A RESEARCH ON ISLAMIC GEOMETRIC PATTERNS

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A Research on Islamic Geometric Patterns

Introduction

In this work, I will focus on the mathematical aspects of Islamic geometric patterns in order to give the reader an extensive view on Islamic geometric patterns.

Firstly, I will look at what the term art means in Islam. This then will be followed by a short history of Islamic geometric patterns. Secondly, I will focus on the geometrical patterns, namely calligraphic, arabesque and space-filling patterns in Islamic art. I will also talk about the principles and the features in geometrical patterns, including symmetry, repetition, scalability, adaptability, movement, translation, reflection and rotation. Thirdly, I will discuss the structure and the construction of Islamic patterns through looking at the key shapes, such as a circle, triangle and star.

Finally, I will give world-known examples of Islamic art, and conclude this part of my study which will be followed by the reflection on my learning experience in the second part.

I chose this topic because Islamic patterns include both mathematics and arts, pleasant geometric patterns, history of mathematics and the most importantly I have been interested in both arts and mathematics. Because, I am familiar with Islamic geometric patterns, and I grew up in Turkey which has an extensive Islamic art heritage: the Blue Mosque, the Suleymaniye Mosque and the Topkapi Palace all are good examples of Islamic Art which contain various rich Islamic geometric patterns on their interior and exterior walls and doors.
Islam and art

Islam has a significant impact on art, and the term “Islamic” refers not only to a religion but also to a culture and a civilisation, so what is Islamic Art? Grabar (1987) defines Islamic art as that produced by “a culture or civilization in which the majority of the population, or at least the ruling element, profess the faith of Islam” (p.2). It was also noted by many scholars that the artist who produced Islamic art could or could not be a Muslim. Islamic art “not only describes the art created specifically in the service of Islam, but it also characterizes secular art produced in lands under Islamic rule or influence, whatever the artist’s or the patron’s religious affiliation” (Komaroff, 1999). Islamic art includes the great achievements in architecture, design and geometric patterns. In this paper, I will focus on the latter, Islamic geometric patterns.

As iconography was forbidden in Islam, Islamic artists created and developed geometric patterns to represent Islam. According to Sawyer (1955), pattern is “any kind of regularity that can be recognised by the mind” (p.12) and “mathematics is the classification and study of all possible patterns” (p.12). Calligraphy and geometry were the principle methods for the Islamic artists to show the principles of Islam (Burckhardt, 1976). Islamic geometric art is based on complex geometric patterns which show the mathematical level of the Islamic world. Islamic geometric art has developed a complex and authentic geometrical design while its roots go to Byzantine and Roman times, and the shapes and structures are based on the geometry of Euclid.

The artists in the Islamic civilisation produced a large number of symmetric geometrical patterns with the help of the mathematicians from the 10th to the 13th century AD (Ozdural, 2000). Later, with the expansion of Islam, Islamic geometric patterns were used in the buildings throughout Europe, Africa and Asia. Geometric decoration in Islamic architecture has two-dimensional (mosaic) patterns on flat and curved surfaces and three-dimensional structures.
(muqarnas), seen mostly in the interior of domes. These patterns are well known to Americans and Europeans through the Alhambra Palace in Granada, Spain (Irving, 1931). Nowadays, modern science began discovering Islamic patterns, for example, under the category of tessellations (Grunbaum & Shephard, 1989).

“A regular tiling of polygons (in two dimensions), polyhedral (three dimensions), or polytopes (n dimensions) is called a tessellations” (Wolfram MathWorld, 2008) which is the base of Islamic geometric patterns.

