AN ANALYSIS OF CONTRIBUTIONS BETWEEN VIRTUAL AND PHYSICAL MOCKUPS INTO ARCHITECTURAL REPRESENTATION.

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ABSTRACT
The overall aim of this research is to advance an understanding of architectural representations, particularly in relation between physical and virtual mock-ups. Moreover, this research is going to describe and evaluate critically both architectural representations approaches, in a phenomenological methodology by using one case of study, finally this exploration will formulate some suggestions for future research.
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CHAPTER ONE: INTRODUCTION

Architecture, most of the time, may be struggling to find the best way to represent an idea, through years this concern has developed many manners to visualize a thought, during the renaissance, the implementation of mock-ups were developed as an alternative to improve architectural representation (Dunn, 2010), at that time this type of representation was conceived as a process of experimentation, that aided to understand, visualize, evaluate and criticize ideas and has become as a powerful design tool that allow translating an intention into three dimensions. This physical representation has developed as a design element that constitutes a part into a total entity in future projects, expressing its characters into scale (Pietroforte et al, 2012) and by materializing in miniature before coming to reality.

Technology advances have created the possibility to develop model scales using virtual tools, converting these new methods as a design innovation in production (Dunn, 2010), these advances have permitted to consider it as a complete graphic representation compared to the appearance of the perspective and the geometric code; in the Renaissance and the XVII century, respectively (Carazo, 2011). But, at the same time this technological phenomenon, introduces the necessity to compare both architectural representations and understand contributions by facing contributions, for instance, physical representation, as a conventional tool, is still developed by designers, and virtual representation implies as a modernize tool that is affecting architecture invention.

So, on one hand, there are some advantages of physical representation that allow it staying alive (Carazo, 2011), such as, its ability to express tacit knowledge (Pietroforte et al, 2012); expressed by its reliable characteristics when represents real parts of a system building in miniature (Scheer cited in Frascari et al, 2007), and the easily manner to transmit the shape of an idea. Also, on the other hand, there are some advantages that introduce virtual representation as an implementation of these times (Uria, 2011), that develops ideas into new methods that traditional tools could not achieve (Dunn, 2010), by its capacity to express explicit knowledge (Pietroforte et al, 2012) that let this representation to appear as a good way to share information to people involved in the project.

Nevertheless, at the same time, there are some authors that specify, that virtual representation is in its initial beginning and this new application tries to imitate reality by using a style that forgets reflecting objects in a truthful way, furthermore, drawings are produced without sense using an instinctive tool with generic properties, and as a result of that, designers forget the imaginative process of thinking and conceiving architecture (Frascari et al, 2007)

For instance, paper drawings have been one of the most common ways to exemplify an idea, currently this illustration can be produced by software technologies excluding handmade skills. Subsequently, the wish of virtual representation to become into physical representation, allows analysing its performance and introduces a debate to understand contributions between old techniques such as physical representation and new implementation methods such as virtual representation, this could be a motivational approach for design purposes. This process of representation has established a new relationship between both alternatives, so, a virtual tool may contribute for obtaining a physical representation, and this example, is going to guide this research by using one conceptual model developed in both representations.

The purpose of the architectural representations could be understood as a relation directly with human being, this might be expressed as man primeval experience and artifacts (Norberg-Schulz),
based on the perception of the author, and the thesis of language as reality (Bachelard & Jolas, 1994), the relation between architectural representations and human perception will be analysed, differentiating the representations before, during and after each development. Describing the processes of creation by using words as poetry that let the perception appear from the soul in state of the thought (Bachelard & Jolas, 1994), prepositions and adjectives might denote character (Norberg-Schulz, 1980), and this intricate representation phenomenon could be described.

Both representations will be described, first, the rules before creating the shapes, after, the process of construction, then, the final piece as a plaything and finally, the outcome as an object of contemplation. This research will try to establish the main parameters that influence the development of each representation, trying to describe the whole complexity of the relation during every stage.

The analysis of contributions of each representation will try to confirm the extremely important relationship established between them and the necessity to complement each other, the palpable elements of physical mock-ups and imaginative approaches of virtual models might benefit architectural objectives so the complex composition of each representation may allow increasing the capabilities to scope a better designing solution. This research will highlight the importance of both types of representations and encourage the inevitability relation between each other to develop a broad design approach. The aim of this work is to analyse the contributions between virtual and physical mock-ups to represent an architectural outcome.

