

Integration between Vernacular Design and Adapted Design Process to Accomplish 3D 1:1 Physical Product

Prof. Maha Emam Ahmed EL Halaby

Professor at faculty of Applied Arts, head of the department of Interior Design and Furniture, Helwan University.

mahaelhalaby@gmail.com

Assist. Prof. Dr. Dalia Mohamed Ezzat Selim

Associate Professor at faculty of Applied Arts, Helwan University.

Drdaliaezzat2016@gmail.com

Abstract

Understanding and gaining practical experience and how to improve the performance of the design process is one of the priorities to the design disciplines. The design process is a complex journey with social influence to explore and discover new approaches. (Cross, 2011). With the participation of second year undergraduate students of the Special Program of Furniture Design Science, the design process adapted by the professors was the core of the Islamic furniture design studio course and the integration of applying reformed vernacular design in a real piece of furniture. The implementation of the adapted design process was applied on all of the students; however, the analysis of the Muqaranas group was put under speculation for the case study in this paper. Students were asked for a real-world project that aided them to build an understanding and acquire knowledge to improve their own professional grounds and drive them out of their personal comfort zones to professional growth zones. They chose Islamic architectural elements as new ornamental elements that have similar effect within the limit of Islamic values, in order to present new ornamentation grid. Then applied the new grid in models of furniture as a real-world application to produce the new visualization as a contemporary Islamic ornamentation. This paper will present a case study at the Special Program of Furniture Design Science in the areas of concern which were supported by a collective approach to design projects that participants are able to inhabit. In addition, student groups' models that reflect the impact of the heritage on contemporary furniture design and establish the practical experience will be presented. The aim is to influence inexperienced students with limited professional resources to gain practical experience to come up with productive ideas for furniture design/production in spite of their limited boundaries.

Key Words:

Vernacular Design- Design Process- professional growth zones -Physical Product.

ملخص البحث

بعد فهم واكتساب الخبرة العملية وكيفية تحسين أداء عملية التصميم إحدى أولويات تخصصات التصميم. عملية التصميم هي رحلة مقدمة ذات تأثير اجتماعي لاستكشاف واكتشاف أساليب جديدة. بمشاركة طلاب المرحلة الجامعية الثانية من البرنامج الخاص لعلوم تصميم الأثاث، كلية الفنون التطبيقية جامعة حلوان، كانت عملية التصميم التي تبناها هيئة التدريس هي جوهر دورة استوديو تصميم الأثاث الإسلامي، كيفية دمج وتطبيق التصميم التراثي المحلي الذي تم ترجمة في قطعة أثاث حقيقة. تم تطبيق عملية التصميم المعده على جميع الطلاب طلب من الطلاب تنفيذ مشروع حقيقي ساعدهم على بناء فهم واكتساب

المعرفة لتحسين الأسس المهنية الخاصة بهم وإخراجهم من مناطق الضعف وقلة الخبره العمليه والمهنيه الخاصة بهم إلى مناطق النمو العملي والمهني. اختاروا العناصر المعمارية الإسلامية كعناصر تصميميه لها تأثير مماثل في حدود القيم الإسلامية ، من أجل تقديم شبكة تصميميه جديدة مخرجه من الشبكات الاسلامية. ثم طبقت الشبكة الجديدة في نماذج الأثاث كتطبيق حقيقي لإنتاج التصور الجديد للتصاميم الإسلامية المعاصرة. سيقدم هذا البحث تحليلاً دراسة حالة في البرنامج الخاص لعلوم تصميم الأثاث في المجالات ذات الاهتمام التي تم دعمها من خلال عملية تصميم معدله تم تبنيها من هيئة التدريس وأيضاً المشاريع تم تنفيذها عملي. ؛ ومع ذلك ، تم تحليلاً دراسه حاله لمجموعة محدده من الطلاب(مجموعة المقررنسات). بالإضافة إلى ذلك ، سيتم عرض أمثلة مجموعات الطلاب التي تعكس تأثير التراث على تصميم الأثاث المعاصر وتأسيس الخبرة العملية. الهدف هو التأثير على الطلاب ذو الخبره المحدوده و ايضا ذو الموارد المهنية المحدودة لاكتساب الخبرة العملية والخروج بأفكار منتجة لتصميم / إنتاج الأثاث على الرغم من خبرتهم المحدودة. التصميم الداخلي والأثاث بحاجة الى الخبره العمليه لتلبية متطلبات الاسواق اليوم مع التشجع على استراتيجية النمو العملي للطلاب.

الكلمات الرئيسية:-

التصميم التراثي المحلي- تأسيس النمو العملي- اكتساب الخبرة العملية للطلاب.

Introduction

Over the last span, the design process has experienced a grave amount of changes. The design process adapted here is the dynamic process which has led to how far the students have come from their comfort zone to practical growth zone. This adapted design process in the projects enabled students to reach the holistic phase; a physical 1:1 model.

Students looked at the solution in a broader view beyond the interior design and furniture discipline such as history, ornaments arts, service design, etc. Integration between Vernacular Design and Design Process to accomplish 3D 1:1 Physical Product is a dynamically growing associative research area through different approaches. Exploring patterns in multitude of learning environments and providing practical design solutions in Physical Production is a huge challenge for merging strong and flexible learning criteria.

