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USING OF PAPER FOLDING ART AND COMPUTER SOFTWARE TO PRODUCE ARCHITECTURAL MODELS

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Abstract

The aim of this study is to identify the possibility of exploiting paper folding (origami) technique using computer-aided technology as a method of producing architectural models, next to the definition of the art of folding paper (origami) as a science and art, and the definition of its importance and its role, focusing on unwrapping or unfolding mass surfaces techniques, it provides method of transforming the 2D shapes to 3D forms, printable on paper. The result is a multi-layers of different colour grids and lines. Then transforming the 2D shapes to 3D object, by folding the printed guidelines, all processes were performed by computer-aided programs. This serves the students and the graduates of the architecture department, other engineering and all those familiar with modelling technical fields, depends on combining between the computer software and handworks. Moreover, the study purpose is to propose new ways to produce architectural models using simple techniques. The complex geometry is reproduced in economic, fast and accurate techniques. In addition, the study examines the origami paper types to give an evaluation for all available paper types. The experiment was done to randomly selected architects team, and they distributed to four groups to test the whole process. All four groups used the procedure to produce models based on the technique of paper folding art. Finally, all work variables are discussed by a questionnaire that was applied to them.

Keywords: Architectural models, Engineering programs, Folding art, Origami.

1. Introduction

1.1. General

Students and graduates of the architecture departments in Iraq are suffering from a hesitation between the old and the modern schools; they suffer from ranging in terms of usage between the reliance of computer or handmade technique in designing operation. Some completely depend on and invite for the reliance of one of them purely to produce architectural designs. In one side, people with a classical vision, who proclaim the handmade technique, claiming that the computer techniques restrict and limit the designer's creativity, because of the available facilities and functions in the software specializing in the architectural design. On the other side, the handmade technique consumes much effort, time, and high cost as compared to what computer software has offered. Hence, computer software has led a giant jump in the field of architectural design in terms of video and picture shows and these techniques facilitate all of the engineering computations [1].

Art of origami paper folding, which is Japanese in origin, is considered among the most important formats of the handmade arts. In this kind of art, the paper is converted from the two-dimensional plane to the three-dimensional shape depending on folding. Therefore, two kinds of folding are formed; the first one is called the peak folding, and the second one is called the bottom folding. Using the two kinds, any three-dimensional shape can manually be formed [2]. Although origami is an old art, began sometime after Buddhist monks carried paper to Japan during the 6^{th} century, while paper invented around 100 BC in China [3], the factors of time and effort in forming folding and dimensions of figures represent an obstacle against this art to go ahead and be widely unfold. In the late sixties of the twentieth century, it was reused another time in the fields of engineering, space, medicine, and the different sciences. The mathematical algorithms were used in forming structure, angle calculations, and dimension computations in it.

Tantawy [4] explained his study mentioned the art of paper folding is increasingly unfolding, both practically and scientifically. This is, first, through creating methods for sheathing and folding mobilizing houses parts that are easy in building and assembling. Secondly, origami is utilized in building the architectural interfaces for self-folding and self-unfolding towers to remedy the atmosphere and to control the desired amount of sunlight entering the architectural spaces. Further, it contributes to mobility and changes the shape by using identical architectural shapes having new beauty value. Therefore, the influence of taking benefit from modern techniques must be limited to save creativity, and it must be supportive of it [5]. Furthermore, mixing between computer capabilities and paper folding concept directly contributes support to the architectural presentation that is specializing in characterizing the architectural figures without having a problem of misusing the computer techniques.

There is a school that connects between the modern and the classic schools; with the modern school, it shares the means, where it shares the method of the manual activity approval of the architectural presentation in the second school [6]. This harmony is performed by exploiting the engineering software capabilities in characterizing and drawing the three dimensions geometric shapes, then getting the lines grid that specializes in the top and the bottom folding, and reproducing the two-dimensional paper into three-dimensional shapes and figures using the origami method.

As the methods used in modelling of architectural presentation may be summarized by many researchers (Suzuki, Mitani, Tachi and Demaine). It was explained in details by Mitani and Suzuki [7] that this study proposes a computational method that helps in designing the origami architecture and establishing a geometric figures group to form models of architectural masses within right angle surfaces, in which, the manual method is focussing on using the folding of papers to create the model is called origami technique. Another group of holes was added to the models, which perform the up-right angles. These angles are utilized in the architectural fronts to be printed on the origami papers to have holes on it and to adjust the depth to have a three-dimensional front model in an easy and a very fast way. The study concluded applying this operation on two models through a reactive approach to get into a final model of a three-dimensional front. This front can be folded like a book to help in its storage and to retain the models produced by this technique.

Tachi [8] studied the problem of generating the origami layout from the three-dimensional figures into two-dimensional figures. His study suggests a new pattern to fold papers and forming three-dimensional figures without a need for cutting paper. This helps in simplifying the complex surfaces and contributes to creating designs for the multiple surfaces in a non-intersecting and a foldable manner. In addition, shows a pattern that is able to form three-dimensional figures characterized by a computer with less than 400 polygons. Two levels in the proposed pattern algorithm were approved; the first level was for dividing edges, and the second one is for assigning the polygons positions in the three-dimensional figure, but the study was not able to come up with an algorithm to solve more than 400 complex model polygons and cannot be used with designing complex origami models.