The structure of the dissertation is the following, in chapter two, the paper is going to introduce a general description about three dimension graphical representation, then show the importance of materializing an idea into tangible objects and finally how technology has influenced current works by contrasting advantages and dis advantages of physical and virtual representations, after, chapter three is going to define the methodology adopted for this current research, then one case of study developed in both architectural representations will be described and evaluate the contributions, finally chapter four will formulate a summary of findings and resulting conclusions presented in this study and some suggestions for future research.
CHAPTER TWO: REVIEW OF LITERATURE

PAST APPROACHES

In architecture, the concern of a project and its translation, is to introduce a symbolic order (Scheer cited in Frascari et al, 2007), so a project might be considered first, as an idea that later, has to be expressed using a language that will allow communicating its intentions, and as a result, converting this idea into an understandable representation would be one of the aims during design process.

In the renaissance, template drawings were considered as crucial technological information for buildings that authors considered as a private knowledge to keep under safe (Scheer cited in Frascari, Hale, & Starkey, 2007) This reflects the difficulties to share, obtain and produce information that is why designers tried to hide productions from other colleagues and consider drawings as valuable treasures. Moreover, according to Pietroforte, Tombesi and Lebiedz, ‘design and construction began to be under- taken separately with the use of architectural drawings, the need for interfacing devices, such as construction models, became essential to verify the feasibility of innovative design intents and/or construction methods’ (2012), so these design parts started working independently, and new features such as construction models were used as an element to test and evaluate design intentions or building methodology. So, the isolation of building from planning, introduced another way for conceiving buildings by using a new instrument that would become as one of the most remarkable advances of the epoch comparing it to the perspective. For instance, one of the first mock-ups was probably the model of Brunelleschi’s dome of Santa Maria del Fiore in Florence, Italy, (Pietroforte et al, 2012).

BUILD AN IDEA

From the Renaissance, as Dunn establishes ‘the proliferation and status of the architectural scale model grew significantly. It not only complemented drawings, but also frequently became the primary method for the communication of design ideas in architecture’ (2010). In other words, the intensely increase of using physical representation changed the vision of architectural representation and this increment allowed considering this representation as a technique to announce ideas by complementing normal drawings So, the development of this powerful representation has influenced the manner to represent architecture and at very early stage its contributions were considered as a fundamental part of the final exemplification.

During design process, physical mock-ups allow proposals to be analysed because architectural components could be seen in three dimensions and this operation, permit these elements to be expressed in a more experimental way than any other media (Dunn, 2010), besides, this architectural representation could be one of the most accurate design tools that expresses the sense of design intentions, by facing three dimensional aspects, and it appears as a process of experimentation that confirms its value to explain physically any idea, as well as Porter & Neale expresses, ‘there has always been a fascination with the idea of physically miniaturizing both fictitious and planned architectural projects as a means of previewing their impact at full scale’ (2000), to put it more simply, physical representation has always captivated intentions and final proposals because of the possibility to visualize, in advance, impressions of real space
subsequently it may be an attractive design factor that in some way anticipates thoughts before becoming real, then this capability to materialize in a scale model may help designers to realize their proposals before converting into a big measure.

The importance of physical representation includes its presence in educational programmes, so during the design process for a student, physical representation has significant benefits because ideas can be decode and the initial concept of a project starts (Dunn, 2010), in addition, this starting point certifies its impact into architectural representation, because of the way it interprets ideas and introduces them in the first steps to fulfil a project, so, the translation of an architectural project may be initiated when is represented in three dimensions.

TECHNOLOGY ADVANCES

As Carazo suggests, ‘Simultaneously, a traditional mechanism such as the scale model has become, throughout history, an inescapable partner-competitor in the drawing in all areas of production and management of architecture, being as effective an instrument, as specifically disciplined, but not free of the old and well-known debates about the adequacy of the procedures of the architect’ (2011), at one time, mock-ups have been considered as a ‘partner-competitor’ to drawings in many areas such as architecture production and management, so, graphics and models, were rivals but at the same time associates, this relevant characteristic, permits introducing the start of the constantly contest for working together or stand out individually, both parts into architectural representation have been producing a phenomenon when sometimes could contribute between each other, and other times just staying separate from each other.

Then, from sixties of the XX century, with the invention of computer drawings, the necessity to distinguish physical than virtual representations appeared; according to Carazo, 2011, the words, scale model for physical representations, and model, for virtual representations, may be the suitable names that describes each representation, also this concern introduces this interrogation that, goals and purposes of virtual models and scale models would be analysed to establish their similar approaches and to find the answer for why physical 3-D models are still used in these digital times (Carazo, 2011). Physical models have survived from a Darwinian survival perspective, by constantly behaviour changing between the meaning and the outcome, but forever into a drawing system that might be considered the entire organization (Carazo, 2011), so physical models in a natural analogy, have survived because its durable qualities into a representational structure that envelops their performance, moreover, they have been a portion of a whole representation that through years has become significant information.