Interior and furniture design structure is in need for upgrading in order to meet the requirements of today's field. Discipline strategy must encourage students to gain comprehensive skills and experience that empowers them to be qualified to potentially grow into product innovators and industry specialists. This paper is about the experiences adapted in Islamic furniture Design studio where the problem-solving process of analysis and examination utilizes multi-sided design-based techniques to cultivate ever growing products for real-world applications and solutions. These production solutions have been tested with the needs of the design opportunities, from the first proposals to the technical decision-making ones, from the understanding of student's involvement in the production activities and from the concept to the final settings.

Research Problem

Integration between vernacular approach and adapted design process as a methodology that strategically guides students in achieving innovative and dynamic design solutions and gaining practical experience to respond to contemporary design aspects is the core idea surrounding all research questions. The research poses to ask the following questions:

Islamic Ornamentation is one of the most characteristic to identify Islamic art and architecture, from this exact point the research problem initiated, which is what technique can we implement to achieve the integration between the vernacular approach and design process as a methodology to strategically guide students in achieving innovative and dynamic design solutions to respond to contemporary design aspects.

How to improve students' professional ground and take them out of their personal comfort zones to growth zones? which grants them experience; consequently, we ask how a student could gain comprehensive skills and experience that empower them to be qualified to potentially grow into product innovators and industry specialists through understanding the academic and industry standards in professional methodologies?

How the strategy of the design process methods which had been adapted improved the outcomes generated during the implementation phase to instill in-depth education and accomplish a real-world 3D scale 1:1 furniture product?

Research objective

The objective realized by the application is the examination of the design and adapted methodology to advance production.

The aim is to influence inexperienced students with limited professional resources to gain practical involvement experience and come up with productive ideas for furniture design/production in spite of their limited boundaries.

One of the objectives is to support students to gain comprehensive skills and experience that empower them to be qualified to potentially grow into product innovators and industry specialists.

Research Methodology

Research methodology to achieve the research goals and reach the results is a hybrid methodology:

Descriptive approach through definition and description of research concepts, accurate description deriving results is used. More importantly, this research includes an analytical descriptive study on the Islamic ornaments through place, time, and the different expressions of geometry. The methodology will operate on Muqarnas definition and the historical background behind it, and the employment of Muqarnas in historical buildings and properties of Muqarnas. This will explore the origins and traditional development of Muqarnas in the direction to evolve the potentials of historical Muqarnas compositions. Patterns and grids of historical and traditional Muqarnas compositions and the technological development will be discussed to provide data for practical geometry in this study. The collected data by site visiting and Doctors' lectures represents a network of comprehensive information, both theoretical and practical aspects of the Muqarnas presented to the students.

Secondly, a case study is a useful tool for investigating specific situations in many scientific disciplines. The research case study focuses on the integration between the vernacular elements and the design process to accomplish 3D one to one physical furniture products. A classroom of undergraduate students were asked to visit historical sites in Cairo in order to collect elements of art and architecture; more specifically Islamic models. The students were asked to extract original Islamic pattern grids, photograph, study, and analyze them geometrically. Then they should transform their designs under study to new grids while analyzing the original grid's core

and geometric idea, then generating new patterns which still maintain their Islamic integrity in a contemporary manner. Phase two of their project was to convert their extractions to furniture models, then go through the production process. All of the above was progressed by the design process adapted by the professors. One project in specific was placed under the study worked on by the group that chose the Muqarnas project. This group met the criteria required for vernacular furniture based on the information gathering. At the conclusion of the semester qualitative assessment for the final projects had been made by expert examiners. Based on the assessments, observations had been made about the students growing skills to deal with the complexities of design thinking and the development of their design performance and production.

They finally presented their products in a university exhibition and received assessment from their course professors and immediate feedback from other experts.

Literature review

The subsequent literature review discusses the development methods and techniques of the Muqarnas among vernacular buildings in Islamic art and architecture, and the importance of design process leading to the case study.

The importance of Design process to accomplish 3D physical product

In creative aspects, Professional Process Design Thinking is composed of both the use of different and merging thinking. As the key aspect of the project, creating as many opportunities as possible (different) and then narrowing down into a number of promising ideas (merging) (Kimbell, 2011). was evidently the research target. Innovation happens when numerous disciplines assemble together to build a common two-way nation to discover their different perspectives (SAP, 2012). Creative thinking involves the principle of flexibility that designates the given problem from different angles. The design thinking collaborative approach is one of the aims feeding creativity and innovation by framing a problem from different points of view. The designation “vernacular design” refers to local designs that have grown in the fullness of time in one context (Glassie, 2000). Also vernacular design consists of facts and information that are essential to optimizing the design analysis. Vernacular design solutions are developed and identified through countless experiments and have been tested. The improvement of new and contemporary pieces of furniture is a key foundation in the development of future furniture design (Zhai, & Previtali, 2010).

As a result requiring significant transformations in furniture design strategy which is what the paper proposed essentially depends on two major core ideas; problem-solving process and examination of multi-side performance techniques; to gain comprehensive skills and experience that empower students to be qualified and potentially grow into product innovators (problem-solving) and industry specialists (multi-side performance techniques). That's why student's involvement in the production activities was one of the main targets.