Demaine and Tachi [9] explored their study that leads to a great loss in the paper, in which, the problem of wasting in surface folding into multiple layers. Therefore, the study suggests the development of algorithms that are specially designed for printing on paper and converting it into multi surfaces complex models. Furthermore, this algorithm achieves a limitation for the polygon edges in a clear and accurate way. This method was applied to a complex model and proved its reliability in saving the geometrical polygons that can easily be folded with an indicator for the concave and convex positions.

The study noticed the knowledge deficiency of Iraqi graduated and students of architecture departments in exploiting the origami in forming and producing the architectural models and figures, and exploitation of the origami paper properties in producing the architectural models. The study main question is: Is it possible to exploit the origami art and computer software in producing architectural models that depend on the origami paper properties?

The study proposes that there are many methods of paper folding art process via engineering software to produce architectural models. This strategy of producing figures was applied on a graduated team of architecture, who were randomly chosen from previously graduated students to have a diverse sample in terms of education and level. Then, they were divided into four groups having two persons each.

1.2. Origami technique

1.2.1. Origami folding art technique

Origami is the art that stands on the concept of repeated operations of folding for a type of paper to produce simple figures simulating other figures. It has a proportional relationship between the number of folding, the degree of complexity, and the desired detail through this technique. Origami is considered as the classic Japanese art of folding papers. The Japanese word “origami” consists of two parts; the part “ori” means folding, and “gami” means paper [4]. This art can be utilized in many fields that advance human’ life, such as medicine, engineering, astronomy, building, and self-forming robotics [10].

Bauhaus was an active art school in Germany from 1919 up to 1933, and it had an important influence on design, art, and architecture during the twentieth century. Joseph Albers, who was a professor in the Bauhaus, used to present preparatory courses where students conducted experiments with many different materials, such as wood, glass, fabric, and, paper. They were encouraged to check the strange properties of all materials and, then, to learn how to use everyone in the best way of design as in Fig. 1 [11].

There are many methods of paper art, which are the classical, rigid and combined art. The classical refers to the gross folding operations with a square paper piece without cutting or pasting. This method enables producing simple shapes. The rigid method refers to folding operations that are produced by more than one surface to enable figure unfolding, where folding is for reducing volume only. The latter method can be applied in designing the solar plates of satellites for energy supply. Furthermore, the plates are normally folded and, then, open, settle down, and become a hard block. The combined method is a merge between the classic and the hard methods.

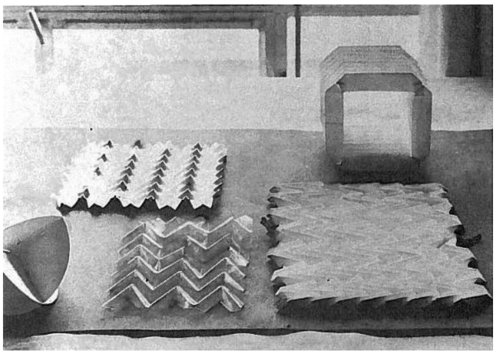


Fig. 1. Bauhaus students’ works of origami designs [11].

1.2.2. Unwrap/unfold surfaces software

It is possible to use 3D software programs to produce the unwrapping mass surfaces that are created via computer and are exploited in producing models of the architectural figures. Its mechanism depends on a group of orders to unfold or unwrap surfaces specialized for architectural designs. Unfold/unwrap surfaces can be limited to the following software programs:

- **Pepakura designer software**

Pepakura Designer 4 [12] is used in unfolding or unwrapping three-dimensional figures into two-dimensional surfaces by the order “unfold”. When this order is applied to any 3D shape, the grid lines, produced from unwrapping (unfolding) the surfaces, will form with leaving appendages used in pasting to form the shape of the polygon from paper.

The figure, then, consists of two types of lines; the first line is continuous and represents the folding line. The second line is a dashed line that represents the appendages used in pasting the folding polygons. It is not possible to design any three-dimensional figure using Pepakura, but can be imported from other modelling programs. Applying for the order “unfold” shows the unwrapped object surfaces (Fig. 2).

The study shows that Pepakura gives the ability to unfold or unwrap the surfaces in it via the order “unfold”, but needs a software specializing in 3D modelling. In addition, the program is able to calculate the appendages and their positions to ease the operation of creating the architectural structure from paper.

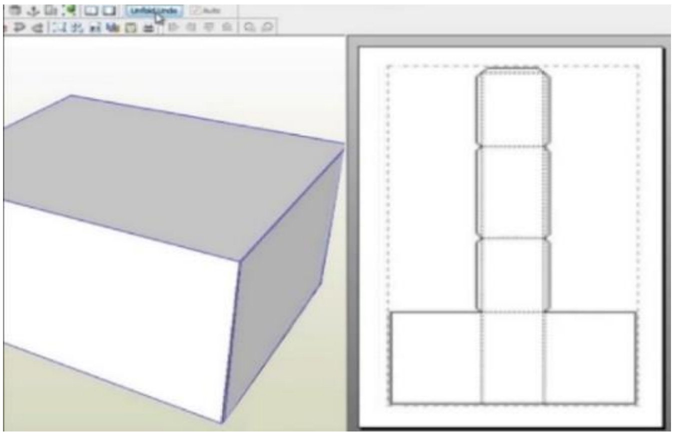


Fig. 2. Unfold box’s surfaces in Pepakura program.

