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# Integrating Virtual Reality Interface into architectural education

## *Virtual Urban Environment Design and Real-Time Simulated Behaviors*

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*This paper proposes an educational approach for learning architecture based on prototype digital reality experiences tailored for students' needs. We use a combination of tools and methods from different disciplines, such as architecturology and game design. The hypothesis is tested on architecture students from the course 'Architectural Design 9: Urban Design' at the National Technical University of Athens, fall semester, 2018-2019. We propose using the demo-application 'Behavior Interactive Interface' (BII) for Unity 3D with preset behaviors of virtual actors, as a demo-tool in order to for evaluate the effectiveness of urban design proposals in serving self-improvement of the architectural designing skills of students. The integration of such a method facilitates cognitive interactions through real-time immersive visualization during the process of learning. We expect to provide students all the necessary new assets of reality's experimentation for their future professional life in a compact theoretical and practical educational package.*

**Keywords:** *interface, interactive, behavior, scale, virtual reality*

### INTRODUCTION

Immersive and virtual reality environments present nowadays an augmenting interest for researchers, designers, psychologists, programmers, neuroscientists, artists and architects as a result of the established visual production and communication of ideas in modern culture. This essay targets architecture's students and the way they perceive the concept of scale and its transformations in virtual immersive and multiuser environments. To be able to provide

methodologies to students, we apply to the epistemological field of phenomenology in architecture, perception and game design. The merge of these disciplines can provide dynamic 3D representations of architectural models in real-time multiuser dynamic systems. The context of this article constitutes the basis of an ongoing PhD research carried out in collaboration between the School of Architecture of Paris La Villette (ENSAPLV) and the Architecture Department of the National Technical Uni-

versity of Athens (NTUA). In the context for this doctoral research we present a pilot-framework of educational workflow in architecture. As a starting point we launch a questionnaire and has been answered by 97 students and young professionals of architecture, with medium age 26 years old. 79.2% replied the affirmatively to the question: "Sometimes during the design, I encountered difficulties in conceiving the space on different architectural scales (1:2000, 1:500, etc.) and make the transition between them». This result [Table 1] indicates that more than half of the architecture students are in need of new methodological approaches concerning teaching architectural work and representation.

### **Scientific Anchoring**

A thorough research and communication with other disciplines as game design, neuroscience and art, is necessary to be done from the architects in education, so as to place the implication of interaction with different scales during the architectural conception. Our didactic proposal expects to elicit the emerging cultural cognitions, biases and perspective illusions and let the student be expressed during the architectural conception at the same time that our proposal provides students a tailor-made tool of analysis for conception's assistance that allows a rigorous and relativist regard at the architectural proposal. The resultant of the two, perceptual illusion and psychological illusion evokes an illusion of reality in the mind, although subjectively varying for each person in strength and experiences. (Panofsky) In a sense, perspective transforms psychophysiological space into mathematical space. It negates the differences between front and back, between right and left, between bodies and intervening space ("empty" space), so that the sum of all the parts of space and all its contents are absorbed into a single "quantum continuum." (Panofsky). We opt to use techniques to facilitate the communication of architects' ideas. L'échelle n'existe pas...il existe des échelles, (Boudon)

### **Toward Interaction**

There is still a huge demand by the students of architecture to integrate in the studies of the university and develop educational methods about approaching architectural interactive design that include the experimentation of creating an ephemeral interactive immersive experience in real-time. (table) We are going to evaluate our experiment by a "mise en scene" of importing simulated behaviors in the virtual environment.

### **Phenomenological object of Architecture**

The object of architecture as 3D model of architecture (physical or digital) is different than the field of tools that architects use traditionally to teach and learn architecture (drawings and maquettes). Philip Boudon and his team differentiated in the past the object of speech and the field of speech (Lecourtois, 2011). In our case the object of that speech is defined as the static 3D object virtual environment able to receive the presence of the user/s as different from the physical in terms of scale, perception and understanding. Understanding the designing transition from one scale to another is made with difficulty by students and professionals in architecture, especially in terms of understanding the sizes of territories and parts of the city. The theoretical model proposed as Applied Architecturology constitutes a solid ground that allows observation and evaluation of the object of architecture independently of the different styles of architecture (Lecourtois, 2011). The scale of global coexists in permanence with the scale of local, in different levels of perception. Although cognitively this is possible, the representation of a map in 1:1 scale is considered impossible (...). Applying the concept of scale is needed for the cognitive process of a "reduction of" or "augment to" the perception of space.