Muqarnas as the vernacular design

Complex geometrical Islamic formations have been matured with the corrections of Islamic scientists in mathematics, these corrections during ages give the perfect structures and magnificent artistic results and visual aspects. Over time, Muqarnas patterns have been developed and have secured the ornamental features. That's why it could be an extraordinary

foundation of inspiration for designers and can be used for problem-solving and multi-side techniques performance.

Definition

Muqarnas is a two/three-dimensional architectural formulation structure, organized in levels and accommodation of layers of small niches, repeatedly interposed with pendant elements (Esposito, J. L. (Ed.). 2004). Muqarnas is a sequence of small niche arches that give the form of a cave ceiling covered with stalactites; this is why the ceiling appears floating up above the room, weightless, floatable with a honeycomb appearance (Palmer, 2008). This complex honeycomb work or stalactite work is an innovative Islamic design element, connecting various groupings of three-dimensional shapes (Harris, 2006). The main motivation behind Muqarnas was to generate a wide span of domes over square buildings as domes are more established and could enclose a big area in comparison with straight roofs. Therefore, Muqarnas were exposed to be a smooth transition method between two shapes that are different in size, form or position. They usually fit into domes in more than one step to transform a rectangular part to a vaulted one. (Hamekasi, Samavati, & Nasri, 2011). They are to be regarded as a complex transitional method which is to be utilized on various surfaces. Moreover, they create the united structure as a whole in order to arrange a continuous and effortless transition between two levels, two sizes or two shapes.

Brief background of Muqarnas in Egypt

Sequence of formations and geographical backgrounds of Muqarnas are still unidentified (Garofalo 2010). In northeast of Iran and Africa the Muqarnas appeared, moreover the firstborn individual model appeared around the middle of the 10th century. At that time it was established from the 11th century all through the Islamic countries from India to Spain, giving to each country different materials and distinct culture (Necipoğlu, & Al-Asad, 1995).

Researchers state that the most primitive clue for Muqarnas in Egypt is the decorative elements of the cornice at the top of the minaret of Al-Guyushi which is dated back to 1087AC. It is a linear Muqarnas form that was used as a cornice in Egyptian architecture. The other primary samples of Muqarnas in Cairo have existed at the Aqmar mosque in about 1125AC. Muqarnas has been used as filling for a niche hood and corner sloping on the façade of the Aqmar mosque. Since the 12th century, Muqarnas has crossed the borders as formation elements all over the Muslim countries. (Bloom, 1988).

Employment of Muqarnas in historical buildings

Muqarnas had been used as a physical transition component to reinforce a part of a dome, or to establish a part of a building. Therefore, Muqarnas had been found on vaults, domes, niches on the entrance of the building, decorative element on cornices and beneath a balcony to connect two different surfaces (Garofalo, 2010), (Yakar, Yilmaz., Gulec, & Korumaz, 2009).

1- Muqarnas on Niche s(niches or semi vault)

They carved three-sided surfaces into the down curve components on the building with different angles (30° or 60°). This kind of Muqarnas has been utilized on the surface facing forward or facing backward and the most common of this style of Muqarnas belongs to North Africa (Yakar, Yilmaz, Gulec, & Korumaz, 2009).

2- Muqarnas on Domes

Muqarnas present a downwards-facing shape that could construct a line between the floor and any point on the Muqarnas of dome's surface (Akram, Ismail, & Franco, 2016). Using Muqarnas in domes is an integrated arrangement to cover widespread openings that are built on a squared shaped plan in multiple layers with the diverse scale of components. In a transition from a circle to a single point, before reaching dome shape, there are many other steps with different shapes. These steps are called layers of Muqarnas. The first and final shapes of each layer are called layer lines (Hamekasi, Samavati & Nasri, 2011). Then, the first layer that is called layer line has the highest power which is reduced in subsequent vertical layers and is covered by different scale degrees to reach unity in the complete pattern (Kiani, & Amiriparyan, 2016).

3- Muqarnas on Minarets

Muqarnas and minarets are integrated in a relation in the roof space of a building as a smooth transition method between two shapes that are different in size (Hoeven, & Veen, 2010). Also, it can be used on minarets to support a minaret's balcony (Necipoglu, & Al Asad, 1995). It is located between the cylinder and balcony on the minaret of the mosque, to create a transition zone (Bloom, 1988).

4- Muqarnas on Cornices

Islamic builders have derived Muqarnas as a system for formation not only sim-vaults but also other architectural components such as cornices (Carrillo, 2016). Also Muqarnas cornice have become part of the ceiling, it was utilized as a dividing form starting from the wall and given a transition between the horizontal and vertical planes of ceiling and wall (Kaprielian, 2005).

How Muqarnas is a vaulted arch that can be made of cells

Muqarnas is a vaulted arch, that can be made of cells which themselves consist of elements. Cells can be divided into a vaulted arch with two sides. These two sides with their roof which is the upper part of them are forming one cell (beyt). The word beyt is an Arabic word translated as the house (Figure 1). These cells also contain intermediate elements in the form of a triangle or two triangles as a curved surface between the roofs of two head-to-head cells. According to (Hoeven & Veen, 2011), there are three customs to connect two cells:-

- 1- Through one intermediate element.
- 2- Through Two intermediate elements.
- 3- Without the connection of an intermediate element. It is not necessary to fill the space between two elements with intermediate elements. (Figure 1).