- **Origamizer software**

Origamizer [13] software is used to unfold three-dimensional figures into 2D surfaces through the order “develop” from the list “model”. Giving multi grids of coloured lines. Every colour refers to a specific meaning; the red colour refers to an outer view folding, the blue colour refers to a folding that heads to the inside view, the white surface refers to the polygon’s surface, the green refers to folded surface towards the inside, and the grey colour refers to the part folded more than once or to cut.

It is important to notice that this program does not produce any 3D creation, but it is possible to import figures to the program to unfold surfaces. The order “develop” from the list “model” giving “crease pattern” [9] window shows the disassembled, or the unfold object surfaces, where the blue and the red lines, along with the three coloured surfaces (green, white and grey) are presented (Fig. 3).

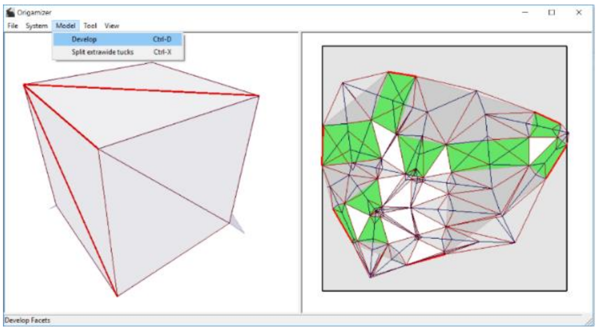


Fig. 3. Unfold box's surfaces in Origamizer program.

• Freeform origami software

Freeform origami [14] software is used in unwrapping or unfolding 3D models to 2D surfaces through the order "developable" from the list "constraints". It contains two types of lines; the first type is grey and thin, which represents the folding side on the structure. The second type is bold grey, which represents the polygon boundary that is desired to be folded. As in Origamizer, it is not a 3D modelling program, but it is for unfolding surfaces that help in creating the model.

The surfaces are unfolded via the list "fold/unfold" in the program, as in Fig. 4.

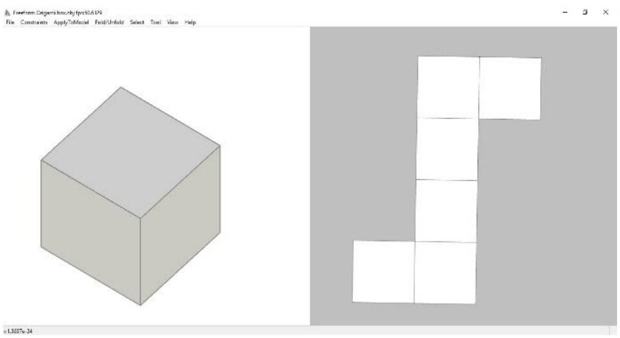


Fig. 4. Unfold box's surfaces in freeform origami program.

• 3ds max software

This software uses the order "unwrap uvw" in modifying ores or filling materials in case of video output, which limits the computation time of reflection, shadow, light, colour mixing, and other changing parameters in 3ds Max [15].

All computations of reflection, refraction, and colour mixing of shadow and light are changed in a built-in manner through the order "unwrap uvw". The order "unfold mapping" from the list "mapping" and the option "walk to closest face" help to unfold the object surfaces, as in (Figs. 5 and 6). It provides the ability to unwrap or unfold the surfaces through the order "unwrap uvw". Consequently, 3ds Max does not require any additional programs in this operation.

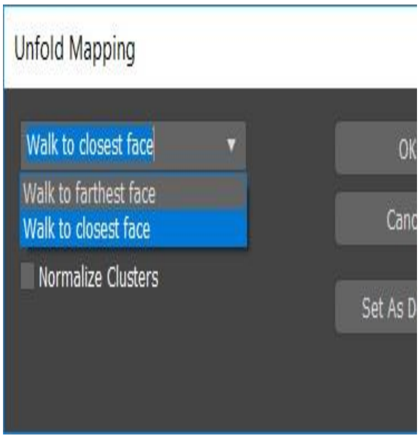


Fig. 5. Unfold mapping window in 3ds Max.

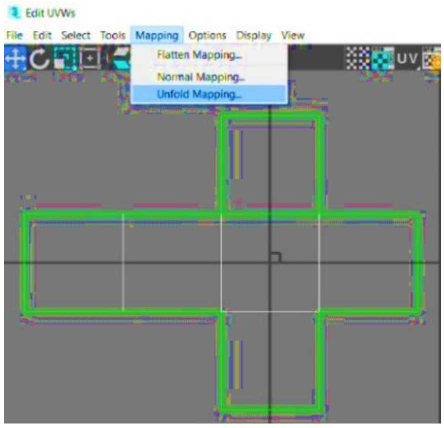


Fig. 6. Edit UVWs window.

- **Maya software**

As in 3d Max, Maya software [16] is utilised to draw 3D models. A plugin can be added to Maya to be able to unfold surfaces. "Unfold 3D" is basically used in modifying object materials in case of video output that reduces the time using "modelling editor", "modelling toolkit". In addition, "UV editor" to unwrap or unfold object surfaces (Fig. 7).