### **Phenomenological object of Perception**

Urban territories as parts of the city are constantly exposed, represented and transformed by international digital media, video games; thus, these urban territories are often interpreted by means of communication.

Table 1  
Multistable image.  
Figure 1  
Circular diagram

Social networks accompanied with the daily use of the mobile phone and perpetual connection on the Internet, creates the sense of direct access to information. This asset of “accessibility” is an asset that increases city’s performance. The cognitive interaction between the user and the application, similarly the interaction between observer and environment leads to cognitive maps (Lynch).

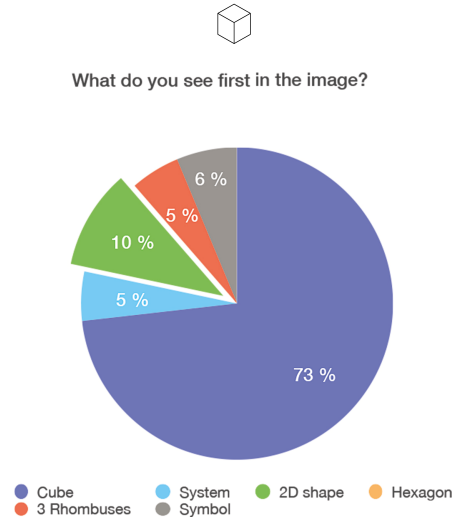
The immediate access to city maps has influenced the perception of urban cartography, giving the notion of distance a new virtual “materiality”. The virtual interactive environment is built to explore a virtual identity, behavior or flow in a cognitive map.

“Architecture is considered as a cognitive activity of thought of future space” (Lecourtois, 2011) and with the digital revolution of the last decade, the perception of future space is changing according to added cultural phenomena and forming reality asets for further exploration.

### **Phenomenology and Game Design**

Lived space than logical space - teletopyGame design and the industry of video games (Sim City, GTA, Minecraft) augment the sense of presence in virtual environments. Games propose realities and world building and give dimensions to them. There is no single one virtual reality (Steur,1993) as there is no “one” reality. “Architecture is considered as space of thought rather than the space itself” (Lecourtois, 2011); computer games can be considered places of action (interaction) rather than places themselves. The field of game design permits interactions into the 3d virtual environment and thus allows the emergence of new aspects of educational approaches for architects, since [...] in experimental forms of urban planning it is hard to oversee all the actual situations that may occur in advance”. (Tan, 2017) - (Mark Schmeink, Real World play the City Game examples)The large-scale methodological approach of traditional teaching has little integrated methods and notions that include interactive digital design. Does a “gamification” of architectural conception reveal content about cognitive operations? How do

young architects conceive and build reality?Several displays and tools can assist during the architectural education, a know-how accessible to the students permits the user to observe and evaluate their models.



### **Hypothesis**

By applying the concept of scale, we use visual interactive representations, to evaluate by means of immersion, the efficiency of urban design proposals and to verify the implementation of complexes’ buildings into the urban tissue. Transforming the virtual environment into a rapidly visitable and habitable place, would be a way to augment learning capacity and self-evaluation for students aposteriori of the activity of conception.The methodology of integration is based on principles from game design field and architectural education.

### **METHODOLOGY**

The traditional educational method of conception of the architectural work involves the creation of small 2-4 student groups working in collaboration.

In the form of atelier, students exercise architectural design, while teachers, in an open space, discuss about the urban design of the proposed theme, in our case to implement complexes of housing buildings into the Athens city's tissue. As an educational method remains an open process, since students of the group can even participate during the correction of other groups. Dialogue and participation are the key foundation of the teaching method, as it includes presence and interactivity of both teachers and students. The experiment was conducted for this research during the teaching work for the course Architectural Design 9: Urban Design under the subject "Social Housing" at NTUA, with the help of the students during 9th fall semester in architecture, 2018-2019. The hypothesis is tested, throughout the prototyping of an experimental application for Android devices, in particular tablets. We launch a demo-application to be able visualize in immersive mode the dimensions of the city, to give measures to values and do observations in a dynamic virtual environment.