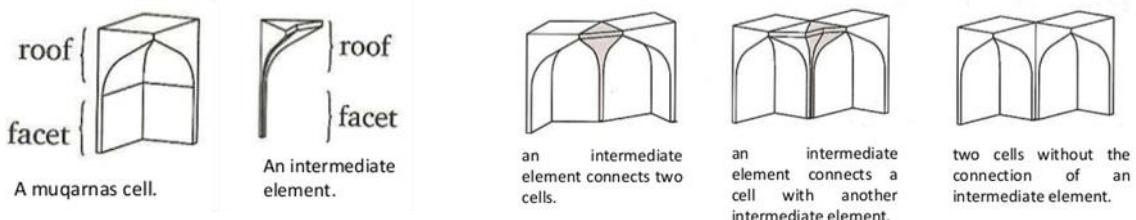


Figure 1. Muqarnas is a vaulted arch, made of a cells which themselves consist of elements. Cells divided into a vaulted arch with two sides. These two sides with their roof which is the upper part of them are forming one cell (beyt). <https://www.slideshare.net/sharmiarchitect/muqarnas-mathematics-in-islamic>

The intermediate elements of Muqarnas which have specific shapes are called (Thakht, Pabarik, Tass(Tassé), Shaparak, Shamssé) (Figure 2), shows the two-dimensional plane projection of a Muqarnas composition with the location of each intermediate elements.

According to the definitions that (Dadkhah, Safaeipour & Memarian, 2012) present about the intermediate elements of the Muqarnas:

1- Shāparak: is an important three-sided element of Muqarnas. The angles between the sides of Shaparak are flexible and fixed by the needs of composition.

2- Takht: appears with one of the forms of regular polygon (triangle, square, pentagon, etc.), multi sided stars. It is the only flat element used in Muqarnas composition.

3- Tāss (Tāssé): curved triangular pieces can be found in all layers but it is mostly seen in the last layer. Located between two Shāparak and connected two or more line of the lower layer to one point at the upper one and form the concaved part of Muqarnas composition.

4-Squinche: arrange for a complexity transition between subsequent layers and provide a transition zone for complex tracks, controls the number of flat elements.

5- Pabarik: is located around takht or shamsse. It is a rectangle in which two sides are equal and the long axis is its axial symmetry.

6-Shamsse: always located in the last layer of Muqarnas and has a multi sided star shape. The number of sides and axis in shamsse must be more than those in Takht (Dadkhah, Safaeipour & Memarian, 2012).

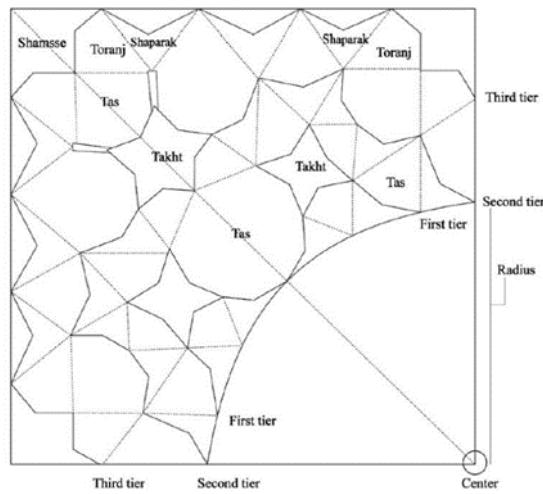


Figure 2. The intermediate elements of Muqarnas which have specific shapes are called (Thakht, Pabarik, Tass(Tassé), Shaparak, Shamssé)

<http://etd.lib.metu.edu.tr/upload/12621155/index.pdf>

Three-Dimensional Muqarnas Structure

Cells can only join other elements in the same layer at their curved sides. The intermediate elements also mostly join other elements at their curved sides on the same layer, but they can also meet other intermediate elements at the front parts (Figure 3). (Dadkhah, Safaeipour & Memarian, 2012).

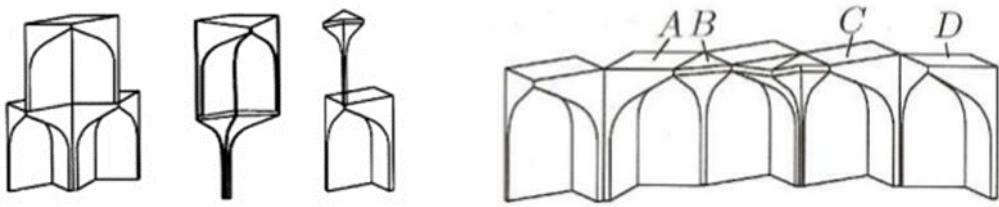


Figure 3. Cells can only join other elements in the same layer at their curved sides.
<https://www.sciencedirect.com/science/article/pii/S2095263517300584#s0065>

Design process had been adapted and case study

During the fall semester, with Helwan University, Special Program Furniture Design Science for students particularly, there were 46 students participating in the course of “Islamic furniture studio”. The whole studio class was divided into 8 groups of 5 to 6 students who have different art-architecture scopes to vernacular items and approaches.