Although the appearance of virtual representation as a popular method, physical scale models are still used by many designers so differentiate contributions of both types of representation might clarify this confrontation. There are some reasons why physical models are still being used and also another details about virtual models have increased, nevertheless, considering both as visualization spatial representations; each one has exceptional and powerful expressions. On one hand, physical models have survived despite the constant increase of technological advances, by providing palpable knowledge, on the other hand, virtual representation has increased in the last few years, based on
interchanging knowledge between users and has established as a tool of this era. Below, both representations show some positive and negative aspects of their performance.

**ADVANTAGES OF PHYSICAL REPRESENTATION**

As determined by Porter & Neale, ‘While the decoding of architectural drawing, especially orthographic drawings, requires a certain amount of knowledge and experience, the physical scale model is a tool that, albeit diminutive, can instantly convey the form and the feel of a building’ (2000). So, in order to understand architectural drawings, is needed some experience and knowledge so physical models appeared as a faster implement, which can transmit, the shape and the ‘feel’ of a project. Additionally, architectural drawings may require skills that the reader can learn through time but in contrast, physical models can give the reader a quicker grasp that even people who do not know anything about architectural drawings may understand, so definitely this approach allow considering this representation as an easy way to describe a project.

Design needs an alternative element, such as physical models, which are considered as tacit knowledge essential through building. Thus mock-ups collect the information that virtual models do not provide (Pietroforte et al, 2012). In addition, mock-ups are a type of tangible evidence which might be, next to the construction development, at the same level of importance, also there is some information that virtual models cannot express, so physical representation might be a complementary part for achieving an entire presentation.

In some instances, most of physical mock-ups express innovation by developing functions and operations that allow them to describe and generate material representation that will be in future building parts (Scheer cited in Frascari et al, 2007). Even most elemental physical representation may be closely related to originality, furthermore prototypes allow articulating future ideas by imitating material performance so, in that way, the selection of material may be a practical issue to visualize a future project. As result, this type of representation might be strongly recognized as an effective tool to understand upcoming reality.

During the period of proposing architecture in the educational structure, the achievement may be trying to be disconnected from reality and technological advances have formed this disruption, nevertheless at this stage when virtual representation is increasing, building consequences of design intentions would be measured by students using physical skills (Pietroforte et al, 2012), so, the expansion of virtual representation may be a design worried that presents the possibility to physical representation, to become a contrasting element for examining design choices.

**ADVANTAGES OF VIRTUAL REPRESENTATION**

As Carazo cited, ‘Leopoldo Uria has considered the significance of the emergence of computer graphics as "the biggest revolution in the field of representation from the Renaissance invention of perspective" or from the geometric coding of the XVIII century’ (2011). So, the importance of the appearance of computer drawings in the representation area may be compared with the arrival of the most important creations in the Renaissance and the XVII century. Thus, drawings generated by computer may be measured as the implementation of this time, as a remarkable feature used in the development of architecture which could become a significant part in history. Moreover, computational model making definitely offers new types of methods compared to
traditional tools, and in this manner architectural knowledge has increased, improving design innovation and production (Dunn, 2010). Under these circumstances, virtual models compared to conventional design graphical representations may seem a new method that contributes features that modify the achievement of architectural drawings.

Moreover the presentation of new alternatives are influencing the way of generate architectural information, as reported by Dunn, ‘computational model making offers a different set of techniques and tools for the designer compared to traditional methods, thereby increasing the development of design innovation and the production of architectural knowledge’ (2010), so, these technological advances may aid conceiving and representing ideas in new ways that design would have never expect, in other words the same idea developed using conventional techniques would be a hard task that virtual tools might be solve. According to Pietroforte, Tombesi and Lebiedz, 2012, another important contribution could be the capacity to transmit information, explicit knowledge may be captured by drawings, calculations and models that is why modelling is an important representation which allows interchanging data to participants into projects. Therefore, the information used during the process of a project conception may be shared to people involved in the execution, in this way, project members might take control over development and management in a successful manner, also it may constitute, first, as a back-up element that reinforce the final outcome by giving the opportunity to see past decisions, and second, as a easily way to share evidence between contributors that allow articulate a general view of project components. As a result, future changes into design project could be managed better by using this aptitude to socialize information between participants.