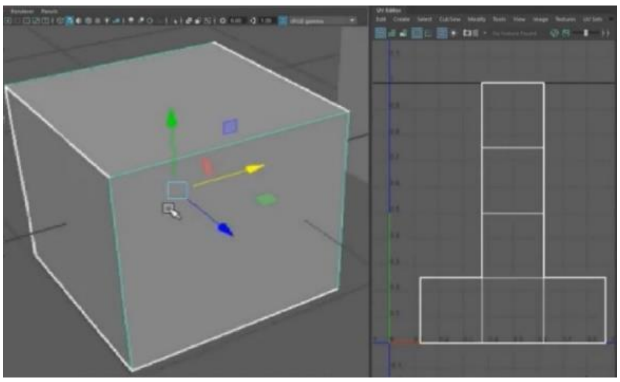


Fig. 7. Unfold box's surfaces in Maya program

- **SketchUp software**

As in Maya, SketchUp [17] software is used to create 3D models with "extension" to be able to unwrap or unfold surfaces. The appendix "unwrap and flatten faces" is fundamentally used to unwrap the surfaces of the geometric polygons, which is an unwrapping of object surfaces, as in Fig. 8. The study finds that SketchUp software, with "unwrap and flatten faces" extension, gives the ability for models creating, and unfolding the surfaces through "unwrap and flatten", which makes it self-depending.

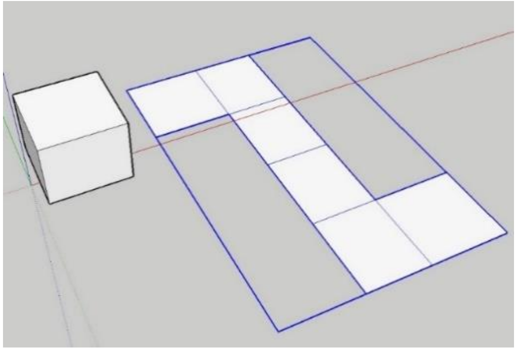


Fig. 8. Unfold box’s surfaces in SketchUp program.

- **Rhino software**

Rhinoceros [18] with reference numbers for every object side and its 2D unfolded surfaces as well (Fig. 9), in which, the software uses the order “unroll developable surface” to produce unfolded surfaces of the designed shapes. The study demonstrates that Rhino has three merits: First, modelling. Secondly, the ability to unfold through the order “unroll developable surface”, which makes it self-depending. Thirdly, giving reference numbers for every side to recognize its position according to the original shape.

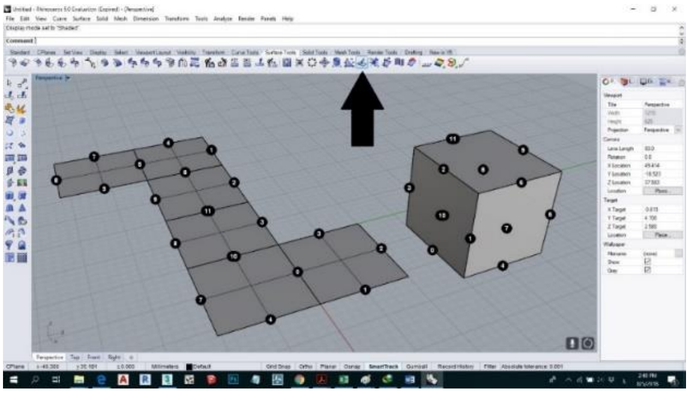


Fig. 9. Unfold box’s surfaces in rhino program.

1.2.3. Types of paper used in paper-based creating

There are many types of papers utilized in origami, and it is, somehow, confusing to identify the best type, because of the diversity in papers according to the requirements. Table 1 demonstrates the pros and cons of every type of paper and the cases upon, which every item is used better. It should be noticed that the term “gsm” is for indicating the paper density (gsm stands for gram per square meter).

The relationship between “gsm” and paper is proportional to each other. For example, most newspapers are 23 - 55 gsm when the plain paper is about 80 - 100 g. On the other side, business cards are about (350 - 400) gsm. A paper with low “gsm” is easier in folding but more sensitive than high gsm paper.

Table 1. Most common paper types used in origami.

Paper name	Density gsm	General appearance
Origamido	20 - 50	Robert Lang describes this paper as thin, strong, clear, foldable, and does not get weak by folding [19]
Unryu	27	In Japanese, unryu means “dragon cloud paper”, where it is manually done by mulberry bark [20]
Kraft	30	It is usually brown and rough on one side and coloured or decorated on the other side. It is very thin and very strong
Glassine paper	40	It is usually transparent, cellulose-based, air and water-resistant, very thin, plastic apparent, and looks like a thin wax paper
Foil paper	50	A shiny thin paper from one side and the other side is usually white. It is very thin and smooth
Kami	60 - 63	It is white, one-side coloured or decorated, smooth, and thin. It is within a large group of colours and decorations. Kami means paper in Japanese
Tant	70 - 80	It is very famous in Japan and is used in almost any model. It is strong, very tight in the surface, very thin, and one-sided coloured
Plain paper	80	It is the most famous type and is available in all sizes. Further, it is white, thin, and cheap
Lizard paper	96 - 116	It consists of a decorated fabric like reptiles skin, is very thick, and is manufactured by one company only
Rhinoceros	107	It consists of an ornamented fabric like a rhino skin, is very thick, and is uncommon
Elephant	110 - 190	It consists of an ornamented fabric like elephant skin, is very thick and is uncommon
Canson	300	It is a fortified, thick, rough paper, and is available in all sizes and colours

1.3. Aim of study

The aim of the study is displaying the methods of producing architectural models using computer and paper in an economic way and high accuracy and speed. Moreover, manual modelling not based on computer needs a lot of time to get high accuracy, which means a much expensive modelling way. The study aims to the following:

- The exploitation of origami art in producing architectural models.
- Identification of the geometrical characterization methods depending on computer in producing two-dimensional origami lines.
- Comparison between the computer characterization software in producing the unwrapped or the unfold surfaces.
- Identification of the capabilities of paper folding art in producing architectural models.