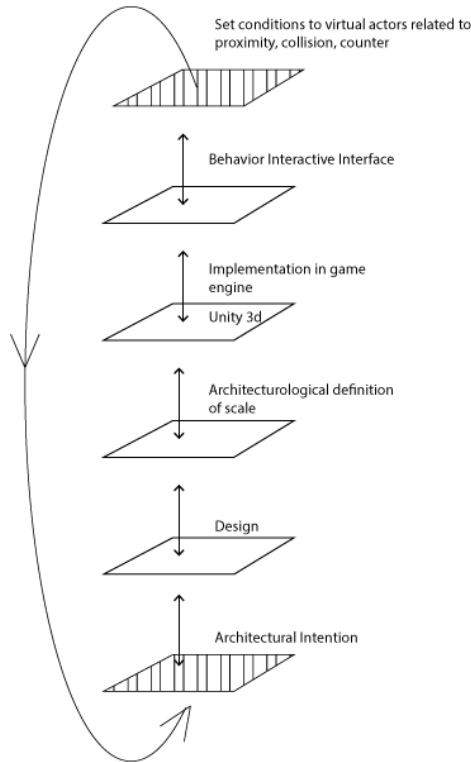


Figure 2  
Educational  
integration.  
Layering Logic for  
learning process.

### **Case study in architecture**

The exercise of the semester consists in the creation of 150-200 houses, for 600-700 persons by designing and integrating new neighborhoods within the urban fabric. In an area of 14,000 square meters, in Philadelphia, Attica, the student groups analyze the urban fabric and propose an intervention strategy based on land use, heights of surrounding buildings, roads' wideness and the natural and artificial landmarks. The study starts with scales of 1:2000 and 1:1000 with either drawings or physical models. The theme of social housing is a complex architectural issue. It transits through many different architectural scales. The scales in which the exercise is analyzed concerned the investigation at the urban

Figure 4  
Case of study,  
Student's proposal  
model.

level (1:2000 and 1:1000), the volumetric integration of the building in the urban fabric in 1:500, the architectural and landscape design in 1:200 and the scale of the residence to 1:100, overall the exercise runs through design reading and understanding to 4-5 scales or more (spectrum of scales from 1:2000 - 1:100). The theme given by the professors, simulated in the virtual environment can be easily explorable, a 1.4-hectare land (or 14.000 m<sup>2</sup>), surface big enough to be considered as a surface of "playing the city" and create interactions. It is here that Applied Architecturologic Scales for example geometric scale, scale of the model, scale of visibility, optical scale, scale of the city can refer to the "mise en scene" of cognitive activity operations that we implement into an interactive game engine. The theme "social housing" impose the interrogation and application of several scales. Every scale has its level of abstraction as well its level of detailing. Moreover, it is collaborative work, the goal is to reconstruct the tissue of the city by the implementation of houses, respecting several cultural and functional rules. It can be described as a cognitive activity of high-level complexity. The three factors of collaboration, participation and immersion during the conception leads to an 3d object implementation in Unity 3d. These three factors are significant during playing and learning cognitive procedures. As trivia anecdotal information, I refer to the three students that participated to our demo, during the exercise of conceiving urban space, when admitted that they were playing Monopoly during conceiving their proposal. The first implementation contains all the cognitive operations to be evaluated.



Figure 5  
Merged Scales  
detailing  
representation.  
Buildings and  
ground detailing.

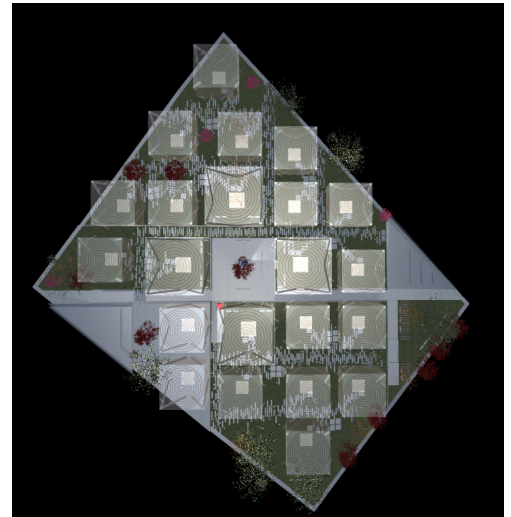


Figure 3  
Case study. Site of  
implementation.