**DISADVANTAGES OF VIRTUAL REPRESENTATION**

Traditional architectural representations have been copied by using superficial style that represent an un-mindful approach; the real objective would be, first, generate images so close to reality that they do not need to emulate the phenomenological approach of perception and, second, describe the building in a way that even comparing to real constructions would be difficult distinguish (Frascari et al, 2007). Actual virtual drawings production may try to use artificial elements that are changing their real objective, in that case the appearance may not be exactly as shown and the representation might suffer significant changes, when instead, it may be a truthful illustration of reality.

Nowadays architectural representations replicate reality accurately and skilfully, by describing superficial features using an automatic way; nevertheless, this type of representation is opposite to the creative approach of architectural thinking (Frascari et al, 2007). Although architectural representations might seem to be a complex process, automatically production is forgetting about factors such as creativity, imagination or uniqueness. By using this type of architectural representation, drawings might be what they are not, thus in some way, the mechanical process may be taking off some important values of the way of conceiving architecture.

As, Frascari, Hale & Starkey, cited, ‘for millennia the design tools used by architects were a pencil, a straight edge, a triangle and a scale. 2-D CAD merely uses a computer to mimic these traditional tools. BIM is a genuinely new tool that is still in its infancy’ (2007). In other words, for many years, traditional tools were the architecture design implements but now, they are imitated by software.
appliances, and these new tool are considered in its initial process. Subsequently, this recent appearance of technological tools such as 2D-CAD may be the starting point of an unknown development so that modelling representation may need more time to show its power because it has not been used for so long, and it could be considered as a new issue in architecture. So, virtual representation might be in the early stages in which architects and designers are still learning to use it, and in some way, it may forget to conceive the intrinsically imaginative process for proposing architecture; furthermore it may create elements extremely different from reality. As Frascari, Hale, & Starkey, 2007, mentioned, virtual architectural drawings amplify elements of the composition by producing artificial parts rather than show real aspects.

Models and drawings digitally produced, have improved in aspects for instance, time and accuracy, nevertheless this product might be generated without meaning because they are been made from a ‘thinking within architecture’, so imagination has been isolated and rational promotion has been emerged basing on ‘thinking about architecture’, forgetting to involve real participants such as architects, contractors and clients. (Scheer cited in Frascari, Hale, & Starkey, 2007). So, technology may be improved some architectural production features but designers might think, that, by using this new software is implicit the way of thinking architecture, in that way, all type of drawings might be followed the same direction to a known destiny, becoming the professional architecture practice in a repetitive assignment, at the same time, this new implementation, may forget including project members and becoming an individual approach that not absorb perception of people involved into design project.

Moreover, during drawing process, architects work using a digital machine conformed by many average properties and this material is used to produce drawings and also to goal a not real professional competence. (Scheer cited in Frascari, Hale, & Starkey, 2007). In that case, digital implementations, such as data libraries may facilitate drawings production, nevertheless, these tools could be described as common features that affects many representations that reflecting in that way, a typical development and restrict conceiving original expressions. So drawings are being produced with prevalent characteristics, and this process is giving the sensation of a competent and capable effort that is not inherent.
CHAPTER THREE: PHENOMENOLOGY AND ARCHITECTURAL REPRESENTATIONS

METHODOLOGY

The character of a place articulates in Norberg-Schulz, will be considered in the present research as a starting point to abstract differences between architectural representations. According to the author, an important issue is that ‘architectural history shows that man primeval experience of everything as a ‘Thou’, also determined by its relationship to buildings and artifacts’ (1980, pag 50). This represents that human being has been constantly influenced by these elements so this research may consider this point of view to analyse the connexion with mock-ups such as artifacts.

Documents on the intense life of language could find in Poetry, collaborating with the thesis of language as reality (Bachelard & Jolas, 1994), what is more, poetry may give an authentic interpretation, so the power of language may create the atmosphere of present times and it could be considered as a feature that transmit existent characters through words. According to Bachelard & Jolas, 1994, by using poetry, phenomenology could be related to the soul in state of the thought, so the combination of words might define a perception and this definition related to the spirit of the writer.

Especially, space is denoted by prepositions such as under, behind, on in etc. and the character is denoted by adjectives (Norberg-Schulz, 1980). So the character of space represented by architectural representations could be explored by phrases composed by adjectives and prepositions. Furthermore, in the structure of places there are two steps peculiarity, firstly, between natural and man-made phenomena or landscape and settlement, and secondly, between earth-sky or outside-inside. (Norberg-Schulz, 1980). In that case the relevant relation between human being and surrounding introduces the opportunity to compare the character of space with natural phenomenon.