In this diverse situation, design thinking process involves a common language to hold different types of perspectives together, go after integration opinions into wider ones, offer holistic solution and lead the projects to success. Using the design process methods, students asked to complete information gathering on a variety of topics related to the design problem: factors leading to problems. Upon conclusion of the information gathering, students brainstormed on concepts and design ideas and built their final solution to 3D scale a one to one furniture product. In addition, they had been studying the Islamic history of Egypt as it was required to be aware of the environment and social impact before starting the project.

The professors meet with the students and present an overview of the module learning outcomes and the structure of the project as well as assessment criteria. Students were given a real-world project that aided them to build an understanding and gain knowledge to improve their own professional ground and take them out of their personal comfort zones.

During 12 weeks the group projects presented a weekly update of their progress to the Doctors reviewing the draft design problem and preparing themselves for a meeting with the professors on the following weeks.

The strategy of the design process methods had been adapted to grow the outcomes generated during the implementation phase to translate and accomplish a 3D scale 1:1 furniture products were :-

- 1- Design problem
- 2- Design activity and dialogue
- 3- Formulation and visualization
- 4- Generation of solutions and creative leaping
- 5- Analysis
- 6- Production and 3D 1:1 model

1- Design problem

Cairo’s Islamic heritage serves as a vernacular design solution. The vernacular approach to design has included the combination of major factors, including: people, religion, traditions, art, patterns, and architecture.

Over the last span, the design process has experienced a grave amount of change to be a dynamic process, leading to the distances the students have crossed from hosting uncertain ideas to achieve innovation and contemporary design till the holistic phase of a physical 1:1 model. The

students' duty is to engage with several art and architecture heritage designs in an innovative way. Regulations and Specifications of the Islamic art and architecture were a mandatory guideline in the design of this course. Islamic geometry grid, patterns and ornaments have already emerged to achieve the goals. Student groups were being asked to design and construct a 3D scale one to one piece of furniture with a specific given and a set of tasks, hence students were introduced to existing contexts in Cairo Islamic heritage with the problem of :-

"A contemporary Islamic pattern based on Islamic grid abstraction led to piece of furniture" and "vernacular adding value from Islamic art and architecture". "A real-world project that constructed their final solution to 3D scale one to one furniture product."

The Doctors presented the design problem to the class with detailed description to get in-depth view of the course target. The group projects' question which the doctors have based on their first weeks into the problem area. And they worked on the design problem during the semester depending on academic and industry standard furniture design methodologies.

2- Design activity and dialogue

In the "Islamic furniture studio", the aim was understanding the design areas by mapping the existing vernacular systems of the ornaments and art-related interior and exterior. All members of the student group took notes during the lectures given to increase the reliability of the results. The first delivery was the "Islamic grid" in the form of drafting drawings during the first classes. All students were aided to use different types of painting or sketching materials to represent their chosen grid. We then started brainstorming classes as a creative thinking method in order to generate ideas. Working as a group and each member of the group individually made selections on the most promising ideas then made a decision on which possible solution could encourage as many ideas as possible. Students had a chance to develop their solutions by taking advantage of feedback and information given continually which revealed some new insights grid and patterns which might lead to extra brainstorming session. Accordingly, students of the course have continued to develop their own design projects in order to present their final outcomes.

3- Formulation and visualization

Starting from planning and organizing processes to visualize the design data visually into a three-dimensional form through the interconnection of a set of constructive proportions, ratios and directed by the agronomics standards.

Furniture visual criteria is regarded as a visual composition. The primary visual rules used are visual balance, arrangement, and a main point of weight. Visual composition is visual balance, to place the mean of the distribution of visual weight at the focus of the composition. That is why Furniture adjustment is three-dimensional, visual balance designates to the appearance of the adjustment from multiple viewpoints, in preparation for evaluating the distribution of visual weight (Lok, Feiner, & Ngal, 2004).

Aesthetics is the factor which differentiates furniture products, and is about the communication between aesthetics and information, to give positive influence regarding emotional and cognitive processes. Achieving aesthetic functions through the integration of the vernacular design and contemporary dimension are the required tasks.

4- Generate solutions and creative leaping leading to production

In general, design process is an integrative system through which problems and solutions change and create progress within the model in a nonlinear way (Demirkan, & Hasirci, 2009). Design for physical products connects the creativity and knowledge through the design process. The existing knowledge structures from which future creativity and design grow relate to particular products (McWilliam, 2009).

Product – studies that focus on the physical results of the creative process, often categorize products according to properties showing their creative value. Creative products definition (shows the properties of being novel, having value and/ or having richness of interpretations) (McWilliam, 2009). This is why creative thinking does not interpret to creative design except when new structure is formed and produced. Value is measured by transformation and concentration. Transformation refers to transforming the constraints of reality through blending design elements in a challenging way with inspiration sources or ideas to overcome constraints and produce new perspective. Concentration refers to products that repeat examinations and get attention in meaning requiring continued review. That's why the creative qualities of a product can only be evaluated after it has been produced (Howard, Culleya, & Dekonick, 2008).

