

SIMULATION MODELS IN ARCHITECTURE EDUCATION

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ABSTRACT

SIMULATION MODELS IN ARCHITECTURE EDUCATION

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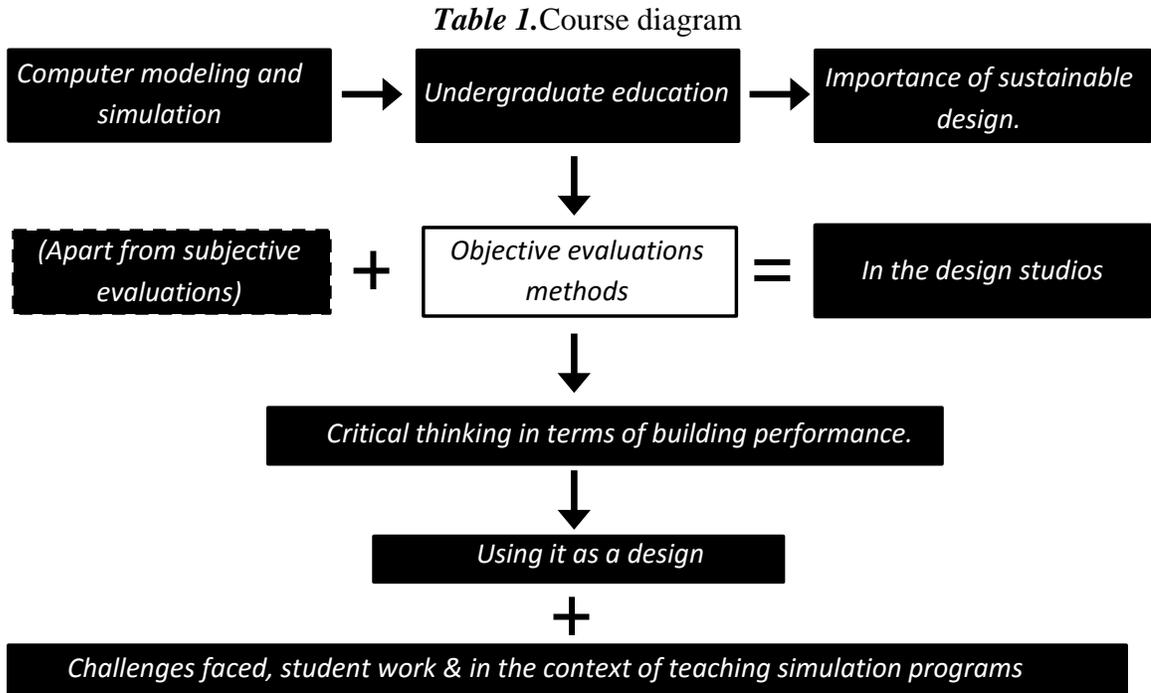
Increased emphasis on promoting resource efficiency and improved occupant well-being in buildings requires the importance for design practitioners to be trained in the use of building performance simulation. The use of stimulation tools, nowadays, has a huge impact not only in building construction, but also in engineering and architecture education. Since the technology of computer technologies and stimulation tools as increased, they provided addition choices for designers and trainers. This is recognized by higher education where building simulation is now regularly taught in numerous programs in architecture and construction [Kumaraswamy, *et al.*, 2015]. Programs in areas like high-performance buildings, sustainable design, and building information management are using building simulation, computational modeling, and simulation for optimizing design and operation of buildings in terms of energy use and indoor environmental quality. Building performance has always been a matter of discussion between all levels of architects when it comes to energy performance and visual optimization.

Architectural schools, as the one of the most important steps of professional education in construction industry, have been now days reestablishing their curricula guidelines towards the direction of energy efficient design approach. Since the architectural industry has performed an enormous progress, the integration of sustainability and green energy into architecture education is needed in order to train the future generation of students. In order to reduce global warming the crucial step which should be taken is to educate future architects for a sustainable environment for the future. The stimulation tools provide an early evaluation of building performances in the early design stage. The most important issues in order to achieve high performance buildings are architecture practice and education. This paper attempts to indicate how the principles of the sustainable design and energy efficiency, play in the architectural education based on the actual technological developments. Exploring the simulation software in the analysis and optimization of the high performance building and systems plays a prominent role in architecture and design [Attia, 2010]. It adequately allows architects and engineers to evaluate, test, and respond to a variety of strategies. Using such software, design professionals have the potential to continuously study and predict how decisions will impact the performance of the building from the early phases of design, without significant investment in mockups or manual calculations. The aim is to scrutinize how to incorporate new simulation and modeling techniques at the design strategies in design studio education, thereby this can serve as a factor to perfect as a unified body of knowledge all the creation process, from very preliminary studies to the final product. The main focus of the study is the development of the building performance simulation delivery within an undergraduate program in Architectural Technology at Epoka University, AL.

It reviews the lesson learnt from the Environmental Control Studio over the second year of the bachelor studies and the use of building performance simulation tools for energy efficiency and daylighting, as well some approaches pointing to a better and more efficient use of this important but non implemented technology. How simulation applications are currently being embedded to influence architectural thinking is being

discussed. This paper provides insight into the challenges faced at an undergraduate level while using simulation in the context of teaching design. The goal is to provide future architects with, tools, knowledge, and procedures for integrated design and operation processes which lead to innovative design, a better energy use, a better indoor environmental quality, and enhanced critical thinking in terms of building performance. The current work is an essential step towards an integrated design and operation environment. The objective of the research is to analyze the role of computational models in architectural education and to with ways of introducing simulation through negotiated understandings that balance qualitative understandings with more experiential and conceptual design.

Keywords: Sustainability, energy efficiency, architectural education, sustainable architecture, sustainable development.



ABSTRAKT

MODELET SIMULUESE NE EDUKIMIN ARKITEKTUROR.

