

# GEOMETRY AS A TOOL FOR VISUAL ORGANISATION AND PROPORTION IN DESIGNING AESTHETIC AND ATTRACTIVE PRODUCTS

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## ABSTRACT

The goal of this paper is to present the teaching experiences and methodologies used in a Product Design Engineering undergraduate course called *Design Project 3* (EAFIT University, Medellín - Colombia). Throughout the design process, there are some steps in which students have to make decisions for creating functional and also beautiful products. Geometric rules are applied during the drawing stages of the design process to define the visual configuration that gives order and structure to the product appearance, as well as the internal components of the mechanism, so students do not make random decisions and the configuration of functional and formal aspects of the product are correctly defined in a rational way. The size, position and space between parts are previously thought and strategically placed in the overall product shape, to obtain unity with a coherent aesthetic. Because of this, harmony, proportion, beauty and attractiveness are achieved. In this way, students feel more comfortable during the design process because the team can choose from among several proportions given to the same product. Dimensions, distances and proportions can be changed as many times as they want according to the different tools used, leading them towards a more beautiful product.

*Keywords: Geometry of design, proportion, beauty, visual organization, ordering elements*

## 1 INTRODUCTION

Throughout the design process, there are some steps in which students have to make decisions. And that is what design is all about: making good decisions to create not only functional, but also beautiful products. "The design philosophy that form follows function is no longer sufficient; the aesthetic aspect of a product has become a more and more important element for success" [1]. We live in a world full of shapes, shapes that we capture through our senses, through our perception. Products with simplified shapes are easier to understand and therefore they have a higher level of acceptance from users. The notion of aesthetics is highly complex [2] and aesthetic properties are related to the compositional characteristics of a design. "There are connections between the aesthetic properties of a design and the emotions evoked in response to it" [3]. "Aside from the fundamental function of practicality, product design must fulfil the aesthetic pleasure of visual appreciation since aesthetic pleasure is usually considered a vital factor for market success in terms of new product development" [4]. Order, balance and symmetry are used to make a design coherent and orderly and, therefore, pleasant to look at [5].

This paper provides an overview of some activities that take place during the *Design Project 3* course in a Product Design Engineering undergraduate program (EAFIT University, Medellín - Colombia) and presents the teaching experiences and methodologies used to address geometry as a tool for visual organization and proportion to design aesthetic and attractive products.

## 2 PROPORTION IS BEAUTY

In order to achieve aesthetic and attractive products, proportion has to be taken into account and geometry is the key for that. Proportion is a matter of numbers, because one cannot talk about proportion without mentioning or dealing with numbers and dimensions [6]. In his experiments, Gustav Fechner discovered people's preferences for the "golden rectangle" (1:1,618). The shapes with this ratio are more pleasant to the eye than shapes with other proportions [7].

The golden rectangle is shown in Figure 1.

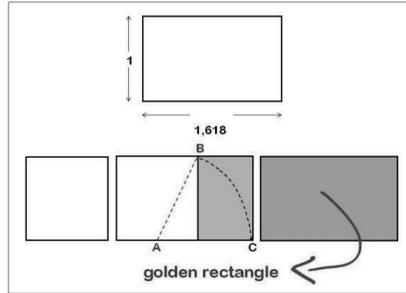


Figure 1. Golden rectangle

Here lies the importance of teaching students “how to see” and “how to make a good observation” of nature and man-made environments. It is very important that they understand the relations between the components of a product and the different options they might have for arranging their compositions. This is because every product is a composition. Students have to find and apply visual relations by ordering the elements they use for their designs. Rowena Reed Kostellow, a teacher at the Pratt Institute in New York, used to say: “Not enough time and attention are given to the designer’s first responsibility: to find and develop the visual solutions for living in our environment”. She also said that a designer should think of a visual problem in terms of organized relationships [8].

“The following seven aspects are commonly acknowledged as the principles of aesthetics: balance, emphasis, movement, pattern, proportion, harmony, and variety. Some are more objective and numerically measurable than others. For example, proportion and balance, which are inherently relative and involve ratios” [9]. Here is what the *Design Project 3* course stresses: applying geometry as a tool for achieving proportion.

### 3 ORDER AND STRUCTURE IN DESIGN

#### 3.1 Geometry as a tool

The ancient Greeks were masters of proportion and beauty through painting, sculpture and architecture, by using geometric rules. For example, the façade of the Greek Parthenon in Athens (see Figure 2) is in a golden rectangle proportion.

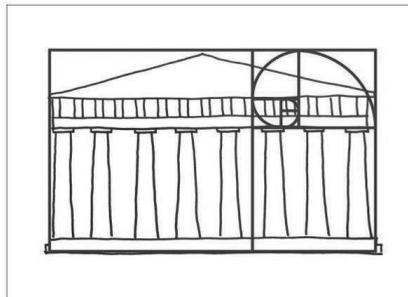


Figure 2. Parthenon in golden rectangle proportion

By understanding classic proportioning systems, it is possible to comprehend the interrelationships of form. Le Corbusier used to say: “Geometry is the language of man” [10]. When designing products, it is very important to understand the visual principles of geometric compositions and apply them.