**History**

Islamic geometric patterns are based on the geometry of Greek mathematician Euclid who is concerned to be the father of geometry. Norman (1998) argues that the Islamic artists used geometrical shapes, structures and mathematical principles to form visual statements about religious ideas. They believed that mathematical principles and art harmonised in Islamic art: “Driven by the religious passion for abstraction and the related doctrine of unity – al-tawhid, the Muslim intellectuals recognised in geometry “the unifying intermediary between the material and the spiritual world” (Abas and Salman, 1995, p.9). Nasr (1987) notes that ‘traditional Islamic art conveys the spirituality and quintessential message of Islam through a timeless language which, precisely because of its timelessness as well as its direct symbolism, is more effective and less problematic than most of the theological explanations of Islam” (p.195).

**Geometrical patterns**

There are three patterns in Islamic art: calligraphic, arabesque and space-filling (figure 1). Calligraphic patterns which may contain verses from the Koran are in written form in Arabic, and like the other Islamic patterns, calligraphy (figure 2) is also linked to geometry as the proportions of letters are formed by mathematics; the Arabesque (figure 3) patterns consist of spirals, vine and plant motifs representing nature and paradise, and it is usually found decorating the walls of
mosques; and finally the space-filling patterns are made of shapes and spaces to create continuous patterns. All these patterns, visual features and principles are the contributing elements to the unity of Islamic art, in other words organisation of design so all parts contribute to a coherent whole. El-Said and Parman (1976) argued that the use of geometry in Islamic art and architecture is a “unifying concept of composition despite the diversity of materials, forms or styles used” (p.xi).

There are several principles and features in geometrical patterns, including:

*Symmetry:* It simply means pattern. It is a characteristic of geometrical shapes, and there is a balance and harmony of proportion between their basic structures. The three types of symmetrical operations are reflection, rotation and translation. “Symmetry is patterns is Islamic art also includes transformations. A symmetry transformation is the repetition of a shape or design by flipping it, turning it, or sliding it to a new position” (Levy, 2006, p.17).

*Repetition:* It is thought to represent the eternal nature of God, and a repeat part or unit is the base for geometric patterns. This can be found in the shape of a square or a hexagon.

*Scalability:* Geometric patterns can be sized differently so it is possible to see a pattern in a large size whereas the same pattern can be found on a miniature painting.

*Adaptability:* Islamic art elements can be applied using various techniques.

*Coverage:* In Islamic art, it is aimed to cover the whole object that is used for the design without considering the size of the object.

*Movement:* Islamic geometric patterns are not static. Behrens-Abouseif (1999) states that “the interlacing of strands of geometric patterns in complex star configurations and polygons conveys an illusion of never-ending movement” (p.7).

*Frames:* It is usually the issue that geometric patterns are framed or placed within a measured surface.

These patterns included a variety of geometrical structures which, in particular, can be valuable in the teaching of geometry. Because Islamic patterns provide a
range of materials for the teaching of geometry at all levels. The mathematical process involved in the creation of Islamic geometric patterns involves translations, reflections and rotations. Islamic artists used to draw a base design and then repeat this design to form a more complicated pattern to create designs in Islamic art. *Translation* was one of the ways to repeat the design. It is copying a symbol and then copying it in a new place through a vertical or horizontal movement. The second method is *reflection* in which the symbol is passed across so that it looks exactly the same in reversed position. The third movement is *rotation* in Islamic patterns. It is when a symbol is moved around a single point in a circular direction – so an object can be rotated from zero to three hundred and sixty degrees.

**Structure and construction of Islamic patterns**

Geometric patterns differ according to their complexity and design so there are complex stars and polygons as well as simple shapes. The main shapes used in Islamic patterns are circles, squares, triangles, stars and polygons.

Islamic patterns start with one of the key shapes. “Due to the maximal visual and constructional simplicity and maximal symmetry, a circle represents the primary geometric shape – geometric archetype” (Jablan, 2002, p.1). The circle division leads to the other three basic shapes: triangle, hexagon and square. “The circle surpasses all other geometric patterns as the symbol of cosmic unity, its inner core or hidden centre becoming the timeless moment of the revolutions of time and the dimensionless point of the encompassing space” (Critchlow, 1976, p.58). Circle does not have starting or ending points so it is itself symbolic of eternity. The circle and the centre of the circle represent God and Mecca – the centre of Islam – toward which all Muslims face in prayer. Burckhardt (in El-Said & Parman, 1976), states that all the geometric patterns are derived by the same method of deriving all the vital proportions of a building or a pattern from the harmonious division of a circle which is no more than a symbolic way of expressing unity.
(Tawhid) which is the metaphysical doctrine of divine unity as the source and culmination of all diversity.