2. Study Methodology:

The study adopts an applied methodology, including practical experimentation with new methods and technical tools. This approach is considered the most appropriate method for studying such cases; a questionnaire was applied to 8 architects, the sequences as follows:

- Definition stage: A lecture consisting of the architectural figures sketching and characterizing methods via computer was prepared. The lecture also consisted of how the lines grid of unwrapping and unfolding the architectural surfaces is exported by computer software. The lecture showed famous paper types utilized in origami art.

- Application stage: In this stage, the groups were ordered to choose and characterize the samples via computer and, then, applying them on one of the types of origami papers to reach the result.
- Discussion and result stage: The groups had the questionnaire containing work nature, stages, and capabilities of the gross operation. Then, the results and all the indicators, which were obtained from this issue, were discussed. Moreover, field study approach was carried out through applied studies that include empirical experiment global architectural projects samples. The study tools depended on the personal notices of the experiment and the questionnaire applied to selected groups' individuals.

3. Case Study

Two of the global projects, which were the US Air Force Cadet chapel and Tadao Ando 4×4 house projects, were chosen as samples to draw and create an architectural model through unwrapping or unfolding surfaces technique in five stages to reach the final result. The first stage started with allocating one of the projects to one of the groups. The selected group sketched the project using one of the common 3ds software (3ds Max, Maya, SketchUp, Rhinoceros, etc.). In the meanwhile, the second stage concerned in unwrapping or unfolding the surfaces of the project design to be converted from a three-dimensional shape into a two-dimensional surface. In the third stage, the two-dimensional shape was printed on one of the paper types (origamido, unryu, kraft, glassine paper, foil paper, kami, tant, plain paper, lizard paper, Rhinoceros, elephant or Canson). The fourth stage concerned about changing and creating the shape through folding, cutting, and pasting to reach the fifth stage, in which, results were presented.

3.1. First sample: US air force academy cadet chapel

Cadet chapel lies within the US Air Force Academy location at the north of Colorado State. It was designed by the American architect Walter Netsch from SOM office and was implemented by engineer Robert E. Mckee. It has been taken as a vigorous example of modern architecture and won the national institute prize of architects in 1996 [21]. The project has been considered among the American national historic sites. Stephen Pete said that the chapel was controversial, at that time, because it was a regular ecclesiastical design [22], as in Fig. 10.

Fig. 10. US air force academy cadet chapel [23].

The chapel design belongs to modern architecture that was obvious in all of the USA during the mid-last century, especially in Washington, New York, and Chicago. This kind of architecture lured the local and the national architects who used different kinds of figures especially surface designs. The designs can be curved, slanted, diagonal, or folded. They are usually carried out as concrete or metals. In addition, concrete and metal exposures were used as decorations with concrete buildings, iron, and glass. Many buildings were designed by famous designers and architects inspired by this style [24]. The chapel consists of a front interior that leads to a stage rising from the middle way between two main floors. One of them leads to the Protestant section in the upper floor, the other one goes to the Catholic section in the down floor, the Jewish section is underneath, where the "all religions" section lies in the basement [23], as in Fig. 11.

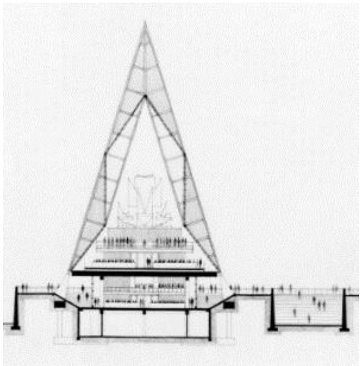


Fig. 11. U.S. air force academy cadet chapel drawings [23].

The general shape of the chapel is the aluminium structure, glass, and iron. It consists of 17 towers, 150 feet each [22]. The frame structure of the walls and the ceilings of the Protestant section involves quadruple chassis having coloured-glass, which becomes gradually thinner as the altar approaches, and it comprehends 1200 persons. On the other side, the Catholic part comprehends about 700 persons. There is a choir stage having 100 seats, and the Jewish part in the back has a circular design, whose circumference is 42 feet with several metal posts and coloured-glass. Its shape resembles a tent [23].

The first group depended on designs to create a cadet model using 3ds Max and they depended on the program to unfold the surfaces of the figure after plotting it, as in Fig. 12. They preferred consuming the regular paper to print the unfolded surfaces, and the process of forming the architectural model lasted 3.5 hours to reach the result, as in Fig. 13.

The second group depended on 3ds Max in designing the Cadet chapel, whereas Origamizer software was used in unwrapping and unfolding figure surfaces, as in Fig. 14. The group preferred using the Canson paper to print the unwrapped surfaces. Further, the program was not able to comprehend all towers one time. Therefore, the towers were shrieked into three towers and then were repeated. This process led the result not to be continuous, and it took 4.5 hours to reach the result of the structural model, as in Fig. 15.