5- Analysis leading to poduction

The product design process jumps with the analysis of information in unity with the requirements of contemporary design. Completing the scope of information in order to achieve aesthetic functions, creative forms and contemporary style which play very important roles in furniture design and production. That is why it had been applied to the system analysis method at the beginning of the generation of the ideas.

Analysis is a method for developing and analyzing a function structure and determining abstract features and components such as shape, dimensions and materials, the product is considered as a technical-physical system. The outcome of the system analysis is an in-depth understanding of the functions that the new product should have. In order to provide specific guidance about how to design and engineer a product, doctors established a set of specifications, which are spelled out in measurable details about what the product should have in order to be successful. At this stage a date will be set on which each group will present the design solution to the doctors at the end of the semester. The student groups completed a detailed project map in the form of CAD and 3Dmax drawing.

6- 3D model 1:1 phisical production

As the results which were generated during the implementation phase are best being translated by the 3D real live model. According to Dam and Siang (2017), 3D model is defined as a simple model of a proposed solution used to show ideas (Dam & Siang, 2017).

The furniture design module taught to the furniture design students can be analyzed in a number of steps which are presented above together with the timeline.

The group project teams present their design solutions to the Doctors through oral presentation and a project report. The project deliverables include items such as: a set of working drawings, computer-aided design (CAD) models and/or renderings in cardboard. Reflection and feedback for the students is built into the module analysis and Doctors are continually improving the module content.

This final phase has outlined the process used to accomplish and construct a 3D scale one to one piece of furniture real-life design products for undergraduate students in their second year product design stream. The Project assessment criteria depend on: Innovation, Technical Content, Teamwork, and Construction of the furniture products and Presentation of the project. As soon as the class project was accomplished, each team displayed and exposed their piece of furniture.

This was a significant part of the design process, which can include student self-assessment and physical testing where designers, students, and doctors can test the product themselves rather than watching it in a static mode (Oygur & McCoy, 2011). The students could see and feel their design concept, get direct response on an idea, and gain an appreciation for human scale (Konkel, 2014).

Results and discussions

Improving students' professional ground and taking them out of their personal comfort zones to growth zones grant them experiences and comprehensive skills that empower them to be qualified to potentially grow into product innovators and industry specialists through understanding the academic and industry standards in professional methodologies Figure 4.

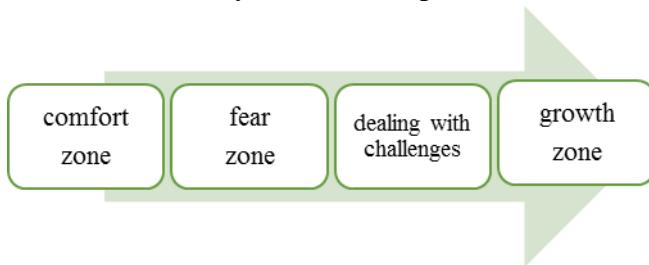


Figure 4. Improving students' professional ground and taking them out of their personal comfort zones to growth zones (by researchers)

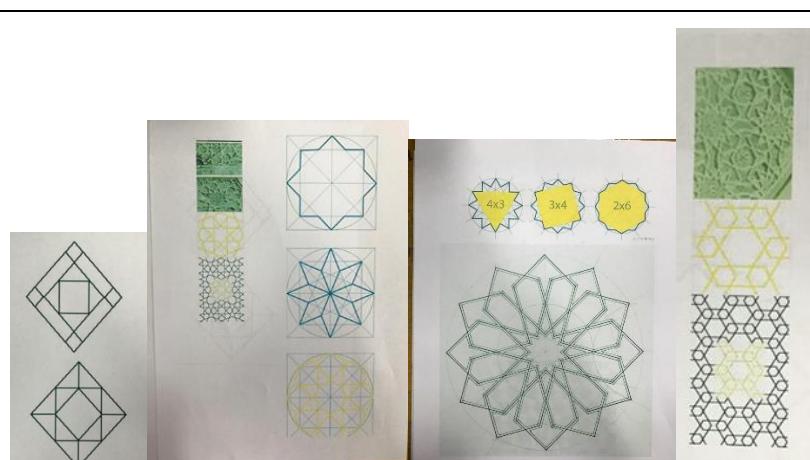
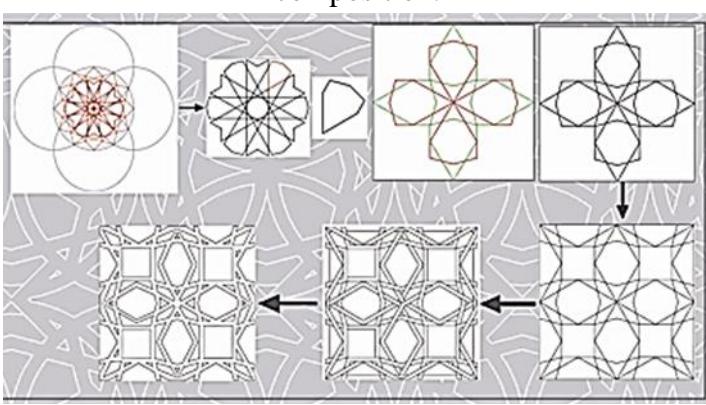
Students are estimated to complete each part of the design processes within the assumed time. One project in specific was monitored and worked on by the group that chose the Muqarnas project; this is due to the fact that Muqarnas are a vernacular item with sound mathematical proportions which enable it to become a source of redesigned evolving inspiration surviving through all the generations. Also this group met the criteria required for vernacular furniture based on the information gathering. The foundation of the design circled around the inspiration from Muqarnas, which this group handled, was critical in creating patterns that can go under production. At the conclusion of the semester qualitative assessment for the final projects which had been made by expert examiners. Based on the assessments, observations had been made about the students growing skills to deal with the complexities of design thinking and the dynamic development of their design performance and production.