El-Said (1993) argued that Islamic patterns are based on the square and hexagonal shapes repetition and the root two (√2) dividing a circle into four, or multiple of fours, equal parts; and root three (√3) system of proportion dividing a circle into six, or multiple of six, equal parts.

When the centre points of three circles are connected, a triangle is created. Triangle is one of the most fundamental figures in Islamic art. Critchlow (1976) stated that triangle symbolises “human consciousness and the three basic biological functions: ingestion, digestion and creation” (p.16).

Expanding circle creates two other fundamental shapes in Islamic art, square which symbolises earth, physical experience and the physical world or materiality, and hexagon representing heaven. A square is created by drawing lines intersecting the circumference of a circle’s centre whereas hexagon is created by connecting the five circles’ centres.

Star as a regular geometric shape in Islamic art symbolises equal radiation in all directions from a central point which represents Mecca and the spread of Islam. Stars were used to represent light so providing a link to God. Islamic art features stars with up to ninety-six points (Cast’era, 1999). Regular stars have 6, 8, 10, 12, or 16 points and are drawn by a division of a circle into equal parts. The typical pattern design has a major star in the middle and other accompanying stars or other type of geometric shapes around. The centre of the star is also the centre of the circle and its points touch the circle’s circumference. In addition, rosette is another most beautiful motif in Islamic art which may be seen as a star with hexagons attached to it.
In creating geometric patterns various colours were used. However, the main colours used were green, blue and gold. “Nor are the colours used in Islamic art and architecture accidental – green, the Prophet’s favourite colour, is the colour of life, and therefore of paradise. Blue, the colour of sea and sky, is the colour of infinity, of God’s eternal mercy. Gold, the colour of precious coin, is the colour of sun and of the night moon reflecting the sun’s light” (Holm, 2001, p.100).

**Famous examples of Islamic art**

From the 10th century onwards, Islamic patterns blossomed in the architecture and continued for four centuries. The earliest architectural monument in Islamic art is the Dome of the Rock (*figure 4*) in Jerusalem, constructed in 691-92. It has mosaics with beautiful patterns and crowns in various colours, green, blue and gold.

Later, two of the most impressive constructions were built: the Nasrid Palace of Alhambra (*figure 5*) in Granada in Spain and the Taj Mahal in Agra in India. The latter was the most exciting structure built by the Mughals who were the Muslim rulers of India. The Alhambra was built by the Nasrid Dynasty-Islamic Sultanate. It has beautiful tile patterns on most of its ceilings, walls and floors. Also, the Blue Mosque (The Sultan Ahmed Mosque) (*figure 6-7*) which was built in the 17th century was one of the greatest mosques with its geometric patterns; it is well known with more than 20 thousands handmade ceramic tiles lined interior of the mosque, and its minarets were mathematically placed.

**Conclusion**

Through this research project on Islamic geometric patterns, my aim was to investigate the unity of mathematics and visual art through Islamic patterns. I chose to study this topic because these patterns are one of the most beautiful
examples of the combination of mathematics and Islamic art. I am also culturally familiar with Islamic patterns.
References


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Reflection on my learning experience

Introduction

In this part of my work, I will reflect upon my learning experience in my Islamic geometric patterns project, including my presentation of the study to my colleagues on the Mathematics Development Programme.