Filipi, Efris

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Rritja e rëndesise se promovimit te efikasitetit te burimeve dhe permiresimi i mirqenies se banoreve ne banesat e tyre kerkon qe praktikuesit e dizajnit te trajnohen ne perdorimin e simulimit te performances se ndertesave. Ne ditet e sotme, perdorimi i mjeteve simuluese ka nje ndikim te madh jo vetem ne strukturimin e ndertesave, por edhe ne inxhinjeri dhe edukimin arkitekturor. Zhvillimi i teknologjive kompjuterike dhe i mjeteve simuluese i ka ofruar arkitekteve me shume mundesi. Kjo pranohet edhe prej instituteve te larta te edukimit, te cilat perfshijne simulimin e ndertesave rregullisht ne programet e tyre mbi arkitekturen dhe ndertimin[Kumaraswamy *et al.*, 2015]. Programet ne fushat si performanca e larte e ndertesave, dizajni i qendrueshem dhe menaxhimi i informacionit mbi ndertesat po perdorin simulimin e ndertesave, modelimin kompjuterik dhe simulimin per te permiresuar skicimin dhe funksionimin e ndertesave ne aspektin e perdorimit te energjise dhe cilesise se mjedisit te brendshem. Performanca e ndertesave ka qene gjithmone nje ceshtje teper e diskutuar mes

arkitekteve të gjitha niveleve kur bëhet fjale për performancën e energjisë dhe përmirësimin vizual. Shkolla arkitekturore, një nga hapat më të rëndësishëm në edukimin profesional mbi industrinë e ndërtimit, ka përfshirë në kurrikulumin e saj drejtime drejt arritjes së efikasitetit energjetik. Meqenëse industria arkitekturore ka arritur zhvillim të madh, integrimi i qëndrueshmerisë me energjinë jeshile në edukimin arkitekturor është e nevojshme për të trajnuar brezin e arkitekteve të ardhshëm. Në mënyrë që të zvogëlohet rreziku global duhet të merret hapi i rëndësishëm, i cili përfshin edukimin e arkitekteve. Mjetet stimuluese na pajisin me një vlerësim të hershëm mbi performancën e ndërtësive në stadi të fillimit të dizajnit. Çështjet më të rëndësishme për të arritur performancë të lartë të ndërtësive janë praktika dhe edukimi. Kjo diplomë tenton të tregojë se si parimet e qëndrueshmerisë së dizajnit dhe efikasitetit të energjisë, luan një rol të rëndësishëm në edukimin arkitekturor të bazuar në zhvillimet aktuale të teknologjisë. Studimi i programit të simulimit në analizën dhe përmirësimin e performancës së lartë të ndërtësive dhe sistemeve luan një rol më të rëndësishëm në arkitekturë dhe dizajn [Attia, 2010]. U lejon në mënyrë adekuate arkitekteve dhe inxhinjerëve të vlerësojnë, testojnë dhe përgjigjen strategjive të ndryshimit. Duke përdorur programe të tilla kompjuterike, dizajnerët profesionalë kanë potencialin për të studiuar në vazhdimësi dhe për të parashikuar si vendimet do të ndikojnë në performancën e ndërtësive që nga faza më e herët e dizajnit pa investuar në llogaritje manuale. Qëllimi është të ekzaminojmë se si të përfshijmë simulimin e ri dhe teknikat e modelimit në strategjitë e edukimit të dizajnit. Për të përdorur atë si faktor për të përfeksionuar procesin krijues si në trup të unifikuar të dijes që nga studimet e para deri tek produkti final. Fokusi më i rëndësishëm i studimit është zhvillimi i performancës së ndërtësive falë simulimit në programin studentor të Teknologjisë Arkitekturore në Universitetin e Epokës, Shqipëri.

Studimi shqyrton mesazhin e dhënë nga Studioja e Kontrollit të Mjedisit gjatë vitit të dytë të studimeve bachelor dhe përdorimin e mjeteve simuluese të performancës së ndërtësive për efikasitet të energjisë dhe ndricimin gjatë ditës, si dhe trajtimet që të çojnë drejt përmirësimit dhe përdorimit më efikas të kësaj teknologjie të rëndësishme

por jo te zbatuar. Menyre sa se si do te ngulitet aplikimi i simulimit ne ndikimin e mendimit arkitekturor eshte ende e diskutueshme. Ky studim paraqet depertimin ne sfidat qe do te hasin studentet ne studimet gjate perdorimit te simulimit ne dizajn. Qellimi eshte te pajisim arkitektet e ardhshem me mjete, dije dhe procedura per integrimin e dizajnit dhe proceseve operative qe cojne ne dizajne inovative, perdorimin me te mire te energjise, permiresimit te cilesise se mjedisit te brendshem dhe rritjes se mendimit kritik mbi performancen e nderteses. Puna aktuale eshte nje hap i rendesishem drejt dizajnit te integruar dhe funksionimit duke rritur shfrytezimin kushteve mejedisore. Objektiva e ketij hulumtimi eshte analizimi i rolit te modeleve kompjuterike ne edukimin arkitekturor dhe te prezantoje simulimin nepermjet diskutimeve qe baraspeshojne dijet kualitative me ato eksponencile dhe dizajnin konceptual.

Fjalët kyçe: modelet simuluese; modeleve kompjuterike; edukimi ;performances se ndertesave; dricimi natyral ; performaca termike.

Dedicated to my father, mother; Adonis and Brunilda.