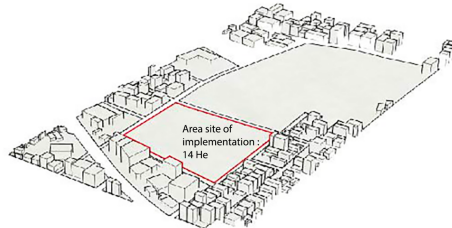


Table 2  
Applied  
Architecture  
for the students'  
proposal.

Architecturological Scale	Pertinence	Dimension	Reference
Geometric scale	Persistent of the cubic geometric layout	Maintain a cubic form measure, Resistance at deformation	Cube, Rigidity

**Framework description**

The framework of the experiment is to build an educational digital example based on 3d environment of the students and to implement to it a meaningful interaction. For this process, we use the software Unity 3D as game engine for the development of our demo. The scientific team of Paris 8 University developed the open source plug-in Behavior Interactive Interface (BII) for virtual actors. The Behavior Interactive Interface (BII) build by Unity 3D, is an open source software that is developed inside the framework of the European Project Virtual Artistic Laboratory: @postasis with Paris 8 University, (2018-2020). For our demo we use the beta version of this interface. This interface is made with a procedural logic approach of designing and setting models in action. The ideation of this plug-in was made by two architects and one artist inside the framework of the European project @postasis and the development of the beta version by architect Calin Segal.

**Characteristics of the Interface**

The user can change different views, Top, Axonometric, First Person Controller and Observer. Then, the user of the interface BII can set direction (random, forward, on map) to the actors (3d objects), as well as functions (spawn, destroy, follow, increase, etc.) by controlling conditions of proximity, collision and counter time.

**Define scale for experiment**

Favorable scale for urban implementation 1:500 concerning the level of abstraction. This is the level of abstraction for the buildings' implementation for the exercise. Though the level of abstraction about the

ground floor (landscape) is 1:200. At the 1:500 scale stage, students evaluate their measure and integrate 150-200 residences and public uses in the study plot. Guided by the movement of pedestrian-car, private, public and intermediate space, the students place their buildings in the study plot. Emphasis is placed on the accesses of the movements, the difference between the axis and the canvas, the scale of the road and the relationship between the road width and the building, the natural lighting of the apartments, the good orientation, the possibility of volatility of the construction, also the materials that the students choose to propose and use. Determine an objective scale of presence. Here the scale takes temporal notion, that needs dimensions of presence to exist. Time and distance perception changes into the application of virtual environment.

**Preparation of implementation interface.** The three-dimensional model of the background is given by the teaching team in Sketch Up File and Rhino and set the virtual environment. Unity 3D software, plug-in BII **Implement low polygon environment \* Define the total volume of the space as a Navigation Mesh** Define your lightening conditions

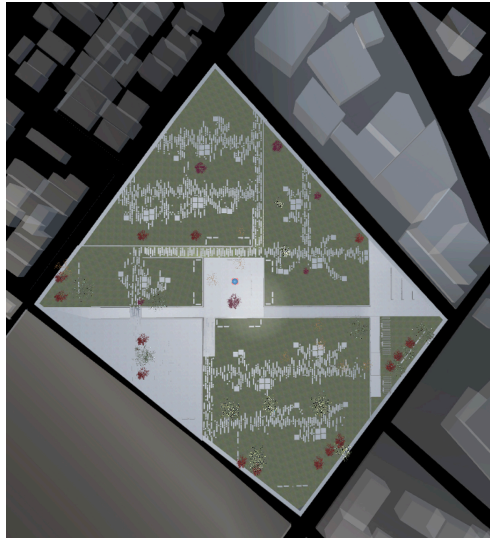
Test: merge scales as cognitive operation for understanding dimensions, and their correspondence to real dimensions.

**Define Navigation Mesh**

The second part of integrated methodology refers to the definition of the terrain for "gameplay", in informal language the Navigation Mesh, as a rigid surface where actors can navigate and interact. Our surface to explore must be one single mesh, as one 3d object. We will use the "bake" button into BII to make

the demos surface our navigation mesh. In our case, this mesh refers to the 14 he real territory of Attica concerning the architectural exercise of implementation. Tools of delocalization can help this set up background environment for the demo. The navigation mesh provides presence measurement techniques as perception of reality is given to students through mediated by both automatic and control processes. (Pilai). The Navigation Mesh represents the terrain of interaction and it is a part of the 3d virtual environment where virtual actors can interact. It is where we take measures of virtual presence, interaction and time passed inside.