¿Why is it so important to reveal those visual relationships? Designers, and in this case design students, need to make the design process conscious. Just by thinking, analyzing, changing and searching for different options, they can obtain proportioned compositions. As Kimberly Elam

explains in her book, *Geometry of Design*, “The purpose is to lend insight into the design process and give visual coherence to design through visual structure” [11].

Golden sections, Fibonacci sequences, dynamic rectangles, tessellations, halves and thirds are applied during the drawing stages of the design process to define the visual configuration that gives order and structure to the product’s appearance. “Dimensions should not have random values in size, but a structure is determined on advanced” [12]. Harmony, proportion, beauty and attractiveness are achieved when using these tools (see Figure 3).

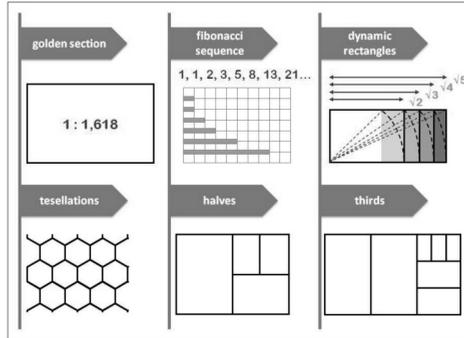


Figure 3. Geometric tools

In order to arrange components and seek a better, organized and more structured composition, students have to apply geometric tools. This is important because “every modification in the form of the artifact is another added value (positive or negative) in this communication, which may modify (expand, reduce or even alter) the ways for interaction” [13]. The objective of the exercise done during the *Design Project 3* course is to design a vending machine for delivering promotional products (such as watches, yo-yos, candies and perfumes). While designing it, students must take into account the aesthetics elements of a specific movie. Two examples are presented in Figures 4 and 5.



Figure 4. Vending machine for delivering watches for the movie “Captain America: The First Avenger”



Figure 5. Vending machine for delivering yo-yos for the movie “The Amazing Spider-Man”

By using lines and elements from geometry, students are able to define the new shape of the product. Aesthetic and attractive products are designed when their components are correctly placed and organized in a way that something governs the composition.

### 3.2 Visual control

Some products failed during the process simply because aesthetic parameters were not correctly defined at the beginning. “The design process is best described metaphorically as a system of spaces rather than a predefined series of orderly steps. Designers have played no earlier role in the substantive work of innovation, come along and put a beautiful wrapper around the idea” [14]. Visual control has to take place from the start by revealing the visual organization of the composition, so that the design “makes sense” and everything is coherent and cohesive. Each element in the overall design has to have a sense of belonging. Figure 6 shows the design stages in which visual control is necessary.

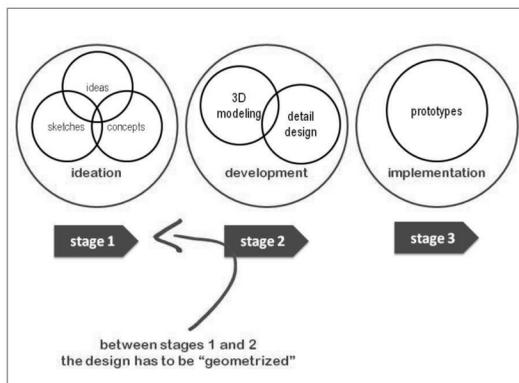


Figure 6. Design process

Once the students grasp this idea, they gain more confidence when the “product shape limits” can be clearly delineated. The design process flows, so they do not make random decisions and the product shape is correctly defined in a rational way. For that methodology, we have made use of geometry in various ways:

- It is an action that happens during product embodiment.
- Proportions can be changed as many times as required.
- The intention is to give order and structure to the design.
- Regulating lines reveal visual the relationships between components.
- There are diverse geometric tools for controlling the product shape.

### 3.3 Teaching experiences

At the *Design Project 3* course we arrange teams of four students to design a vending machine. The exercise lasts 12 weeks, out of which 6 are utilized to define engineering aspects. Students make use of morphological charts and functional synthesis to work on diverse concept designs. After choosing and defining the product architecture, a tridimensional and functional model of the mechanism is built to test the engineering components and its performance. Once the mechanism is approved, the external product shape has to be “adapted” to the internal architecture, in order to guarantee total coherence and respond to the course’s main goal: *to design from the inside out*.