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LIST OF ABBREVIATIONS

DF	Daylight factor
Lux	Illuminance level
U- value	Overall heat transfer coefficient
Hp_01	House Plus – Orneala Gjoni,Kejsi Fusha
Hp_02	House Plus - Alban Bathoria,Mario ,Alla,Sindi Balla
LEED	Leadership in Energy and Environmental Design
BREEAM	Building Research Establishment Environmental Assessment Method
UNESCO	United Nations Educational, Scientific and Cultural Organization
UIA	International Union of Architects
EU	European Union

CHAPTER 1

1. INTRODUCTION

1.1.Motivation

Architectural design has become more complex over time, and it is currently facing enormous technological and institutional transformations. Architecture as profession has changed dramatically with the emerging and fast growing needs of the construction industry such as improving sustainability, more effective cross disciplinary collaboration amongst industry professions [Nicol, *et al.*, 2000]and with greater client sensitivity and responsiveness. . Parallel to the architectural practice, the integration of sustainability and green energy technologies into architectural education is required to instruct and train future professionals and generations in design and construction. It is appropriate to say that, technological progress and society's demand for a more sustainable environment thoroughly amend architectural education. The profound interest on designing energy conscious and ecological buildings to reduce global warming effects has exacerbated the demand for introducing the principles and practices of environmental sustainable design to new generations of architects. With the help of rapid advances in both computing and engineering, various simulation tools have been produced to evaluate building performance in the early design stage[Göçer, *et al.*, 2016]. The uses of these simulation tools make the architects analyze and evaluate their own design. The ongoing development in the construction industry also had its influence upon architectural education. Architectural schools which create the contents and curriculum of their program based upon trends in the architectural world being to take a sustainable design approach into account. Apart from individual attempts of certain academic and architectural education institutions, there has also

been a collective initiative which has greatly encouraged architectural schools to flip their direction onto a focus in sustainable design principles.

The technological ongoing development make it is essential for projects and research conducted in academic institutions to invent new solutions for the present and the future. It is important that the vision of the future world cultivated in architectural schools should subsume the goal of balanced ecologically and sustainable development of the healthier building environment.[Ceylan, Salih, 2014]Architecture not only as design of profession, but also a field of science and art is facing nowadays to find a solution to help designers in design problem-solving and to use the relevant knowledge to solve new design problems. The rising awareness on sustainability and sustainable design in the academic institutions as well as in the society evokes the professionals to perform more research and development in the construction industry. The innovative approach brings improvements like the use of recycled materials, development of renewable energy resources, or the effective use of water, reclaim of rain and grey-water. Similar implementations immensely help the constructions and buildings to be more energy efficient. Together, with the widespread use of these energy and resource saving applications, the necessity continues to set standards which could be used as a handbook for architects and other professionals consuming knowledge about sustainable design principles in order to formulate them in an integrated design process. Building certification programs such as LEED and BREEAM, which are created by energy efficient building foundations in different countries, use sustainable construction and ecological design as the key strategy to overcome the problem involving energy and resources, and they establish their fundamentals on the integrated process of sustainable design.[Ceylan, 2014]The main criteria in building certification programs become the basis for any architectural design process that is considered to be energy efficient in the context of contemporary architecture, and they are also used for educational purposes in architectural schools.

Along the twentieth century, there have been numerous inventions and significant developments in science and technology causing the twentieth century to be considered as a great leap forward in the history of mankind. The industrial revolution, initiated at the end of the 18th century, attained an advanced level during this century as the progression became rapid, common, and prevalent. Any encountered difficulty became possible to be solved through technological methods and devices. It was admitted that nature can no longer come up with any conflicts that would stop the progression of mankind. This period might be known as the time when human beings thought that they had established their sovereignty over nature using technology and science. Peterson, in “Ecology of Construction”, [Kibert, *et al.*, 1999] established the uniqueness of the human kind with the capability to have control over their own destiny. He stated that there is a fundamental difference between the natural and human thinking systems: Humans work forward looking and planning ahead based on their experience while other inanimate objects cannot. Resources of nature, considered to be everlasting by human beings, turned out to be at the edge of being consumed away. The population growth and industrial progression led to the increasing demand of energy and resources which also lead to the increasing depletion of those energy and resources. Humankind lost sight of the billions of non-human creatures whose rights were also needed to be defended to live on the planet Earth, therefore, with the corruption of the balance in nature, many issues formed including: A global energy crisis, global climate change, desertification, soil erosion, deforestation, acidification, eutrophication, and the last but not least the loss of biodiversity. The competition of economic and technological progress between developed nations caused the above-mentioned problems to enlarge all over the world and to become almost impossible to solve. In the early 1980’s, the world started to realize that some precautions were needed to be taken against the environmental problems which were getting severely dangerous, affecting all kinds of lives on Earth. Authorities began to search for a different development method which offered a brand new way of reaching the environment and its relationship to everything else that is cared for in a society; It was called “sustainable development”

[Dernbach,2011].The first significant international attentiveness on sustainable development occurred when it was mentioned in 1987 by the Brunt land Commission, World Commission on Environment and Development. The commission’s report, “our common future,” states the following definition:

“Sustainable development is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.[World Commission on Environment and Development, 1986]

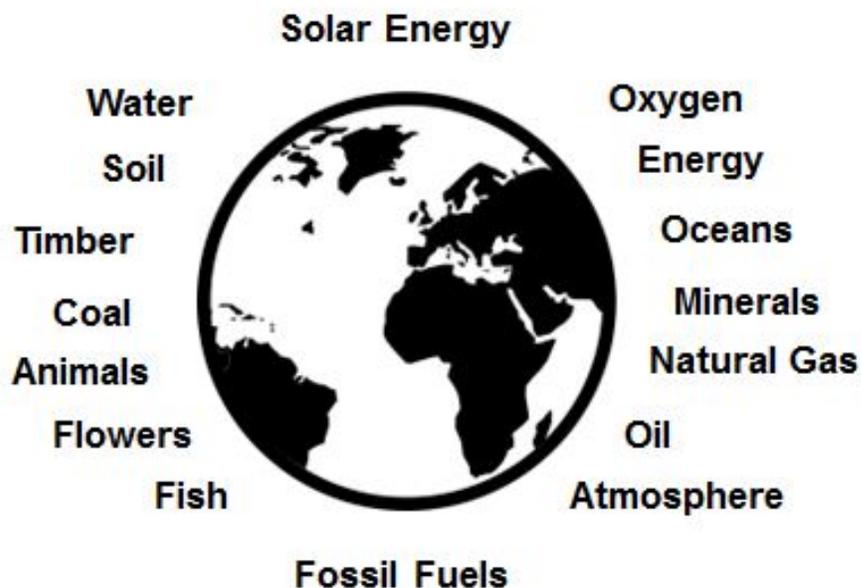


Figure 1. Sustainable development, world and the rescues.