CASE OF STUDY

The paper is going to discuss about the differences between a conceptual mock-up made in two representations. In one hand is a virtual model developed in Revit Architecture and on the other hand is a physical model created with a 3d printer, the aim of the research is to identify the character of both representations using a phenomenological approach.

Both architectural representations will be analysed, before, during and after the process of creation. First, the paper is going to discuss about the rules before creating the shapes, second, the elements during the processes of construction, third, mock-ups as playthings, and fourth, the results as an objects of contemplation.
DESCRIBING ARCHITECTURAL REPRESENTATIONS

RULES BEFORE CREATING THE SHAPE

VIRTUAL MOCK-UP. In this case of study, the first phase was the creation of the shape using a software for modelling, this step may be conceived as the born of the form when it appears for first time furthermore this process of creation is developed by the collaboration between designer and software, designer may use the software as a tool to convert ideas into graphics.

Designers may need to assume some characteristics before the construction of the virtual mock-up so the project development could follow some rules that guide and restrict at the same time. This assumption of directions might allow experimenting into another atmosphere where an application guides the process for generating a shape, so as a consequence, understanding application behaviour, may permit to get a better result.

Before creating the shape, a translation of real movements into virtual representation started by using a pointing device, in that way, device movements are converted into screen actions. This phenomenon allowed staying inside the software atmosphere, so the device was the connection between reality and the virtual field. Once inside, the software exposed its alternatives and the device allowed navigating through them.

PHYSICAL MOCK-UP. The physical mock-up is created by a 3d printer and responsible printer staff guided this process. So, the model changed parameters such as the dimension and file extension, then material is selected and after this, price and time is calculated.

First, model size is scaled into mock-up real dimension and it is cut in five pieces because the printer could just create parts of one specific size, and second, the extension file is changed to a compatible printer parameter.

Then, a significant discussion about the materials alternatives introduced the interrogation of how the final outcome would look like, for this case the printer used PLA Filament and there were two colours available, white and black.

Finally, time and price to print are calculated based in the quantity of material and time of using the printer.

On one hand, before creating the virtual mock-up, designer and software may create a process of translation from reality to virtuality, this process of conversion from tangible information such as device movements into visible actions seen in a screen may be the starting point of interchanging information between software and designer. According to Norberg-Schulz this may be the information translated from outside to inside, and, on the other hand, before creating the physical mock-up the features adopted such as, change extension file, scale in real dimension, cut the model in pieces, and select material, were modified as a recommendation of the workshop staff so the guidelines were transmitted by printer responsible using a communicative way and these changes were directed and supervised by the staff, thus, all these requirements are mandatory elements that the physical mock-up need to fulfil before printing. Hence virtual mock-up may adapt its features to come to real world and let the imaginary field.

In both cases, before creating the mock-up is a necessity to adapt initial ideas to rules for developing the model, so all the information in the mock-ups may increase in order to be created. Also, firstly the virtual mock-up was conceived and then after, the physical mock-up, so the conversion of the first
idea into graphic was the initiative step of the process and could be conceived as a translation from untouchable into visual representation.

To sum up before creating the shape, the virtual representation translated tangible information such as real movements into virtual knowledge that may be perceived as a not complex achievement because the interaction between designer and software is a relation established by previous training, so the working assumption in the virtual environment could be an early developed skill that was learnt before using the software, and in the other case, the physical representation demanded following some specific rules that guided the process of construction and they are compulsory issues to use the 3d printer. Nevertheless both cases may be categorized as a result of the designer interaction, in one case, designer situated into a virtual environment trying to transform ideas into visible representation conforming a relation from reality to virtuality and in the other case the designer stayed into real world interacting with people and following established rules.

PROCESS OF CONSTRUCTION

VIRTUAL MOCK-UP. Virtual atmosphere allow generating different types of shapes by using some tools for instance extrusion, blend, revolve, sweep, swept blend, in this example the shape was created by using the revolve tool as a generic model. As, figure 1 shows the shape is created as a whole entity nevertheless as figure 3 illustrates, it cut into five pieces as a recommendation of printer staff, so the model was created twice, first it was created as a total and second divided in parts.

During the modelling the parts, First, the mock-up is divided in parts, with real parameters such as dimension and thickness, then each part is saved in separate files. As a result, this process of adaptability of new features took around one hour of modelling.