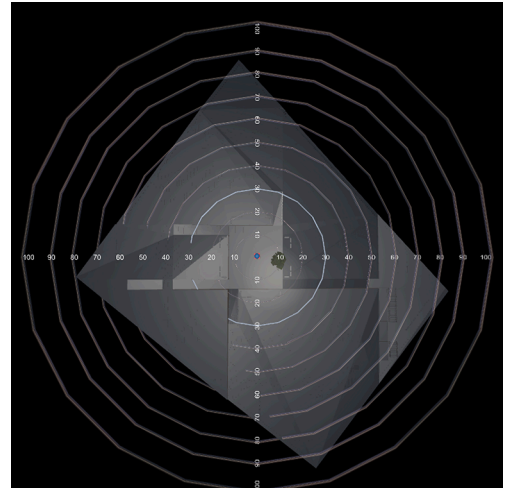
Figure 8  
 Define Navigation tool  
 of reference.



### Set Metrics

Questions arise regarding perception of time and distance into the virtual environment. Set a point of reference so as to measure distance in the virtual environment. We are working in an abstract way to representations that correspond the scale 1:500, thought the experience provide a first-person navigation as well, an axonometric and a top view. True reality exists independently of perception (Pilai).

**Set Conditions to virtual actors.** The Navigation Mesh is the terrain for setting specific conditions to virtual objects (relations and interactions between objects). These variable conditions can be controlled based on proximity, collision, and counter. (distance, limit, time) of 3d objects. The user defines a constant movement to actors (directional, random, on path, targeted object, avoid, collide, etc.) (common conditions) Finally, by creating actions (functions) by setting movement and conditions. Define interactions and relations by proposed actions. Functions: Spawn, Increase Scale, Follow, Destroy, increase speed, Decrease speed, etc.)



### Demo and virtual environment proposed

Pertinence: persistent of the cubic geometrical layout , rigidity, resistance at deformation Dimension Maintain a cubic-metric mesure

### Observations and feedback

Reference Economise space, create centrality First Person Perspective Compressed perspective Exploration in 1:10 scale Manipulation Graphic design

The 3d model or the virtual environment ensures the transformation of perspective. From a first



point of view, the creation of an application that concerns a specific view by giving size to this territory.

**Demo and Spawn actors' function.** This demo proposed can be seen as a architecturologic model, not a model in design neither a model for designing. It is posed as a knowledge model on activity of design (Lecourtois, 2011), as tool for evaluation. This demo creates a reality of place to instant visualization with the notion of "inhabiting the unbuilt and the far". The simulation of vivid representations of reality; as actors, is facilitating the apprehension on a cognitive level. The function (or concept) of applying scale is scientific and it is related to the perception of scale we have for the reality and the world as known terrain. "All of these concepts help to describe the operating mechanisms of architectural conception in general, that is to say detached from reality.", (Lecourtois, 2011) Spawn Function, Counter Time passed 12, distance 10 We experiment with an interface so as to introduce dynamic objects in the static architectural virtual environments of the students and make observations about the movement and the "mise en scene" of the building. Interaction with dynamic objects that can simulate actors into the virtual environment as it permits the researchers and students to observe actual situations that may occur at the urban planning. This process of combination to pass from the virtualized to the virtual space, can be a highly immersive cognitive process as the student of architecture is becoming part creation of a reality.

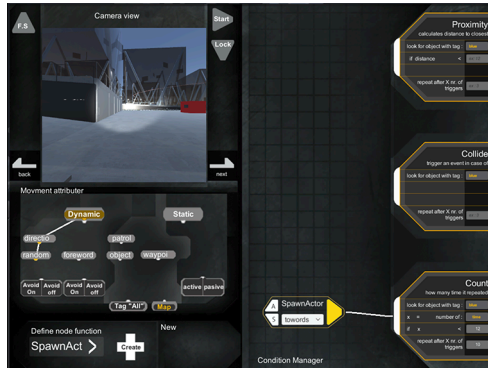


Figure 8  
Behavior Interactive Interface (BII). Set movement and create Spawn function.