Humans are the main factor in the climate change that has been happening during the last few decades. CO₂ emissions in the atmosphere are increasing drastically and they contribute to the greenhouse effect. Buildings are one of the main factors responsible for these emissions; they contribute approximately 47% of the CO₂ emissions (estimated in 25 countries of EU). Energy consumed by buildings, either for residential or commercial purposes account to a large share of the total energy expenditure of the world. It is estimated that for developed countries, the energy consumptions of

buildings amount to 35% of the total consumed energy worldwide, and this figure increases by up to 40% of the total, globally [Laustsen, 2008]. In this context, reducing the energy expenditure of the buildings as much as possible would contribute to a huge amount of energy expenditure reduction worldwide. The implications of more energy-efficient buildings could be really substantial by cutting the energy expenditures for a nation allowing the possibility of transferring funds to important public services such as health or social security or even improving a nation's strategic position by making it less dependent on foreign energy resources. These implications add up globally to have a huge impact on climate change, CO₂ emissions, and general population welfare. Specifically, there is a growing recognition of the need to significantly improve the performance of Albanian buildings.

With the climate change that is occurring, the need to take measures is the main concern of all industries and for each type of discipline. Nowadays the building sector uses of primary energy are so large that they consume around 45.7 % of electrical energy for lighting HVAC and lighting energy use in Albania [Republika e Shqiperis., 2012]. With this condition going on, many countries and also the EU directive have introduced measures to improve the building energy-efficiency standards. There have been important strategies from passive houses to self-sufficient houses to reach the state of "nearly Zero-Energy Buildings." That means that sustainable construction and the reflection of sustainable development in the construction industry must be taken into account because those are inventions to provide energy saving in a building.

Computer modeling and simulation are powerful examples of technology for addressing interacting architectural, civil engineering, mechanical, and energy issues in buildings systems. Building performance simulation can help by treating buildings and the systems which provide for them with optimized entities components in terms of reducing emission, greenhouse gasses and in ensuring substantial enhancement in fuel consumption and comfort levels and not as the sum of a number of separately designed and optimized sub-systems. It is only by taking into account dynamic interactions as

indicated in *Figure 1*, that a complete understanding of building behavior can be obtained. Simulation is undoubtedly a powerful training tool due to have the advantages of systematically control the, presentation of feedback, schedule of practice, and easy to apply then the predictive methods. The generation of the design-performance space through the use of computational models, is built with a variety of design variables that must be parametrically changed as well all design dimensions and the resulting performance attributes should be expressed in terms of corresponding numeric ranges along the performance dimensions. Variety of environment computational model prototypes can be focused on the thermal performance and daylight comfort, a sample of such purpose was selected and used for extensive parametric analysis in this thesis. The data that can be obtained can be used to for analytic network possibilities, resulting in a variation of models that represents the relationship between design variables and the performance attributes. Using this model, the entire design-performance space can be constructed. Thus, a design can be analyzed by viewing it among other possible alternatives. The exploration of the environment with the use of simulation tool helps the user to identify possible solutions and yield better performing designs. Given the ranges of the design variable a set of values can be generated, 2D, 3D and 4D design performance associations plots can be generated and updated.[Mahdavi, 2003].The utilization of the computational models in architectural practice and education has an essential importance in how dynamic environmental forces and ecological processes can inform design thinking and strategies importance in achieving high performance buildings.

Many architectural design faculties throughout the use of the simulation tools have attempted to integrate environmental comfort and building physics theories with design studio focusing on energy efficiency and daylighting issues. [Göçer, *et al.*, 2016]The Simulation in practice is a digital real world base design in a way real time project-based learning, this approach in architectural education gives the student the possibility to understand the problem solving process and learns to use information for a specific purpose. Architectural education thought the utilization of these tools can provide a

better understanding and visualizing of building performance. The integration of simulation tools into the design process in an ongoing discussion actively targeted in architecture education [Delbin *et al*,2006].