Initially, I will discuss the term reflection and the importance of reflection in educational practice. I will then analyse my knowledge, skills and understanding before going into a discussion about my experience of giving a presentation on Islamic patterns and mathematics. This will be followed by looking at the importance of doing research in mathematics, by looking at my research from a different perspective-mathematical investigation, by analysing implications for teaching and learning, and finally I will evaluate what I have learned from this project, and I will finally draw some conclusions.

What is reflection?

Reflection is an intellectual process which, applied to the process of learning, encourages the researcher to carry out critical thinking, to examine collected data, question its validity, and come to conclusions based on the resulting ideas. It is an ongoing process which results in achieving a better understanding of the concept. In other words, “the skills of experiential learning in which people tend to be the most deficient is reflection” (Duley, 1981, p.611).

Reflection is thoughtful and critical examination of one’s action by taking varied factors into serious consideration in a systematic way. Reflection has been defined by Boud, Keogh & Walker (1985) as an important human activity in which people recapture their experience, think about it, mull it over and evaluate it.
Thus, there are reflection models to use in this process which are extremely crucial for the benefit of the practitioner.

The concept of reflective practice goes back to the 1970s when it was first stated by educationalists to define actual learning. It then, a decade later, became familiar as an educational term. In the early 20\textsuperscript{th} century, it was accepted by educators such as Dewey, Lewin, Piaget and Donald Schön that learning is a combination of experience, which is the basis of learning, reflection as an essential part of the learning process and theory with practice. Today most thinkers agreed on this approach on reflection, and they further argued to strengthen its importance as well as its role in education.

Reflection provides a theoretical framework within which the complexities, pressures and inconsistencies of the practitioner’s work can be explored. It also provides an opportunity to judge the intrinsic value of the practice. Through self-awareness, the practitioner’s knowledge, skills and professional practice can develop. Through questioning, better understanding of the problems appears.
Analysis of my knowledge, skills and understanding

Gardner (1983) proposes a theory of multiple intelligences in which he claims there are seven relatively independent intelligences. Those intelligences are logical-mathematical, linguistic, musical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal. I believe that I have developed extensive skills in the most of the above mentioned areas as a practitioner researcher during my research on Islamic geometric patterns and mathematics in “The teaching of mathematics programme”. Having a different culture had a positive effect on my professional development progress. As previously stated, I was keen on research in Islamic arts and mathematics. My cultural background encouraged me to work in this field. I looked at the issues from two different perspectives. Gardner (1983) argues that culture plays a large role in the development of the intelligences. Everyone is born possessing the seven intelligences. However, pupils have different sets of developed intelligences, in other words unique set of intellectual strengths and weaknesses. These determine how easy or difficult it is for someone to learn information when it is presented in a particular manner.

Applying Gardner’s model of intelligences, I can demonstrate my intellectual ability in the following ways below:

*Verbal/Linguistic Intelligence:* I think in words rather than pictures; my skills include listening, speaking, writing, teaching and analysing language usage. I developed my intellectual ability further during the preparation and presentation stages of my Islamic geometric patterns PowerPoint presentation.

*Logical/Mathematical Intelligence:* I have ability to use reason, logic and numbers. I think conceptually in logical and numerical patterns making connections between pieces of information. This research helped me to enhance my intelligence as I focused on the geometry and Islamic patterns by looking at in depth to prove the mathematical relation of the geometric patterns.
**Interpersonal Intelligence:** I have ability to relate and understand others. I effectively use both verbal and non-verbal language in communication with others. My skills include listening and establishing positive relations with other people. My presentation in Islamic art helped me to enhance my interpersonal skills further.

**Intrapersonal Intelligence:** I have ability to self-reflect and am aware of others’ inner feelings, relationships and strengths and weaknesses. Among my skills are recognising my own strengths and weaknesses, and understanding my role in relationship to others. These intelligences match with my career path: teacher, researcher and mathematician. With this project, I acted as a researcher to find out the relations between geometry and Islamic patterns, I reflected on my findings as a teacher, and finally developed my mathematics skills and knowledge as a mathematician.