The shape is created using the architecture ribbon model in place as a generic model, lines are drawn with the dimension of the physical mock-up so the thickness of the material is an offset of 2 millimetres, as figure 2 shows, pink line is the boundary of the generic model and the blue line is the axis of the shape, this is the first part modelled, then the rest of the five parts are created using the same process. As figure 3 shows, the five parts of the virtual mock-up are developed separately and each part is saved in one different file.
Figure 1. Virtual mock-up

Figure 2. Modelling the virtual mock-up
PHYSICAL MOCK-UP. First, the parts are produced by the 3d printer, then, these parts are assembled using a specific glue and finally each part is hold until it is glued.

After 24 hours of printing, as figure 4 shows, the five parts are completed and the model started to be assembled, this construction part by part allow the designer to feel how the shape is connected and how these elements can be fragment of a complete entity. As figure 5 reflects, five parts of the model are joined together with a special glue for this material, even in this assembly step, the interaction with people was needed, the process to join the parts required that the elements stay together and still, so one person had to hold the parts and then another person brushed the glue between them. Subsequently, this process required a communicative skill between the person that hold the parts of the model and the other that brushed the glue, also manipulate the parts was a hand skill ability that permit operating the components during the construction of the object.

Even though the parts are produced by a machine, the assembly was a complex procedure of communication between the responsible group of the machine and the designer, communication and also imaginative skills were necessary to acquire the best result for the model.
On one hand, in the specific case of the process of construction of the virtual mock-up, the software presented some alternatives for expressing the idea but was a designer decision to select one tool and discard another. So designer may need to know about software capabilities and manifest modelling skills, in some way during the process of construction, the virtual model was led by final purpose of creating a physical model, so the size, thickness and number of pieces were requirements to produce the physical mock-up, moreover the adaptability to adopt requirements may evidence the ability to change characteristics by consenting substantial variations that convert this representation as a versatile tool. On the other hand, the process of construction of the physical mock-up takes time, as an artifact made by hand, accuracy was needed to be assembled, so this methodology could give the category of unique piece, and categorize as an unrepeatable essence that express individuality
furthermore this procedure involves a complexity understanding of the combination of every portion contributing to a whole composition. Also there were some valuables aspects about this representation such as the presence of social skills inspiring group work ability, hand skills and communicative aspects that enrich the experience and contributing to the character of the object.

To summarize, virtual representation may be a dynamic way for shifting aspects and operating the shape by recreating features for instance size, dimension, length, thickness furthermore this capability to modify easily, presents this representation as an active way to adjust parameters, on the other hand, as a particular piece made by hand, physical representation might express a particular exemplification that combines values that magnify the final product into a complex unity conformed by many human skill factors.

PLAYING WITH THE OUTCOME
After the process of construction both representations allow the possibility to interact with the final outcome, this experimentation is going to be analysed from two points of view, firstly, when it is considered as a plaything and secondly, when it is showed as an object for contemplation.

VIRTUAL MOCK-UP. There are many ways to modify the model but in this part of the paper is going to describe the move and navigate commands. Both commands are in the modify tab, firstly, for moving option, is necessary to follow some steps, first the model is selected, then the option tool is designated and after the new position of the model is chosen, this sequence of steps allow fulfilling the movement, so consequently this could be seen as an aim of stage by stage.

Secondly, there is the navigation tool, which permits interacting with the object without touch it, so the model is suspended in the virtual field where any force pulling it to the ground, this visualization tool allows generating views from different angles by moving yourself around the model, the shape could be seen from different perspectives and points of view.

PHYSICAL MOCK-UP. At the first stage during the process of creation, the birth of the idea was conceived as a translation of an untouchable impression into a visible representation, this may be the time when thoughts are being manifested but in some way, this translation may not be enough to believe that the idea becomes into that form so the physical mock-up appears as a confirmation of the translated thoughts into solid material. One of the most important capabilities of the physical representation may be the opportunity to manipulate the object, the experimentation provides concrete information that is instantly absorbed by human senses, this sensitive experience confirm the model as a reliable item. The object aptitude as a plaything allows interacting directly with the form, moving and rotating actions permits making a general understanding and in some way the object could express characteristics by itself.

Both representations may be considered as dynamic ways that allow playing and as a result this experimentation may give a sensorial background, for instance, firstly, virtual representation may be a visual experience related to an imaginative skill that allow understand an activity from eyes to brain, this process may transmit visual characters, and secondly, physical representation may be a tactician
experience allow experimenting a relation between hands to brain, this experimentation might be a palpable evidence.

To conclude, in the specific example of moving or rotating the physical model, the essential knowledge to fulfil the actions transmit liberty to play with the outcome and enjoying the freedom to manipulate the object just by using fundamental skills comparing with the virtual representation where as a guide to be pursued the model in order to be displaced and rotated may follow some steps that may be learnt before.