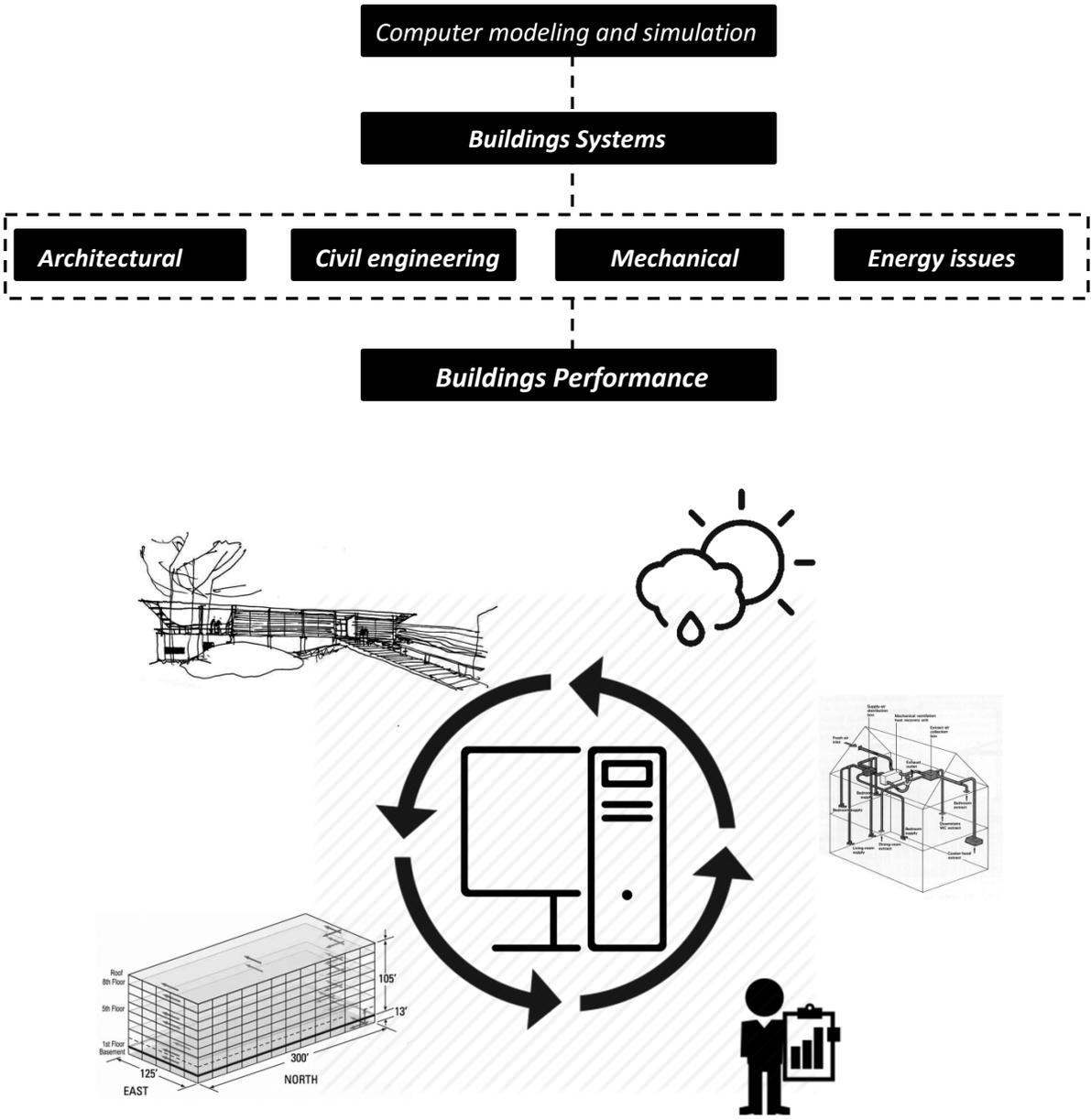


Figure 2. Dynamic interacting sub-systems in a building context

1.2.Objectives

- i. This study seeks to develop and continually improve practice, procedures, products, curricula, services and standards that will enable the implementation of sustainable design; and to educate their fellow professionals, the building industry, clients, students, and the general public about the critical importance and substantial opportunities of sustainable design.
- ii. Through the use computer modeling and simulation technology at the undergraduate architecture education, this thesis provides students with insights about the importance of sustainable design. By this way to enhance the use simulation tool in design project due to powerful training advantages of systematically control the schedule of practice, presentation of feedback and easy to apply then the predictive methods.
- iii. By using performance simulation to help in reducing emission of greenhouse gasses and in providing substantial improvements in fuel consumption and comfort levels, by treating buildings systems which serve as complete optimized entities.
- iv. On the other hand aim to increase the role of the objective evaluations methods in the design studios apart from the flattened attitude of applying intuitive, artistic, subjective evaluations used and to follow the emergence of new software, representation/ simulation techniques, and shifts in paradigms and strategies in design/design education.
- v. The main focus of the study is the development of the building performance simulation delivery within an undergraduate program in Architectural Technology at Epoka University, AL. How simulation applications are currently being embedded to influence the architectural thinking is being discussed.

- vi. This paper aim to provide insight into the challenges faced at an undergraduate level while using simulation in the context of teaching design.
- vii. The ultimate goal is to provide tools, knowledge, and procedures for integrated design and operation processes which lead to innovative design, a better energy use, a better indoor environmental quality, and enhanced critical thinking in terms of building performance.
- viii. At last but not the least one of the key interests with this paper is the delivery of simulation teaching to find tangible evidence of application in building simulation in practice and as a tool in the design development at the undergraduate level, developing understanding of the simulation and using it as a design skill

1.3. Literature review

The approach which is getting more popular and wide-spreading in the last few years is about adapting the principles of sustainable design and energy efficiency directly into the basic structure of architectural education. Due to this, architecture schools need to form architecture education to fulfill the demands of the new construction industry and society. In 1996, UIA and UNESCO created the Charter For Architectural Education in order to assure the understanding that architectural education constitutes both the sociocultural and professional challenge of the contemporary world. This, as a whole, is particularly based on ecologically balance and sustainable development of the built environment. This means that the curriculum of architectural education needs to be revised. It is a radical modification of the concept, but the definition of architecture in

the world is changing drastically. An undergraduate education should prepare students to understand and deal intelligently with modern life and its issue [Chickering, *et al.*, 1987]. The most prominent, leading architectural schools in the world have already altered their programs with concerns about sustainable design. The Bachelor of Architecture program at Cornell University, USA embedded a course about sustainable design called, “Environmental systems 1: Site and Sustainability,”[Cornell University.,2011].It examines the relationships between building, site, landscape and sustainability through the lenses of ecology and systematic thinking. When the first semester course descriptions are examined, it can also be seen that the course, “Design I,” has sustainable design in its contents as well, with practices on the transformation of physical environment and exercises aimed at the processes of environmental design. The tendency to focus on sustainable design principles in the Cornell Bachelor of Architecture Program continues in the following semesters with different courses and approaches with the aim of educating architects who are truly aware of and well informed about the principles of sustainable design and who are able to apply their knowledge in the projects of their professional life.

Elective courses, lectures, seminars, and workshops as well as graduate and postgraduate programs focused on sustainable design can be considered as different techniques of this kind of approach.. It is asserted that multiple experiences in multiple areas that are educationally convenient have a great influence on student learning [Terenzini, *et al.*, 1996].Examples of this can be found in anywhere in the world.

At the School of Architecture of Yıldız Technical University in Istanbul, Turkey specializes the course of redesigning architectural education: an exploration of energy problems worldwide and its impact on architectural education based on the changes in the education program contents of architecture schools,[Ceylan, *et al.*, 2014].

In the International Journal of Sustainable Human Development, first published by Eduserv Group Publishing Division, UK uses their designs and who is able to minimize energy loss in a building in order to contribute to the development of the national and

global economy. Although this master program has a well-built structure, useful courses, and favorable objectives, it needs to be based on a strong substructure without a bachelor education degree that gives the students the consciousness of energy efficiency and basic knowledge about energy efficient buildings.

