by various educational institutions (for example [27]), where they are described as means to connect mathematics with other disciplines and with real life. This connection is supposed to give mathematics learning additional meaning. What happened in the current experiment is that the connection between various disciplines turned natural through treating a common phenomenon.

Actions/interactions:

The various types of conditions affected the actions and interactions of the moderator and friends of the golden ratio page. The contextual conditions of the Facebook, being a social environment, made social actions and talk prevail during the whole experiment. These contextual conditions affected also the type of social actions and talk in the learning environments, being 'likes' and 'comments'. The contextual conditions also influenced the mathematical and scientific work of the moderator and friends, for example the mathematical and scientific texts were uploaded to the page through media files and not text files. The intervening conditions also affected the moderator and friends' work in the Facebook page, where the consultation with the researchers helped the moderator decide which actions and interactions best fit the learning situation. The background of the friends influenced their work in the golden ratio page. This background, being varied, made the page a multidisciplinary environment, where the participants exchanged experiences and ideas, and where they widened the phenomenon in various directions. In this environment they gained a sense of a discipline as "a special culture shaped by specific ways of seeing and interpreting the world" [28].

Consequences:

The actions and interactions of the moderator and friends influenced the consequences of the environment, giving the participants insights in 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 in social networking sites. Thus, working with an inter-disciplinary phenomenon in a social network enriched the educational experience of the participants and contributed in their professional development as learners and/or teachers in the new technological era full of social networking sites.

## 8 CONCLUSIONS

Social networking sites with multimodal potentialities can be rich and fruitful educational environments for the representation and research of mathematical phenomena, especially for inter-disciplinary phenomena like the golden ratio. The learning done in the social networking site is influenced by various conditions: the features of the social networking site, the properties of the inter-disciplinary phenomenon, the background of the learners and the strategies of the moderator. In our case, the learning included: justifying, exploring, experimenting, giving solutions, criticizing, connecting with real life, connecting with other disciplines, connecting with history and searching for information in 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, so we suggest these sites for engaging students with inter-disciplinary phenomena, and as a consequence of this engagement it is expected that these students exchange rich mathematical and scientific ideas and experiences as it happened in the experiment which we report.

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