In addition, I can demonstrate knowledge of standards and regulations that apply to my research; I can demonstrate understanding of the various codes of practice for good research that apply to my field; I can explain the range of research methods and techniques that I have considered for my research programme and justify the choices I have made; I can undertake a personal audit to identify my strengths and weaknesses; and I can identify areas where I need to make any changes for improvement.

**Presentation of Islamic geometric patterns and mathematics**

I had an opportunity to present my initial research findings about the Islamic geometric patterns which was a highly effective activity as an integral part of my research.
“There are three elements to a great presentation: content, design and delivery. Content includes the research and organization of materials. Design is the architecture of the slides and the graphical enhancements. Delivery is how you voice your message. To make the presentation great, there must be synergy of these three elements” (Rotondo et al, 2001, p.2). From this point of view, I first created my content. Then I designed for that content. Finally, I developed my delivery strategy and style. I thought ahead and through preparation in order to give an excellent talk. For example, I benefited from having the venue organised prior to my presentation. Ober (2001) states that there are physical distractions such as noise, activity and temperature which further obstruct a listener’s ability to fully understand what the speaker is trying to express. With some help, I did not experience any disruption and managed to successfully bring my presentation to an end.

I used a PowerPoint presentation as the media to deliver my findings which was highly accepted by people with auditory learning preference in the class. The participants appreciated the materials I planned to integrate into my research. “The PowerPoint is the investment of time necessary to create a presentation ahead of the scheduled time of the instruction, speech, or lecture” (Montogemery et al., 2004, p.129). The length of my talk with a PowerPoint presentation was 15 minutes in total. There were roughly 15 people including my lecturer. I refined and narrowed the content as much as possible in order to present main issues effectively in the set period of time. My talk had a clear beginning, middle and end.

I also used brief notes written onto sheets beside the presentation that helped me to cover the full content of my presentation in the right order. Although I practised beforehand, I was aware of that it would not be easy to pass my message to the audience and the effectiveness of my talk would depend upon two main factors: the extent to which I have well prepared for the talk; and how well my PowerPoint presentation presented my research findings. “An effective
presentation does not happen automatically but rather is a product of careful research and decision making concerning presentation skills” (Montogemry et al., 2004, p.68).

In this presentation, I examined symmetry and geometric patterns which are used in Islamic art, and I explored the Islamic monuments such as the Alhambra in Spain and the Blue Mosque in Turkey. My presentation focused on mathematical principles and patterns in Islamic art: arithmetic operations; shapes including circles, triangles, squares, six-pointed stars, eight-pointed stars and twelve-pointed stars; and relationships of shapes were presented. Firstly, I started my presentation with history of Islamic arts & geometry. Then, I continued with Islamic arts and geometry including geometric designs taking into account of shape, space, symmetry and colour. This was followed by presenting shapes, namely circle, square, star and triangle. Finally, the construction of various Islamic geometric patterns was presented in detail.

Research for deeper understanding of mathematics

The term deep-understanding means understanding something in depth rather than in a superficial way. Perkins (1992) argues that learners who understand something deeply can demonstrate this through performances of understanding, including explaining, creating ideas, applying, justifying etc. I believe I presented my understanding of the Islamic patterns and explained the structure well and also the relations of mathematics and geometric patterns throughout this project.

Bell (2005) suggests that a researcher needs to select a topic, identify the objectives of their study, plan and design a suitable methodology, invent research instruments, negotiate access to institutions, materials and pupils, collect, analyse and present information, and produce a good report at the end. I followed this sequence recommended by this author, and so I believe I have learnt a lot throughout the whole module: not only did I experience a presentation...
of my initial findings in Islamic patterns but also did I successfully manage the whole process from describing to evaluation of my research findings effectively. In other words, a number of lessons have been learnt from the experience of my research and from the evidence provided by the evaluation of the findings as a result of the research and of collecting verbal feedback given by my classmates. The main lessons are briefly listed below following a brief review of “research” and its aims in general.