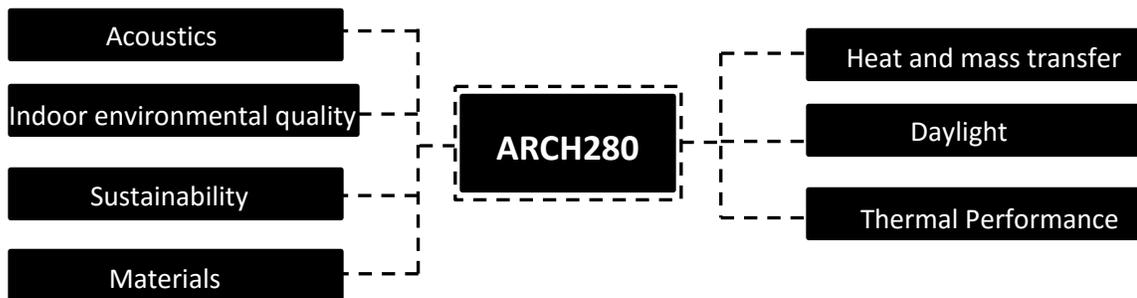
Another institution that adds sustainable design into its program is Pratt University's department of architecture. In the bachelor program of the architecture mission statement, it is indicated that the program is firmly committed to contemporary material practices and is constantly integrating new technologies into the curriculum.[Part University 2015].In addition to the goals and objectives section, it is intended that the students will demonstrate the aptitude to integrate sustainable practices, material research, and interdisciplinary approaches to find sustainable design solution. To achieve this goal, in different periods of study, the students are canalized and encouraged to think widely about what it means to design living space and working space as well. Also in some of the courses, like, "Building Services," and, "Building Environment," the students are given information about certification systems like LEED in order to be prepared for the emerging needs of the Professional world of architecture.

CHAPTER 2

2. METHODOLOGY

2.1. Context of the course.

Environmental Control Studio ARCH280 course conducted spring semester 2015-2016 is the sustainable design studio is where the students are expected to create energy efficient buildings with sustainable design principles over the second year of the five-year integrated program studies in architecture [Dervishi, 2016]. In the first weeks, the students were primarily given lectures to get acquainted with building physicist. Subjects covered include heat and mass transfer, lighting, noise and acoustics, and indoor environmental quality, sustainability and energy efficiency. Students are also required making researches about these topics in order to get to know the working systematics of the systems and be able to choose which features they can use in their design.



*Figure 3.*Environmental Control Studio ARCH 280, Course Content

The second phase of the course was designed to give students an opportunity to investigate and understand a particular building typology and technology in detail, and to understand some of the key technical implications of building design decisions in

relation to building sustainability through the use of the simulation tools. Students are required to perform analysis of daylight conditions of their own design and documenting daylight levels and to simulate building performance regarding energy consumption.

2.1.1. Daylight

Through the first weeks students are introduced with the importance of the natural lighting, the sun as the main source of daylight. The proportion of direct to diffuse light impacts the amount and quality of daylight. Solar radiation and the concept of the direct sunlight and diffused daylight. The sky terminology and the properties of each climate has different composition of daylights and different cloud coverage, so daylighting strategies vary with site locations and climates. Students are presented with different series of light measurement typologies for Daylight factor calculations in order to evaluate the light levels at a specific height and daylight performance of Sun light evaluated by simulating the illuminance levels in different parts of the building during various times of the year and sky conditions. Further is discussed the role of the daylight in the design process as important factor to consider when designing buildings and shaping our cities, offices and homes. Daylight as design tool to create environmentally-friendly low-energy buildings with a strong focus on the health and well-being of their occupants.

2.1.2. Thermal Performance.

Thermal performance indicates to the process of modeling the energy transfer between a building and its surroundings. Students learn to calculate building cooling and heating loads so the selection and sizing of heating, ventilation and air conditioning can be accurately made. These assessments enable them to resolve effectively the design of the building and to revise indoor condition in order to achieve appropriate decision. Student go through the concepts of passive solar building design by understanding ways how to maximize solar gains and how control it during warmer months. The process give insights for the future professionals to judge how design decision affect energy loads, or if it needs additional design change, by doing all this it helps them to choose a convenient alternative. The overall process seek to help students to understand how the thermal performance can be used as an environmental and economical benefit, combined with the energy saving and carbon emissions.

2.2. Case-study.

Students form the second year are asked to work with computer simulation software's Velux Visualizer & Ecotect to analyze and test the House Plus Concept of the student's own design developed in ARCH 201- Spring 2015. The studio project was chosen due to its mixed-use design concept and because its represents universal living and working space values which is actual trend of the 21century, "Home as a working space". Responding to radical changes in the concept of privacy and introduction of new concepts of work and domestic life in parallel to transformation of the family life, which makes this module an universal tool in the course context.

2.2.1. Case-study Description

House Plus as a hybrid building is a structure that can be defined as a place to dwell and/or a place of living/working milieu. The students work consists to propose a program for this small scale building complex – the residential unit, and a working place for a specific program. The program proposal/ scenario should be not only a mere desire of the student for any kind of “working place”, but it should rely on the land-use analysis and site potentials, as well. The building is designed for a couple (husband and a wife) where both might be engaged in the work activity, thus both live and work in the same place. They have 2 children (boy and girl). [Pashako, *et al.*, 2015].