CONTEMPLATION
In this part both representations will be described as objects of contemplation, virtual representation as a final image in the screen, and physical representation as a final piece of artwork.

VIRTUAL MOCK-UP. The virtual mock-up is exported to a different software to render and obtain a final image consequently some parameters are modified to simulate the physical mock-up material. First a camera and a sunlight system are created, second the material is selected and finally the render setup parameters are specified.

As taking a picture inside the software, a camera is created, so distance and angle are configured, then a sunlight system is introduced to illuminate the object, that is designed with a day and an hour specifically, finally the material is selected and applied to the model, under these circumstances, the visualization of the virtual representation into a final image could be as an exposition of the model in a picture that reveals the mock-up, watching from one perspective. Moreover, as figure 6, illustrates, this final photographic exposition may reflect model characteristics in a virtual portrait.

Figure 6. Virtual mock-up final image.
**PHYSICAL MOCK-UP.** The model is exposed outdoor in a corridor between two buildings inside a green area next to a foot path. The mock-up is put next to plants, and as a flower into earth, stands up next to vegetation. This physical representation that was created by machines and assembled by humans is being part of this complex green nature environment, for many people it was unnoticed its presence but for the designer it was a remarkable issue that was inserted by force into this new location. In the figure 7, the exposition of the representation may give a different perception of the mock-up in natural atmosphere, this different location guides the experiment to feel the visualization as a unlike phenomenon where the outcome is interacting with natural aspects.

![Figure 7. Physical mock-up outdoor contemplation.](image)

Both cases are static representations of the idea although the physical environment may allow believing that the outcome is into its final step, conceiving this moment of contemplation as the end of the process nor the same with the virtual, when the contemplation could be perceived as a starting point of a new development. Moreover, the natural environment in the physical experimentation, may create an unpredictable atmosphere that the virtual mock-up may not provide, and also, a relevant aspect was that many people did not recognize the physical representation so it could be part of nature and in some way just the designer could notice the imposition of this new item in this part of landscape.

The contemplation of the virtual representation could be perceived as a summary of the orbiting tool that is reduced to just one perspective model in a screen, conceiving this final image as a conclusion of the different views created during the process of formation the image. Also this representation may be trying to simulate the phenomenon of the physical representation, when the recreation of a sun and a camera, shows the exceptionally relationship with reality.
CHAPTER FOUR: FINAL CONCLUSIONS

SUMMARY OF FINDINGS AND RESULTING CONCLUSIONS

One significant field of these architectural representations may be the economic aspect, during the process of construction the elements that intervene in the physical representation such as printer and material costs may be vital factors that permit the representation appear on the other case, the virtual participants presented were designer and software so in the economic field, comparing the costs of construction of the representations, the physical representation may imply an invest of money that virtual might not ask for so this comparison introduces the virtual representation as the best alternative to use when economically aspects effect the representation outcome.

Another significant aspect to analyse is the time spending in every representation, for instance during the process of construction, both representations required time to be developed, on one hand, virtual representation was created in few hours, on the other hand, physical representation took more hours to get the parts and then to assemble the model so definitely virtual representation may be a rapid tool to produce illustrations (Scheer cited in Frascari, Hale, & Starkey, 2007), nevertheless physical representation could be seen as an increasing valuable feature, such as a piece of artwork where the author dedicates many hours to create the final outcome so even if the virtual representation takes less time, physical representation may be measured in an artistic approach, where the object may grow up its characteristics per second of construction. So, virtual representation could be seen as an efficient and productive alternative for saving time although it lacks of personality and ability to express character, nor the same with the physical representation that could be understood as a waste of time to materialize an idea nevertheless its construction may allow find some uncountable efforts such as hand and social skills that may fulfil a truthfulness achievement.

The interaction developed between models and human being creates a sensorial perception especially during the process of playing with the outcome, physical movement might relate more sensitive fields as a real experience collected by tactician and visual senses whereas in the other case, virtual experience may not imply much senses and, as actual combats have simplified by pressing buttons (Willis, 1999), the model movements have simplified into fingers pulsing some keys. So, in the sensorial experience, physical representation could be one alternative that involves most quantity of senses.