Howard and Sharp (1983) define research as “seeking through methodical processes to add to one’s own body of knowledge and, hopefully, to that of others, by the discovery of non-trivial facts and insights” (p.6).

With my research on Islamic patterns and mathematics, I aimed to find out the relation between arts and mathematics in terms of geometry, symmetry and patterns; type of shapes and figures used as Islamic patterns; the methods used to draw the geometrical shapes; and finally to find out the degree of maths used in arts.

**A mathematical investigation**

On the other hand, I consider my research “a mathematical investigation” which begins with summarising the relations between mathematics and Islamic patterns which should be understood and explained in mathematical terms. It is crucial to ask reasonable questions, evaluate findings and to reflect on them for a valid investigation. It is also important to propose assumptions. Testing these assumptions and collecting more data could either support them or result with new assumptions. Reasonable arguments and formal proofs may result with further arguments to confirm or reject our hypothetical statement. This as a result may lead further research. My hypothetical statement was that a high level of mathematics was used to create Islamic geometric patterns. My research proved
this and further research need, mainly to find out how to integrate them into teaching.

Pólya (1957) suggests that problem solving should be approached in four stages: by understanding the problem; making a plan; carrying it out; and looking back. As I accepted my statement as a problem, I applied these stages in my research:

My research project provided me opportunities to examine geometric patterns in depth, to perform calculations, and use mathematical tools in context. It also provided a context for me to reason, explain thinking, to justify conclusions and to analyse situations. Thus, my project involved four thinking processes, namely problem solving, representing, manipulating and reasoning.

*Problem solving:* It is central to mathematics and requires the use of prior knowledge and skills to deal with novelty, to overcome obstacles, to reach and validate solutions, and to pose problems (English, 1998). I used my prior knowledge and skills to understand how geometry and patterns are combined; to find out level of mathematics used to create these patterns; and to examine how to integrate them into my teaching.

*Representing:* It involves the decoding and encoding of information presented in a variety of representational systems including pictures, symbols and diagrams (Diezmann & English, 2001). I represented my research findings to my classmates as discussed in the reflection part of this project.

*Manipulating:* It involves the use of physical and technological tools and objects, as well as symbols to explore and understand mathematical situations (Clements, 1999). My research involved calculation, measurement, and use of tools such as digital media, ruler, compass, and grid paper.
**Reasoning:** It provides insights into the discipline of mathematics by fostering generalisation from observation and experience, and by developing interconnected conceptual knowledge and supporting sense making with mathematics (Russell, 1999). I believe I developed logical arguments throughout this research.

**Implications for teaching and learning mathematics**

Mathematical investigations, based on open ended problem solving tasks, are important from the educational point of view (Ernest, 1991; Mason, 1991). Masingila (2006) argues that setting more open-ended tasks and asking learners to record their solutions mean that information is constructed solely by them providing more detailed insights into students’ perceptions and thinking about concepts. Masingila (2006) further argues that the nature of open-ended tasks provides a rich source of students’ representations of their understandings.

My task in this investigation has an open-ended nature meaning that it could be taken further and be looked for different directions of investigation. The fact that my findings showed that there is more than one way to create Islamic patterns and more than one solution for the same pattern that could also be worked out at different levels.

Problem solving is an essential element of students’ mathematical experience: “mathematics has two faces; it is the rigorous science of Euclid but it also something else (...) mathematics in the meaning appears as an experimental, indicative science” (Polya, 1957, p.vii).

Mathematical investigations encourage student involvement in significant learning; provide opportunities for students at different levels; and provide a complete view of mathematics. I will therefore take my research further asking my learners to create geometric patterns. I will ensure that the activities will be
open-ended which will give them a chance to create different patterns by using their prior skills and knowledge in mathematics. They will also find an opportunity to reflect on their activities.