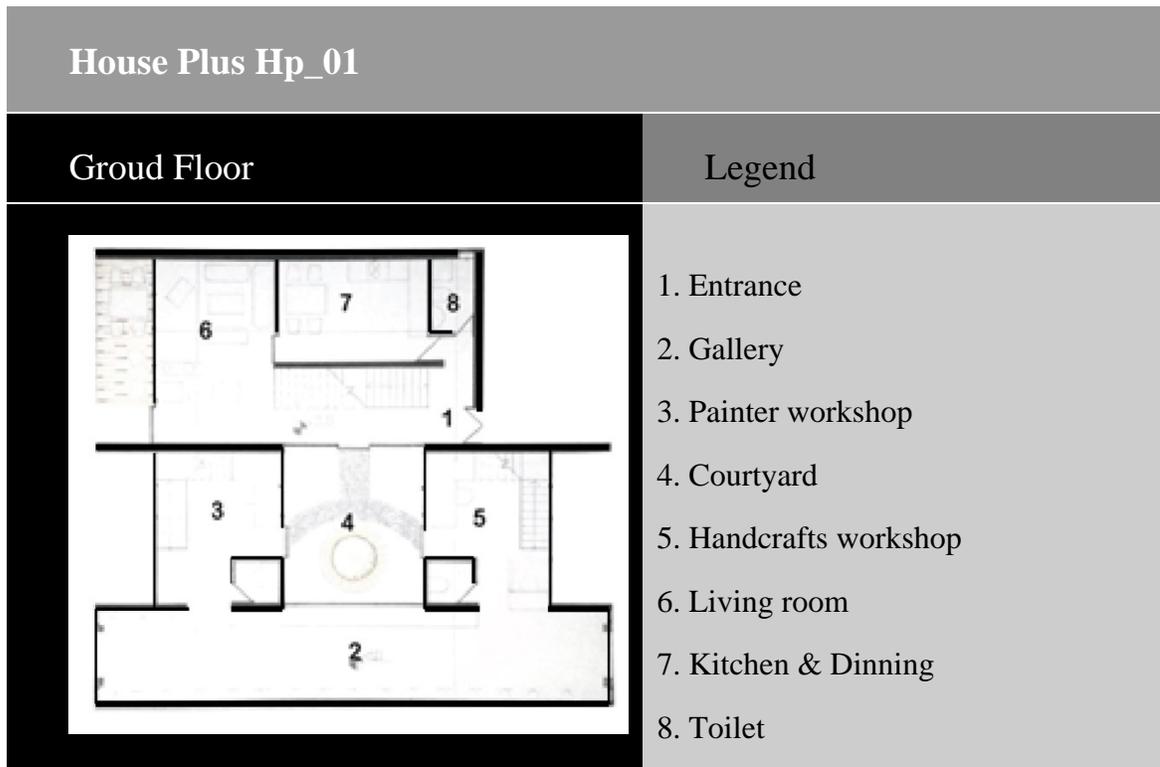


Figure 4. House Plus description, Hp_01. [Fusha., 2015]

House Plus Hp_01 as shown in the (*Figure. 4*) is a proposal for a family of four, where parents are sculptor and painter respectively. Therefore, the plus program makes place for three different space typologies: two different workshops where parents will produce their works of art and a gallery, where these products will be exhibited.

Figure. 5 show the House Plus Hp_02 consists of a domestic house which also encounters working spaces for the family members. This hybrid building is designed for a family of four: mother, father and two children. It is a three story building with an underground level floor which in a way serves as a base for the upper floors. The underground level contains the working spaces for the father who is a boat maker, while the upper floors are the dwelling spaces. The geometry of the house is pure and it has simple openings to provide light entrance throughout the day.

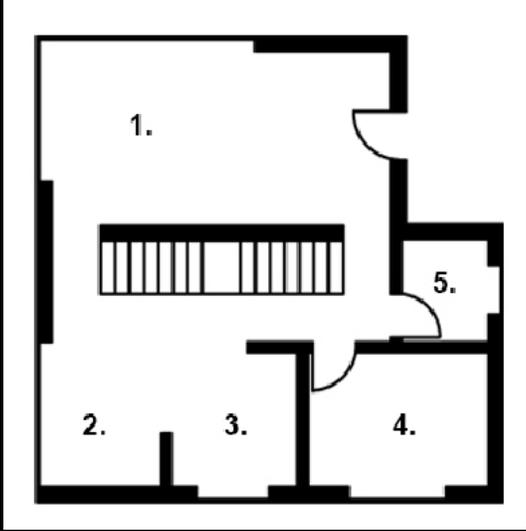
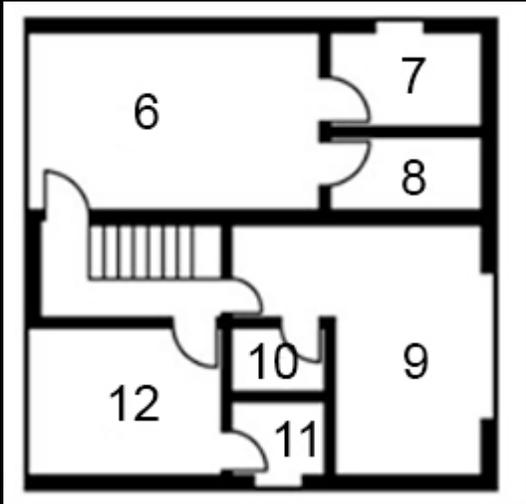
House Plus Hp_02	
Groud Floor	Legend
 <p>The ground floor plan shows a living room (1) at the top left, a dining room (2) at the bottom left, a kitchen (3) at the bottom center, a guest room (4) at the bottom right, and a toilet (5) at the top right. A staircase is located between the living and dining rooms.</p>	<ul style="list-style-type: none"> 1. Living room 2. Dining room 3. Kitchen 4. Guest room 5. Toilet
First Floor	
 <p>The first floor plan shows a master bedroom (6) at the top left, a bathroom (7) at the top right, a closet (8) below the bathroom, a boys room (9) at the bottom right, a bathroom (10) at the bottom center, a bathroom (11) at the bottom left, and a girls room (12) at the bottom left. A staircase is located between the master bedroom and the boys room.</p>	<ul style="list-style-type: none"> 6. Master Bedroom 7. Bathroom 8. Closet 9. Boys Room 10. Bathroom 11. Bathroom 12. Girls Room

Figure 5. House Plus description, Hp_02. [Balla., 2015]

2.3 Simulation Programs.

Students are introduced to series lectures regarding Velux Vizualiser & Ecotect simulation software during the laboratory hours ,where students learn to operate the software and later are required to use these as a design tool in the simulation process of the House Plus case- study , in order to achieve good performance in terms of thermal comfort, energy efficiency, and solar access.