Each student uses a different geometric tool for proportioning the silhouette of the product that the team has designed. The key of this activity is to do it as a “step by step” task as much as possible, so students really make rational decisions:

1. Define the size of the rectangle as a basic frame, in which they will subscribe the front view of the team’s design, by choosing one of the geometric tools.
2. Make the divisions at the inside of the rectangle, which have to be coherent and precise with the chosen tool. These are the regulating lines that create a grid.
3. Finally, place and draw not only the outline silhouette but also the internal components of the product (mechanism), allowing all the details to match the grid that was previously drawn.

Through a “qualitative voting” procedure, the team chooses the proportion - out of four different geometries - in which the aesthetic and attractiveness of the product is attained the most. They make a 1:1 scale drawing in tracing paper of the front view to visualize it in real size. The idea is to check dimensions and components, in order to verify their correspondence with the drawing of the mechanism (see Figures 7 and 8).

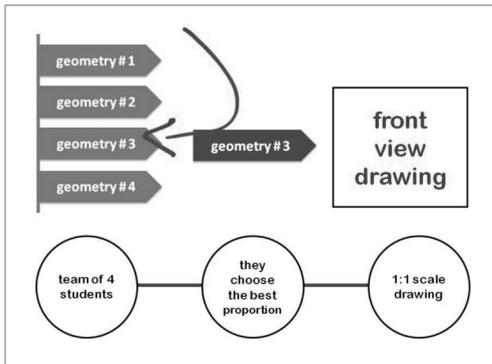


Figure 7. Design process



Figure 8. Classroom activities

Once the proportion is approved with the functional components of the mechanism, the team moves towards detail design, 3D modelling and CAD. At the end, they present a tridimensional and functional MDF model of the complete product: a vending machine that delivers a promotional product.

#### 4 RESULTS

When students use geometry as a tool for visual organization, the main idea is to check the internal components and simplify them in order to facilitate the product’s assembly and manufacture. It requires a balance between beauty and function, with the purpose of rationalizing the product shape to obtain an aesthetic and attractive product.

Geometry is required to achieve good proportions, so a correct composition may allow the designer to: define contours for the overall product design; adjust shapes and correctly place components and product details; distribute silhouettes and explore different product compositions; give formal coherence to the product when using similar geometries; and proportion the design correctly by giving the right dimensions to each component.

In this way, students feel more comfortable during the design process because the team can choose from among several proportions given to the same product, and when they do 3D modelling and CAD, it is both faster and easier, since they already have arguments for selecting dimensions, sizes, distances and so on. Proportions can be changed as many times as they want, according to the different tools used, thus yielding a more beautiful product. Everything that is placed on the product has a meaning. Le Corbusier [15] used to say: “The regulating line is a guarantee against wilfulness. It brings satisfaction to the understanding and it brings order to the task”.

At the end of the exercise, a discussion with 70 third-semester students produced the following positive comments:

- 75% said that the tool they used allowed them to undertake a more fluid design process and helped them develop the product’s shape configuration, instead of taking random decisions.
- 78% felt comfortable using the tool.
- 94% of students will use one of these tools on a future product design process.
- 55% of students find it difficult to integrate the internal components to the external silhouette.
- 62% think is necessary to do this kind of exercise before 3D modelling, because in this way they can have hints for most of the product components’ dimensions.
- 83% said that the product looks more beautiful after applying geometry.

These feedback results are shown in Figure 9.

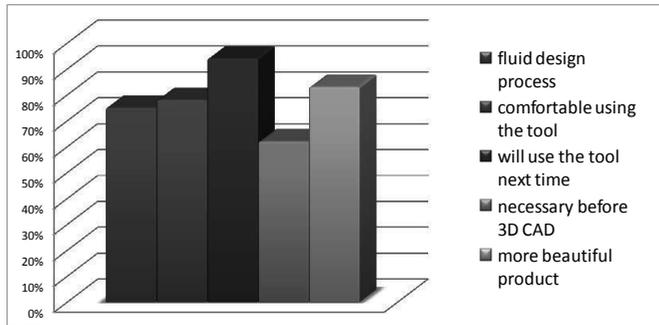


Figure 9. Student feedback

## 5 CONCLUSIONS

Students attending the *Design Project 3* course are trained during one semester. At the end, the knowledge they have gained can be summarized as follows:

- Students understand how geometry can help them control a product's shape through the use of some rules and by giving a sense of compositional cohesiveness.
- The use of different tools allows them to explore diverse compositions. Since there is not just one way of "geometrizing", they can work on several proportions for the same product.
- It is very important to comprehend that a product shape is never defined in a random way; instead, it has to be a conscious task undertaken during the design process.
- When designing products, the main challenge is to place components correctly; geometry is one way to give a rational explanation to many design decisions, both functional and aesthetic.
- Every design requires an effort to strengthen the order and structure of the product appearance, through the use of regulating lines, as well as harmony, proportion, beauty and attractiveness in its shape.

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