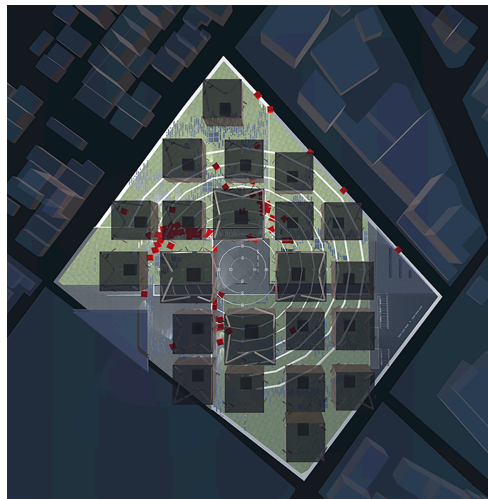


Figure 9  
Spawn Function with Conditions related to time (counter time passed : 12 and distance : 10).

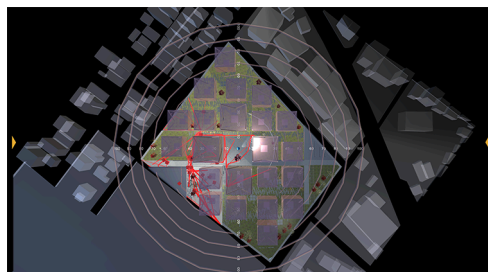


Figure 10  
Movement of virtual actors.

The association of architecture with game design principles could facilitate the comprehension of no-

tions related to scale. By using the interface to generate virtual actors in our virtual environment augments the cognitive immersive capacity for the student as visualizing in real-time several urban realities. We set behaviors to objects of the 3d virtual environment and we observe the relations developed in the virtual environment. The application, as a tool of method, refers to the possibility of the digital tools of virtual/augmented/mixed reality, in terms of presence into the environment, to help cognitive operations about architectural conception and better understand the concept of scale in the urban environment.

### **WHY AN INTEGRATED EDUCATIVE PACKAGE**

A game between architecturological scales and models, as a process of cognitive activity of design (Lecourtois, 2011) in the virtual environment inspired by therapeutic games since games are one of the most ancient forms of designed human interactivity, from a "design" point of view. (example: Block Hood) The user to instantly recognize the navigational pattern (Larsen, 2006) and explore the environment fluidly. The urban environment must be created in a way that the user (player/student of architecture) is working with it and it does not become an obstacle for further exploration of the virtual environment, based on the criterions we set in the pattern design session. In addition, the technologies of virtual reality's display allow cognitive biases and illusions of evoked reality means (Pillai) to be implemented with the daily use of mobile phones, accessible to everyone. The understanding and the perception of virtual interaction by using virtual simultaneous presence as a cognitive operation, augments and merges with reality and stimulates imagination of the architecture's students (Tottem). When the designers of games try to prototype a space, or levels or scales of the space, they strive to prototype it in an interactive form (Tottem, 2014) and this is an experiment we try with students of the Departement of Architecture of NTUA.

### **Gamification of architecture**

The gamification of architecture can be beneficial for architects' skills. To play with models and different scales, by applying sciences of artificial is a way of questioning architecture (Lecourtois, 2011) Playing as architectural conception is an individual conceived cognitive activity (Lecourtois, 2011) and game design notions can offer this conception the new extended means to "qualify" reality. (Lecourtois, 2011). The collective practice of architecture is translated in the multiuser real-time experience of the demo. This can become a systemic model of knowledge of conception in future version. Finally, the experiment includes the use of an 3D dynamic system interface for behaviors to help understand the concept of scale.

**Didactic method.** for architectural training based on game design principles about interaction and architectural scale analysis that can take form in virtual and augmented reality applications/builds for tablets.

**Design patterns.** in architectural conception provide no verbal indications in the buildings, no sound or wind. The analysis of the notion of the pattern design (???) helps understanding the notion of scale, mapping examples of actors' behavior and the dynamic interface. In pattern design we can discover the hierarchy of a project. It reveals the complexity of prototyping and the key for this form of analysis is to set two criterions (Rodwin, 1981). - Identify form qualities significant to the scale of the territory of implementation. These qualities can be controlled by scale. We visualize the urban characteristics of the selected area for implementation and set functions to objects as behaviors with control conditions of distance, collision and time counter. - The interactions of behavior must concern the physical form of the environment or the distribution of activities or functions as two separate things. By influencing the object behavior by size, hierarchy, functions, speed, the patterns of influence become strategic linkages and interactions within and between objects that interact. The aim of the pattern design pattern is to generate events as manifested forms of interaction.