The core of applying and accomplishing 3D 1:1 Physical Product method in design is an intangible approach where the functions of the products are used to prototype the realization of production difficulties. It resources to establish designer features like functionality, aesthetics, ergonomics, technology and development of a product.

As a result requiring significant transformations in furniture design strategy which the paper proposed essentially on two major core (problem-solving process /and examination of multi-side performance techniques), to gain comprehensive skills and experience that empowers

students to be qualified and potentially grow into product innovators (problem-solving) and industry specialists (multi-side performance techniques). That is why student's involvement in the production activities was one of the main targets.

Design process and case study examination

Design process for the case study	
1- Design problem	A contemporary Islamic pattern based on Islamic grid abstraction lead to pieces of furniture” and “vernacular adding value from Islamic art and architecture”. “A real-world project that constructed their final solution to 3D scale one to one furniture product.”
2- Design activity and dialogue Mapping the existing vernacular systems of the ornaments. The first delivery was the “Islamic grid” in the form of drafting drawings.	
3- Formulation and visualization Starting from planning and organizing processes to visualize the design data visually into a three-dimensional form through the interconnection of a set of constructive proportions, ratios and directed by the agronomics standards. Furniture visual criteria is regarded as a visual composition.	<p>Visual composition is a visual balance, to place the mean of the distribution of visual weight at the focus of the composition.</p> 

<p>٤- Generate solutions and creative leaping leading to production</p> <p>Transformation refers to transforming the constraints of reality through blending design elements in a challenging way</p>		
<p>٥- Analysis leading to production</p> <p>Analysis is a method for developing and analyzing a functional structure and determining abstract features and components such as shape, dimensions and materials. The product is considered as a technical-physical system.</p>	<p>The outcome of the system analysis is an in-depth understanding of the functions that the new product should have. In order to provide specific guidance about how to design and engineer a product.</p> <p>Processes of manufacturing our Mirror</p> <ol style="list-style-type: none"> Cutting phase: [pattern was cut by laser cutting machine] Sanding phase: <ul style="list-style-type: none"> The wood boards are sanded properly to smooth all sharp edges & the surface of the timber[wood]. Finishing this process should be done for getting the beautiful touch to the furniture. To give the wood the high end quality and look it has we add mogra Veneer on the compressed wood. This is used to provide good looking pieces of furniture at lower cost and they are cheaper than solid wood and still provide endurance and longevity. Each side in the blocks is being sanded well then a layer of sealer is placed to cover all the pores of the wood then number of painting layer was being added: shellac to give the mirror light glossiness. Splicing [wood pressing process] hot presses: <ul style="list-style-type: none"> The pressing machine compresses the veneer sheet with the soft wood board to be one solid board by exerting pressure & heat. The previous two processes were repeated more than once according to 	
<p>٦- 3D model 1:1 phisical production</p> <p>As results which were generated during the implementation phase which are best being translated by the 3D real live model.</p>		
<p>Student groups' examples</p>		

<p>Student groups' examples that reflect the impact of the heritage on contemporary furniture design and establish the practical experience.</p>		

Conclusion

Vernacular design and historical compositions consists of facts and information that are essential to optimizing the design analysis. Creating as many opportunities as possible (different) and then narrowing down into a number of promising ideas (merging) (Kimbell, 2011). This is the course topic that Doctors achieved the course goals through.

Students will graduate and become future leaders in tomorrow's furniture design field. Consequently, they need to upgrade to meet the requirements of today's field, therefore inexperienced students with limited professional resources need to gain practical experience and come up with productive ideas for furniture design/production to build an understanding and gain technical knowledge to improve their professional grounds and drive them out of their personal comfort zones to professional growth zones. This was achieved by adapting the

dynamic process of design. Understanding and gaining practical experience and improving the performance of the design process is one of the priorities of the design disciplines instilled in our curricula. This adapted design process in the projects enabled students to reach the holistic phase; a physical 1:1 model. Providing practical design solutions in Physical Production is a huge challenge for merging strong and flexible learning criteria.

Transformations in furniture design strategy essentially depend on two major core ideas; problem-solving process and examination of multi-side performance techniques; to gain comprehensive skills and experience that empower students to be qualified and potentially grow into product innovators (problem-solving) and industry specialists (multi-side performance techniques).

The design process adapted was considered as a strategy that encourages to achieve the course goals (grow into product innovators (problem-solving) and industry specialists (multi-side performance techniques)) and give them understanding of the academic and industry standards. Lectures represents a network of comprehensive information, both theoretical and practical aspects.

Acknowledgements

We would like to acknowledge the effort of our colleague; Islam Fawzy Mohamed Othman, the assistant lecturer who was involved with us in the production phase as without him the study would not have been possible.