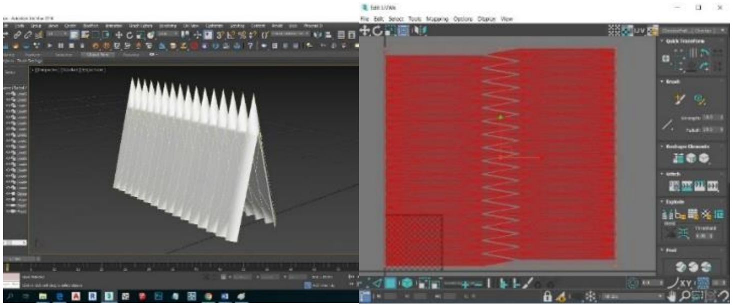


Fig. 12. Cadet creation in 3ds Max program (1st group).

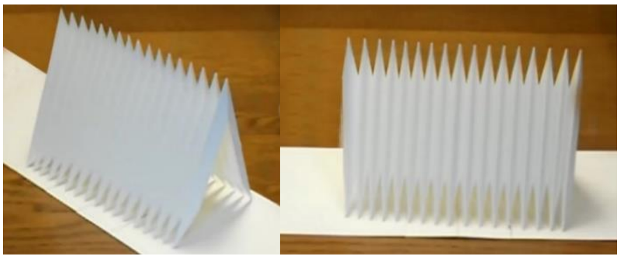


Fig. 13. Cadet model with plain paper (1st group).

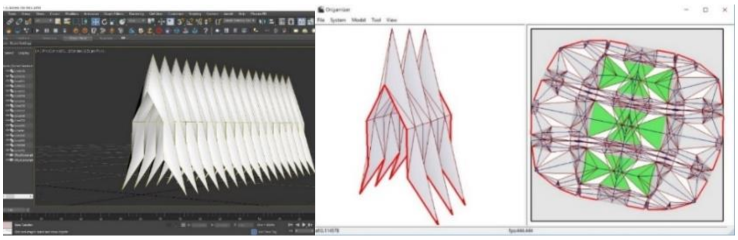


Fig. 14. Cadet creation in 3ds Max and Origamizer programs (2nd group).

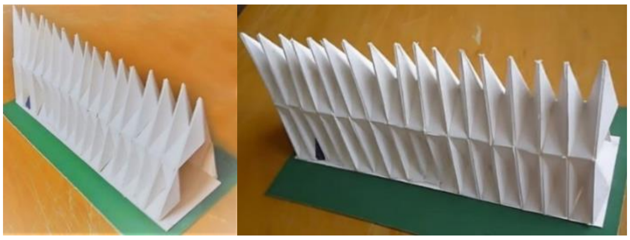


Fig. 15. Cadet model with Canson (2nd group).

3.2. Second sample: Tadao ando 4×4 house

Tadao Ando 4×4 house exists in Cobi, Japan, with 5 m long and 5 m wide in the sand beach of the city. The house has a tower fingerprint [25]. It came due to a competition of architectural design of the building within a very small land area. To meet user's criteria, the building was built with a basement, ground, and three upper floors. Every floor includes a different activity. The basement is allocated for storage, the first floor is for sleeping, the second floor is for space of study, the third floor is for the kitchen and the dining room, and the fourth floor is for a nice shot toward the sea, as in Fig. 16 [26].

It is noticeable that the project mass formation is a three-sided solid cube, intersected with a perpendicular box and its sketching and forming is easier than the previous figure due to the right angles.

Depending on the available sketches of the house, the third group sketched Cadet building using 3dS Max. They depended on Pepakura to unwrap and unfold the figure after sketching it, as in Fig. 17. The group preferred the Canson paper for printing the unwrapped surfaces, and the process took 3 hours and 5 minutes to reach the result, as in Fig. 18.

The fourth group worked on SketchUp software to build a Tadao Ando house, where they used the order “unwrap and flatten faces” to unwrap and unfold the sketched figure, as in Fig. 19. The group preferred using Canson for printing the unwrapped surfaces and it took 2.5 hours to get into the result, as in Fig. 20.

Fig. 16. Tadao Ando 4×4 house image [27].

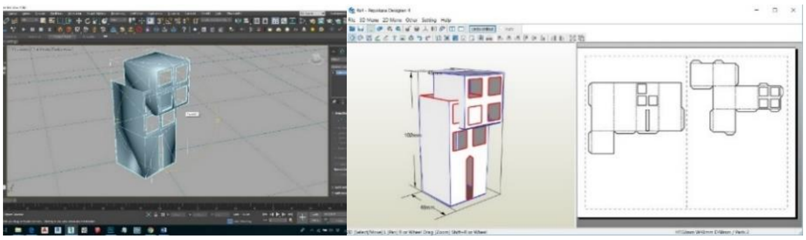


Fig. 17. 4×4 house creation in 3ds Max and Pepakura programs (3rd group).

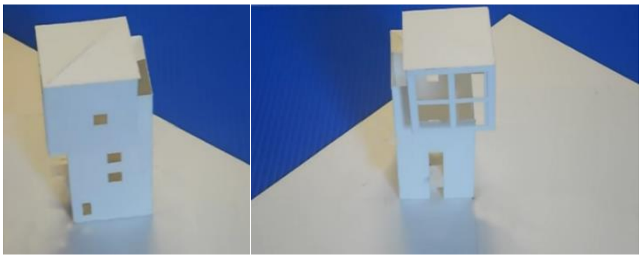


Fig. 18. 4×4 house model with Canson (3rd group).