## Results

Concept of merging realities to understand the notion of scale. The application consists an implication in practices of virtual reality, the theory of Fundamental Architecturology. Architectural process of conception as to qualification of reality (Lecourtois, 2011) Systemic model of knowledge and experimentation of parameters of conception through scale-Knowledge on Architecture to Architecture, pattern, self-evaluation

## Problems and Future work

Not very intuitive- Not enough open data for the city of Athens. As a matter of fact, the digital representation of a single site, it is a manual texturing and 3D implementation of the setup environment.- Students could have reasons in advanced 3D modelling skills that will facilitate later the implementation of their models in virtual immersive applications- The construction of the virtual environment for a vr application, is not the same as the principles of construction of a 3D modeling, students are not familiar with the constructions of virtual reality (from computer games, art or commercial vr applications)

## CONCLUSION

Transmission of meaning through symbolic forms of buildings in gamespaces that can augment behavior (Totten, 2014). This is a formal interaction, signifies that form is communicated with the user by means of symbolic or metaphorical form. If we apply the Fundamentals of Architecturology (Lecourtois, 2011) in video games, precisely the concept of scale, it could be called formal symbolic interactive scale, proposing the criterions of interaction and presence as criterions for architectural research. By Applied Architecturology we put in evidence students' intentions for their conception of the space, by questioning the design in terms of the concept of scale. As well, visually represent cognitive decisions and evaluate them into immersive environment. By defining a scale or a combination of scales, our proposal integrates the possibility of designing (conceiving) the architectural

environment as an interactive one. The environment is able to receive visualized interactions or behaviors that also reveal information about architectural dimensioning. Implementing actors / claiming the virtual space as your own A methodology toward building a dynamic system for learning Unity / possibility of application with many relevant technologies Offer possibilities of easy observe notions of complexity and randomness into the environment Hive - Bll interface opensource to settle manipulation to dynamic objects. By setting behaviors to actors, the user can easily populate any virtual environment and create interactions among the actors. Animate the virtual environment, by giving fabrication of the living can in the first place increase the immersive capacity into a virtual environment (case studies my researches in the domain of video games) The design of the interface simulates the reality in question. Didactic proposal as post educational material, after the finish or the semester so as not to charge students with extra demands. Increase empathetic experience to the students (Alan Craig, 2009) Finally, the dialogue remains open about how digital applications, video games, 3D cinema are cultural phenomenon of communication that manifest strong visual representations, in the level that architects can search for new evoked methods of learning architecture and building realities.

**Discussion.** In questions of perception, phenomenology of architecture, architect Steven Holl describes the task of architecture as the concrete example that enable us a continuum of culture. The task of architecture is to shelter us, to become our home and domicile that provides us an identity and this identity is embodied in architecture as an existential metaphor, as body and being (Holl, 2006). The phenomenological approach to modern digital tools by architects, arise the question of concepts of place and emplacement in relation to the phenomenon of globalization (Champion).

The profession of the architect has undergone a fundamental mutation in the last twenty years which has been based much on the widely used media in

the world of work as a computer game. The advantages that CAO offers to architects are important in terms of speed of design production, schematics, synthesis images and even videos. Despite the increase in architectural designs and drawings, architect Rem Koolhaas, when interviewed, commented on a difficulty in architects communicating their ideas and nuanced the weakness of architects to interpret each cultural phenomenon that is based on its own system of values. That means that the perception of concepts as scale, dimension, are not always facilitated to be explained to students simply by exhaustive production of drawings. As a learning tool, immersive visualization of conception, can help the student to measure 'quality' understanding of those concepts by in a relation to dimensions. Creating model of mechanism of cognitive operation for integrating VR into architectural basic studies. Merging methodologies toward an autotelic educational experience of evaluation of design.

The urban virtual environment escapes its static nature, by dematerialization, as well as its locational coordinates and geographical constraints in terms of representational reconstitution. In the same time the First-Person Perspective view immerse into a virtual ephemeral identity. Several philosophers consider the place more as a spontaneous event rather than a static and neutral scenery. (Champion, Phenomenology of virtual and real Places). The conception of space consists a dynamic process of cognitive activity for designers with studies in architecture that can be observed and evaluated by in virtual reality environments.

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