We would like to extend our appreciation to the participation of second year undergraduate students of the Furniture Design Science program, Helwan University for their enthusiasm through 12 weeks of the course projects. Special thanks to the group Amal Ashraf, Mariam Khaled, Rana Ahmad, Roba Foad, Salma Mohamed, Shereen Ashraf, and Sinar Amr for being part of the case-study.

References

1. Cross, N. (2011). *Design Thinking: Understanding How Designers Think and Work*. Oxford: Berg Publishers.
2. Kimball, L. (2011). Rethinking Design Thinking: Part I. *Design and Culture*, 3(3), 285-306
3. SAP (2012). Introduction to Design Thinking. User Experience Community. [Online]. Available at <https://experience.sap.com/skillup/introduction-to-design-thinking/> [Accessed 13 June 2017].
4. Glassie, H., (2000) Vernacular Architecture, University Press: Indiana.,
5. Zhai, Z.J. & Previtali, J.M.(2000) Ancient vernacular architecture: Characteristics categorization and energy performance evaluation. *Energy and Buildings*, 42(3).
6. Esposito, J. L. (Ed.). (2004). *the oxford dictionary of Islam*. Oxford University Press.
7. Palmer, A L. (2008). *Historical Dictionaries of Literature and the Arts*. Plymouth, Scarecrow Press.
8. Harris, C. M. (2006). *Dictionary of Architecture and Construction*. McGraw-Hill.
9. Hamekasi, N., Samavati, F. F., & Nasri, A. (2011). Interactive modeling of Muqarnas. In Proceedings of the International Symposium on Computational Aesthetics in Graphics, Visualization, and Imaging. ACM.

10. Garofalo, V. (2010). A methodology for studying muqarnas: the extant examples in Palermo. *Muqarnas*, 27, 357-406.
11. Necipoğlu, G., & Al-Asad, M. (1995). The Topkapı Scroll: Geometry and Ornament in Islamic Architecture: Topkapı Palace Museum Library MS. Getty Center for the History of Art and the Humanities.
12. Bloom, J. M. (1988). The introduction of the muqarnas into Egypt. *Muqarnas*, 5, 21-28.
13. Yakar, M., Yilmaz, H. M., Gulec, S. A., & Korumaz, M. (2009). Advantage of digital close range photogrammetry in drawing of muqarnas in architecture. *Information Technology Journal*, 8, 202-207.
14. Akram, O. K., Ismail, S., & Franco, D. J. The Significant of Islamic Architecture Heritage at Baghdad City, Iraq—Case Studies of Shrine of Lady Zumurrud Khatun and Omar Al-Sahrawardi. *International Journal of Engineering Technology, Management and Applied Sciences*, 4, 133-138.
15. Kiani, Z., & Amiriparyan, P. (2016). The Structural and Spatial Analysing of Fractal Geometry in Organizing of Iranian Traditional Architecture. *Procedia-Social and Behavioral Sciences*, 216, 766-777.
16. Hoeven, S., & Veen, M. (2011). Muqarnas: Mathematics in Islamic Arts. Seminar Mathematics in Islamic Arts, Utrecht University, Faculty of Science, Department of Mathematics.
17. Carrillo, A. (2016). The Sasanian Tradition in 'Abbāsid Art. *Mirabilia*, (22), 0201-226.
18. Kaprielian, L. (2005). Cultural Re-Invention and the Accumulation of Diversity: The 'Christian' Muqarnas. *Contrapposto*, 179-221.
19. Dadkhah, N., Safaeipour, H., & Memarian, G. (2012). Traditional Complex Modularity in Islamic and Persian Architecture: Interpretations in Muqarnas and Patkâne Crafts, Focusing on their Prefabricated Essence. In Proceedings of 2012 ACSA FALL CONFERENCE—Offsite: Theory and Practice of Architectural Production.
20. LOK, S., FEINER, S., AND NGAI, G. 2004. Evaluation of visual balance for automated layout. In Proc. International Conference on Intelligent User Interfaces, ACM.
21. Demirkan, H. and Hasirci, D. (2009). Hidden dimensions of creativity elements in design process. *Creativity Research Journal*, 21, 2, 294-301.
22. McWilliam, E. Teaching for creativity: from sage to guide to meddler. *Asia Pacific Journal of Education*, 29 3 (2009), 281 - 293.
23. Howard, T.J., Culleya, S.J. and Dekonick, E. (2008), Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, 29, 2 160-180.
24. Dam, R., & Siang, T. (2017). Interaction Design Foundation: 5 Stages in the Design Thinking Process.
25. Oygur, I., & McCoy, J. M. (2011). User: Inspiration or constraint? *Journal of Interior Design*, 36(3), 1–13.
26. Konkel, M. T. (2014). Build-to-learn: An examination of pedagogical practices in interior design education. *Journal of Interior Design*, 39(2), 1–16.
27. <https://www.slideshare.net/sharmiarchitect/muqarnas-mathematics-in-islamic>
28. <http://etd.lib.metu.edu.tr/upload/12621155/index.pdf>
29. <https://www.sciencedirect.com/science/article/pii/S2095263517300584#s0065>