Thus, this project also provided with me a means to formulate learning activities suited my learners in the classroom based on their previous knowledge and their learning styles. This strategy could be explained by the constructivist framework; constructivism is a learning theory where students construct their own understanding by developing mental structures and connecting prior knowledge with new tasks. Moon (1999) stated that all learners approach to their studies with a cognitive structure-a flexible network of ideas and knowledge shaped by prior learning.

On the other hand, none of the topics in Maths is unrelated with each other. Basic level of numeracy is the general requirement to develop Maths skills further for learners, and whatever learned is likely to be used in enhancing other areas of the subject. I realised that my previous knowledge in many areas as a learner would help me to develop new strategies in my teaching practice.

Thus, students understand the need to justify their assumptions, expressing their reasoning. Mathematical investigations are good starting points for an inquiry mathematical class (Wood, 1994), providing opportunity to create a new and dynamic learning environment. Reflect on the nature of the activity is equally important. As Bishop and Goffree (1986) state that learning does not result only from activity but from reflecting on the activity.

**What I learned?**

The research I carried out in Islamic geometric patterns was interesting and inspiring. My respect for Islamic patterns increased as I discovered the amount of effort, high level of mathematics and accuracy needed to create such remarkable
patterns. In this part of my study, I will explain what my research was based on, what I learned and how I plan to use the knowledge gained from this learning experience.

Firstly, I learned that the message of the Qur'an is social as well as spiritual and all aspect of life is touched by it so all types of art has to abide by its principles. The Muslims have significantly contributed to the development of mathematics. The Muslims seemed to be more open to accept mathematical ideas from the early development of mathematics. Islamic art and mathematics were never separated. I also learned about Ethnomathematics which is the study of the relationship between different cultures and mathematics (D'Ambrosio, 2001). The aim of this new field of study, Ethnomathematics, is to contribute both to the understanding of culture and the understanding of mathematics. It looks at how different cultures use mathematics and how they incorporate it into their daily lives. Thus, Ethnomathematics can be seen in many works of art, as discussed in this study, from the Islamic culture.

Secondly, I realised the level of importance of geometry as one of the most important elements of Islamic art. “Star shapes and polygons appear in all the arts and provide a source of much architectural decoration (...) geometric shapes are highly versatile and can be extremely complicated” (Candy, 2005, p.8). From this point of view, Islamic artists took the basic principles of Euclid and transformed them into highly complex and sophisticated patterns and architectural designs. There is no question that Islamic art was derived from Greek math which based on pure geometry.

“Two-dimensional geometric patterns in Islamic art are compositions of closed polygons. In Islamic art, geometric and floral patterns are generated by some basic geometry rules such as isometric transformations and Boolean operations. Translation, rotation, reflection, repetition are the isometric transformations (also
known as Euclidean transformations). Boolean operations are operations like union, intersection, subtraction etc.” (Cenani & Cagdas, 2007, p.2).

Thirdly, I experienced that I would be able to integrate Islamic geometric patterns into my teaching by simply asking my students to draw overlapping circles and lines using a pair of compasses and a straight edge. The patterns are very creative and there are two main elements to geometry. The first stage is creating the pattern using a pair of compasses, a ruler and a pencil. When the main ideas of creating a pattern are realised, it is possible to create an infinite number of patterns. The second stage is colouring in these patterns.

To experience this myself in practice, I drew a circle. I placed the point of the compass anywhere on the edge of this circle and drew another circle. I tried to be as accurate as possible in this and all subsequent attempts, through keeping the radius (the distance between the compasses points) the same. I found that the new circle passes through the centre of the first circle. Then, I moved the point of the compasses to one of the two places where my second circle has cut the edge (circumference) of the first circle, and drew a third circle. This cut my first circle at another two points: one is the centre of the second circle, and the other is new. Following this, I moved the point of the compasses to this new point on the circumference of the first circle and drew another circle. I repeated making circles round the edge of the first circle until I got back to where I first started. As a result, I had exactly six circles around the edge and the original circle in the middle (figure 8). I also learned to construct a five-fold Islamic pattern by taking a square and then dividing that square into golden sections, when lines are drawn out and the square is repeated it becomes a complex Islamic pattern.