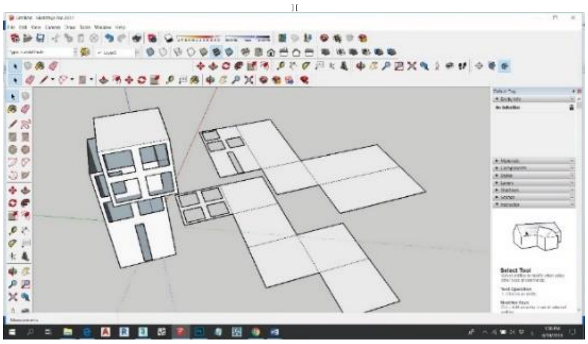


Fig. 19. 4×4 house creation in SketchUp program (4th group).

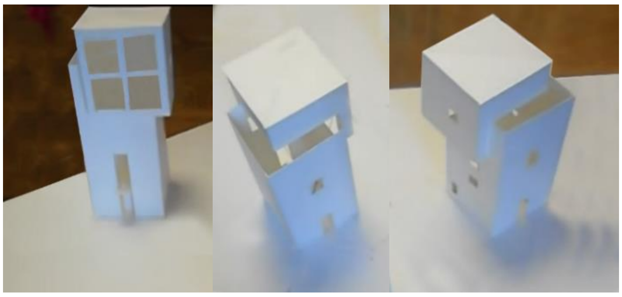


Fig. 20. 4×4 house model with Canson (4th group).

4. Results and Discussion

This study mainly aims to explore new methods that facilitate characterization process of the architectural designs in terms of time and effort. However, it is necessary for students to gain more experience and to be aware of new skills and methods of engineering software. A questionnaire was conducted to all participants as outlined in *Appendix A* and the results are analysed by Microsoft Excel as in the form below, as in Fig. 21.

- Most architects have more than good experience in architectural engineering software.
- All participants have an adequate level of skill, where half of them is able to work on four different engineering software. One of them can work on five software, and the lowermost one can work on two software.
- Most of the participants expressed their satisfaction for being part of the test due to learning new skills in architectural designs.
- The test was easy for most of the participants.
- Most of the participants expressed their agreement on the paper type they used.
- Unlike others, one of the members stated that he did not enjoy the event.
- Most of the participants agreed that the test proved its efficiency in terms of time and cost.

Regarding paper and its properties for the test takers, another questionnaire was conducted, where 50% and above of the results were taken in Fig. 22.

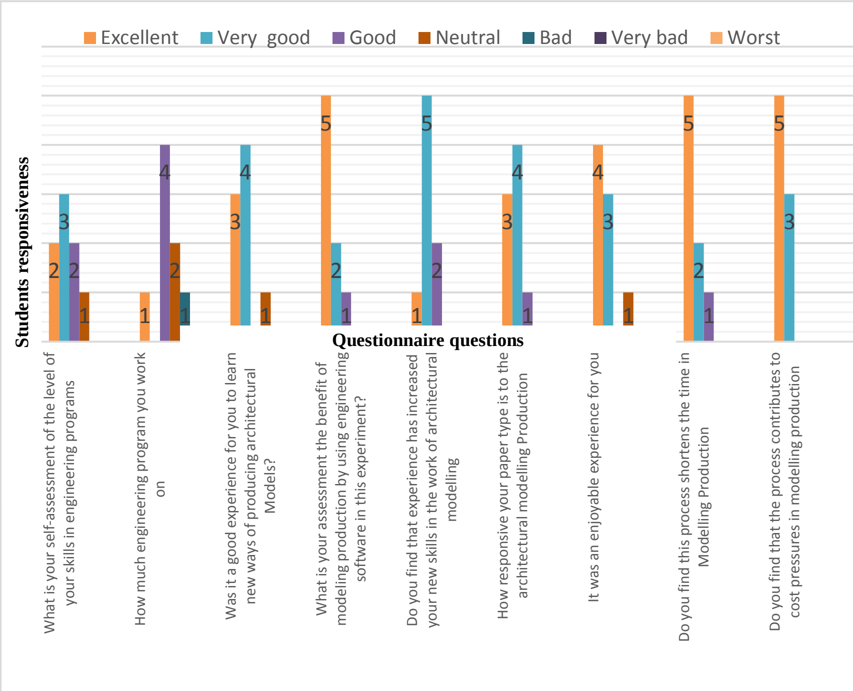


Fig. 21. Groups questionnaire results.

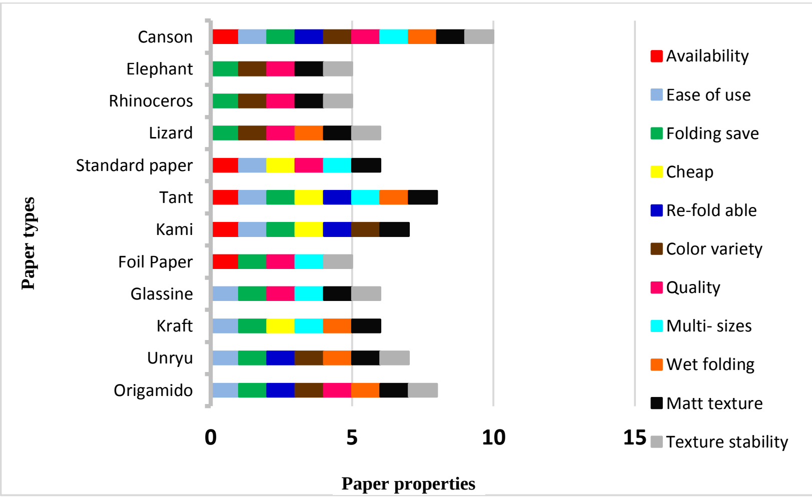


Fig. 22. Properties of paper used in origami.