Another vital aspect is the manner of transmitting information, on one hand, physical representation expresses character as itself and allowing people to recognise its content by using essential skills, so its remarkable ability to socialize evidence, on the other hand, virtual representation permitted changing parameters, for instance, during the rules before creating the shape, some requirements changed to printer specifications, so the aptitude to modify information, let the virtual model to adapt its current features and rearrange its structure as adaptable elements that can be presented in different ways without losing its significance. So in the field of transferring information, the physical representation appears as a positive solution and, in the field of managing information, the virtual representation virtuous ability to transform its portions, becoming as an answer to manage information.
Obviously the most reliable representation close to reality is the physical representation, because it may close a cycle of design when the shape of a thought can be felt, completing the experience by providing reliable and tangible evidence. Moreover, tacit and explicit knowledge (Pietroforte et al, 2012), announce, on one hand, tacit knowledge from physical representation represented by its touchable capacity, confirms its ability to consistent evidence as real experience that the virtual can not express but in this specific example, physical representation would not appear without the virtual.

During the interaction between designer and software in all stages, previous contact was a necessity; software may not give alternatives, just average properties, (Scheer cited in Frascari, Hale, & Starkey, 2007) so the selection was based on previous experimentation by a process of discovering consequently in some way the software is not helping to illustrate a thought, it is just a tool of these days that helps elaborating easier and faster an idea, for instance, during the process of creating the shape, knowing about software behaviour may be a compulsory aspect for designers, recognise virtual tools may be a mandatory ability before interacting with the software otherwise this interaction could become a hard task to learn that could take some time. Nevertheless, the virtual atmosphere allow easily the creation of unrealizable forms compared to the physical representation, there are some requests that could appear as restrictions and limit the growing development of ideas, guiding the initiative to an expected field avoiding the richness procedure of conceiving designs without borders and as Frascari et al, 2007, is becoming an automatic method that avoids architectural thinking influenced by a common pattern, so projects may not depend just in the use of this tool, moreover as Dunn, 2010, its appearance such as perspective, during renaissance, could be a tool that may be not in control yet, and as, Scheer cited in Frascari et al, 2007 and Carazo, 2011, it could be seen in childhood and even for people involve in this common habit of virtual interaction, there are many features for learning, so implementing new techniques could be a constant apprehensive process by practicing.

As Norberg-Schulz categorization, both representations may be distinguished, first, physical mock-ups such as an example of man-made artifacts and virtual mock-up as a landscape; physical representations may be describe as an outside outcome coming from the virtual tool and the virtual representations could be conceived as an inside phenomenon, just in a screen. Individualities of both representations might create a combination such as, earth-sky, where each function is a complement for the other one. In this case, understanding the earth as something palpable where people may consider as where they stand, physical mock-ups express concrete information and on the other side virtual mock-ups contains visual character. Subsequently this comparison, creates the relation between both representations are extremely influenced by each other and they may not separate their performance, so individual contributions increase the capacity of expressing an idea and its r affinity may be crucial to fulfil a totality design goal. Tangible characteristics appear by building and manipulating a physical mock-up, permitting the contact to the real world, furthermore intersection between media and techniques, such as digital and physical improve the discipline even further (Dunn, 2010). So real elements of a physical mock-up and imaginative approaches of virtual models might benefit architecture objectives, in that case both elements may add characteristics to define a complex composition.

Overall, there are some measurable aspects of the representations where they may fit better, such as, economic, time, sensorial experience, managing and transfer information, close to reality, hence,
the differences found all over the work confirm that, each representation possesses own distinctive features and its contributions complement parts that the other one lacks, and constitutes a portion in a whole complex entity (Pietroforte et al, 2012) into architectural representations, nevertheless the capacity to separate each representation and select specific characteristics to fulfil one specific field will depend in the intentions and purposes of the design or designer.

SELF REFLECTION
During the stages of the virtual representation, the processes of construction, modelling, rendering and even when it was contemplated in order to explain the general process, the paper is trying to abstract by steps the procedure of each part, so in some way the explanation of using these software appliances is conceived as a daily interaction difficult to be described.

FUTURE RESEARCH
This experimentation developed first in the virtual atmosphere could guide the investigation to some expected part nevertheless it could be a different perspective starts an architectural representation from a physical representation and then modifying by using virtual tools, the expectation could be a different approach that may be analysed in future approaches by next researchers interested in the cycling design process of ideas coming from virtuality to reality and viceversa.

According to Porter & Neale, 2000, architectural drawings may require skills that the reader can learn through time but in contrast, physical models can give a quicker grasp. In that way even people who do not know anything about architectural drawings may understand a physical model. This could be a very interesting perspective to implement to people who are not involve into architectural representations, when in that case the interaction with the model and the consequently impression may be relevant. Thus, collecting data from non-experienced users may be of assistance to clarify the characteristics of each representation.