In this way, my learners would begin to explore the different symmetry groups within the generation of the basic shapes. This would help them to construct more sophisticated patterns such as eight-fold patterns using compasses and rulers, and to compose floral motifs frequently used in the interior design of
mosques in Islamic art. Thus, I realised that I can encourage my students’ awareness of the mathematics which is embedded in their cultural backgrounds. Following this, I can also create classroom projects in which the students can work in small groups on various complex Islamic geometric patterns which could help to deepen their understanding of elements of mathematics in their own and other students’ cultures. Sharing this learning experience within groups would be essential in developing their maths skills further.

As a result, I developed geometrical awareness and the ability to visualise; knowledge and understanding of and the ability to use geometrical properties and theorems through Islamic geometric patterns; skills of applying geometry through Islamic patterns; an awareness of the historical and cultural heritage of geometry in Islamic art. Finally, I believe that the study of Islamic geometric patterns contributed to helping me develop the skills of visualisation, critical thinking problem-solving and logical argument and proof.

**Conclusion**

Through my project in Islamic geometric patterns, my aim was to investigate the relation between mathematics and visual arts through the use of Islamic geometric patterns. To reach my aim, I carried out an extensive research about the aspects of Islamic patterns as well as their history, and I exploded my cultural background through Ethnomathematics in the field of Islamic visual arts.

There were a number of reasons why I decided to carry out a research on Islamic patterns. First of all, I believe that Islamic patterns have been one of the best examples of the combination of mathematics and art. Secondly, they contain a large amount of symbols, coloured-designs and repeated patterns which I could have explored in my project. Thirdly, I am culturally familiar with Islamic patterns: I have always been interested in Islamic geometric art since I studied Islamic art.
in school in Turkey in which there are also plenty of examples of Islamic geometric art. Turkey was home to both great Seljuk and Ottoman Empires.

To present my investigation through a PowerPoint presentation, I focused on both traditionally and digitally designed Islamic patterns, in which I came across fascinating patterns created by modern artists. On top of that, I presented a short clip about the Islamic geometric patterns taken in the Blue Mosque in Istanbul, Turkey. This summarised what I focused on in my presentation in a visual concept.

I believe that for my efforts in exploring how mathematics and visual arts can be combined through creating Islamic patterns showed that even the simple process of reflection requires a vast amount of time and effort. I had some knowledge of Islamic patterns and during my investigation I enhanced my knowledge in this area of maths. Upon researching Islamic geometric patterns, I was amazed by the details and methodology in designing beautiful patterns. This project was the perfect opportunity for me to look at these patterns as a mathematician. I discovered what symmetries and mathematical principles applied in the creation of the patterns. Finally, I am excited about the incorporating basic Islamic patterns into my teaching in the new academic year.

Retrospectively, the investigation of the ways to combine mathematics and visual arts through Islamic geometric patterns was an invaluable experience for me. The ways in which mathematics and visual arts can be combined are endless, and my attempts show only a very small portion of these ways. Further investigation in this area of mathematics is needed to fully explore the mathematical structure of the Islamic patterns and the methods used to integrate them into teaching.
References


Perkins, D. N. (1992), Smart Schools: From training memories to educating minds, New York, Free Press.


Appendixes

Figure 1 (space filling patterns)

The Islamic Decorative Canon

Calligraphy  Geometric  Arabesque

Figure 2 (calligraphy)
Figure 3 (arabesque)

Figure 4 (Dome of the Rock)

Interior, Dome of the Rock
Jerusalem, 7th c.
Figure 5 (Alhambra)

Figure 6 (The Blue Mosque)
Figure 7 (The Blue Mosque)

Figure 8 (Drawing circles)
Various patterns