It is clear that Canson was mostly the best paper type. The questionnaire result can be summarised as follows: 91.65% of the answers were positive, 6.95% were neutral, and 1.4% were negative. However, 76% of participants expressed that the process was more than very good and 40% said that the test was excellent, as in Fig. 23.

Not all four groups set static variables about their ability and skills and it did not show the clear time used to make the paper-folding model. The time variable related almost to the level of the chosen programs difficulty. However, the paper was for model quality. The software specialized in unwrapping surfaces and the type of paper. In addition, the first group preferred the regular paper and 3ds Max for unwrapping surfaces. On the other side, the second group preferred Canson paper and Origamizer software. This affected the factor of time, hence, the first group needed 75% of the time needed for the second group to reach the result. Having the same figure and paper type, the fourth group only needed 81% of the time needed by the third group, because of the different software and surfaces unwrapping; as the program gets easier, the needed time shrinks, as in Table 2.

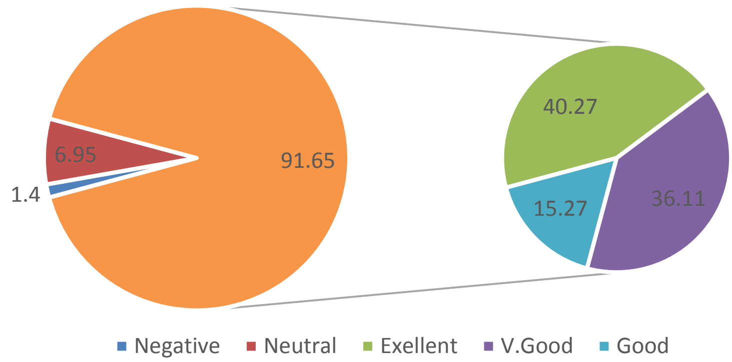
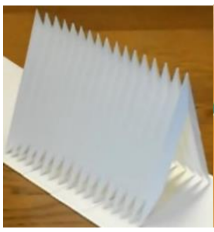
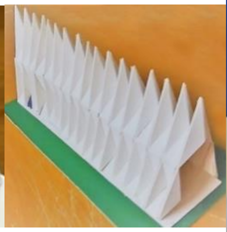
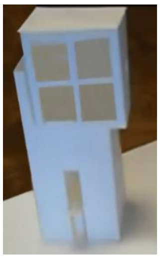


Fig. 23. Percentage of positive responses in questionnaire results.

Table 2. Illustration of drawing program effect on model, surfaces unwrapping and time.

Sample	US air force cadet chapel		4×4 Tadao Ando	
Group no.	1	2	3	4
Software	3ds Max	3ds Max	3ds Max	SketchUp
Surfaces unwrapping software	3ds Max	Origamizer	Pepakura	SketchUp
Paper type	Plain paper	Canson	Canson	Canson
Time	3:30 hours	4:30 hours	3:05 hours	2:30 hours
Result				

5. Conclusion

Classic methods of building architectural models have become costly consuming and not consistent with modern development in computer software. Generally, new methods must be adopted through enhancing of new software programs and discovering their ability in the architectural presentation in general and models in particular. The merging between computer and origami art techniques gave the advantage to transform the paper into the architectural model based on 3D model extension, the study focused on making the computer as a means, not an end.

Architectural models are among the most important idea-communication elements. Utilizing computer software in creating and producing architectural figures is a priority nowadays. In addition, high-cost architectural figures construct a constraint for students and architects. Therefore, exploitation of some kinds of papers folding to construct figures contributes to removing this constraint and reducing cost.

It has found that using software and choosing the proper type of paper increase pleasure, productivity, joining architecture with other fields of work, and benefiting from all capabilities to reach efficient architectural figures and designs. From the beginning, some of the participants hesitated to build models and designed using the computer only. Therefore, they were asked to mix between computers and designing architectural models, and they were willing to respond and work further.

Abbreviations

3ds Max	3D studio max edition software for modelling, animation and rendering program by Autodesk
GSM	Gram per Square Meter
Maya	3D software for animation and visual effects by Autodesk
Rhino	3D computer graphics and computer-aided design application

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Appendix A

Questionnaire

Researchers-made questionnaire on exploitation of paper folding art and computer software to produce architectural models.

2017-2018

Name: ____________________________ (Optional)

ITEM	3	2	1	0	-1	-2	-3
What is your self-assessment of the level of your skills in handwork model making?							
What is your assessment of the provided facilities of model making features in Iraq?							
What is your assessment of your desire of model making?							
What is the computer programs impact of simplifying the model making?							
What is your assessment of architectural model making technology based on paper only?							
What is your self-assessment of the level of your skills in engineering programs?							
How many engineering program you work on?							
Was it a good experience for you to learn new ways of producing architectural models?							
What is your assessment for the benefit of modelling production by using engineering software in this experiment?							
Do you find that experience has increased your skills in the work of architectural modelling?							
How responsive your paper type is to the architectural modelling production?							
It was an enjoyable experience for you?							
Do you find this process shortens the time in modelling production?							
Do you find that the process contributes to cost pressures in modelling production?							

Direction: Please check (x) and rate the process by yourself honestly based on what you actually do give the statement using the following scales:

3: Excellent, 2: Very good, 1: Good, 0: Neutral, -1: Bad, -2: Very bad, -3: Worst