2.3.1 VELUX Daylight Visualizer

VELUX Daylight Visualizer is a professional simulation tool for the analysis of daylight conditions in buildings. It is intended to promote the use of daylight in buildings and to aid professionals by predicting and documenting daylight levels and appearance of a space prior to realization of the building design. It permits Architect to accurately simulate and quantify daylight levels in the interiors.[Velux., 2016]

2.3.2. Autodesk Ecotect

Autodesk Ecotect Analysis is an environmental analysis tool that allows designers to simulate building performance from the earliest stages of conceptual design. It combines analysis functions with an interactive display that presents analytical results directly within the context of the building model.[Autodesk., 2013]

2.4 Simulation Analysis.

2.4.1 Daylight

Students are asked to work with VELUX Daylight Visualizer computer software to perform daylight and comfort analysis in order to realize more and come up with real scientific data about house plus project of the student's own design developed in ARCH201. The main objective of this process is to provide students with real time objective evaluations methods with a strong focus on the health and well-being of their occupants and to create environmentally-friendly low-energy buildings. Through the outcome of the simulations results and the theoretical part discussed in the first part of the course students should provide different scenarios for achieving adequate daylight levels in accordance to its use of HP_01 and Hp_02 (*Figure 4. and Figure 5.*) as case study to reflect the outcome of course.

2.4.1.1 Parametric simulation of the improved scenarios.

Using Velux Daylight Visualizer group of two to three students should simulate and quantify daylight levels in the interiors the current situation of the Hp_01 and Hp_02.

The calculations of the daylight analysis will be based on four reference days of (21 December, 21 March, 21 June, 21 September) at 12⁰⁰ ,under a CIE intermediate sky.

The analysis should include.

1. Illuminance analysis: Floor Plan. Average illuminance for each space of the floor plan. (False color or ISO contour).
2. Daylight Factor :Floor Plan (Average DF) (False color or ISO contour)

2.4.2 Thermal Performance.

Building energy simulation program Ecotect was used with purpose to analyze thermal performance of student's own design developed in ARCH201 with the aim to develop different solutions which can improve the internal environmental conditions and for evaluating energy consumption. Through this criteria students asked to consistently demonstrate their technical understanding and are pushed to be more analytical and reflective, in accordance to the parameters that describe thermo-hygrometric comfort, to the materials of which they are generally made of and to the climatic conditions under which they may be exposed.

2.4.2.1 Parametric simulation of the improved scenarios.

Autodesk Ecotect is used to verify the actual situation of the HP_01 and Hp_02 and to evaluate seven improved scenarios (S1, S2, S3, S4, S5, S6, S7) considered for parametric simulation to enhance the building efficiency. For the generation of the weather data METENOROM [Meternorm., 2016] was applied for Tirana, Albania. It has a Mediterranean, subtropical climate with dry and hot summers and moderate temperature, rainy winters. The average annual temperature is 18°C while the average monthly temperature during the warmest part of the year is 22°C and 18-3°C during the coldest periods. *Table 2* describes the technical construction information for both base cases of Hp_01 and Hp_02.

Table 2. Includes construction information for the base case of Hp_01 and Hp_02.

Code	Scenario	U - Value	Description
Hp_01	Base Case	U-walls = 0.5 W/m ² K-1	Walls- 25 cm brick, 5cm wool insulation, 1 cm inner plaster.
		U-windows = 2.7 W/m ² K-1	Double glazing with aluminum frame. 1 cm air gap.
		U-Floor = 2.2 W/m ² K-1	20 cm thick concrete floor
Hp_02	Base Case	U-walls = 0.5 W/m ² K-1	Walls- 25 cm brick, 5 cm wool insulation, 1 cm inner plaster.
		U-windows = 2.7 W/m ² K-1	Double glazing with aluminum frame. 1 cm air gap.
		U-Floor = 2.2 W/m ² K-1	20 cm thick concrete floor

While (Table 3.) shows the proposed thermal improvements for seven different scenarios. The improved scenarios include changes form different variables, from the isolation width, glazing typology and floor isolation.

Table 3. Shows thermal improvement scenarios.

Code	Scenario	U - Value	Description
S1	Improved insulation.	wall U-walls = 0.3 W/m ² K-1	10 cm wool insulation.
S2	Improved insulation.	window U-windows = 1.8 W/m ² K-1	Triple Glazing .1 cm air gap.
S3	Improved insulation.	floor U-Floor = 0.3 W/m ² K-1	10 cm wool insulation floor.
S4	S1 + S2		
S5	S1 + S3		
S6	S2 + S3		
S7	S1 + S2 + S3		

2.5 Questionnaire.

A number of 20 second-year undergraduate students from ARCH 280 work on architecture simulation tools for sustainable building design participated on the questionnaire that was dedicated to gathering information from student course outcome. How simulation applications are currently being embedded to influence the architectural thinking is used to form the basis for of the survey questionnaire. One of the key interests with this review of delivery of simulation teaching was to find tangible evidence of application of building simulation in practice and as a tool in the design development. The survey aim to probe, how design decision is influenced by the use simulation tool.

-
- 1. The stimulation programs were easy to work with.**
 - 2. I can easily create geometries.**
 - 3. The simulation test/results helped me to create a better idea about building performance.**
 - 4. Simulation programs are proficient tool to evaluate design strategies.**
 - 5. I can understand properly the steps of the process.**
 - 6. I can follow instructor-the interface of the program was user friendly**
 - 7. The use of the simulation tool helps me to create a better understanding about daylighting.**
 - 8. The use of the simulation tool helps me to create a better understanding about thermal performance.**
 - 9. After the course I find simulation programs as an important tool to a archive qualitative design.**
-
- 10. I think that simulation programs should be used in early stage design.**
-

CHAPTER 3

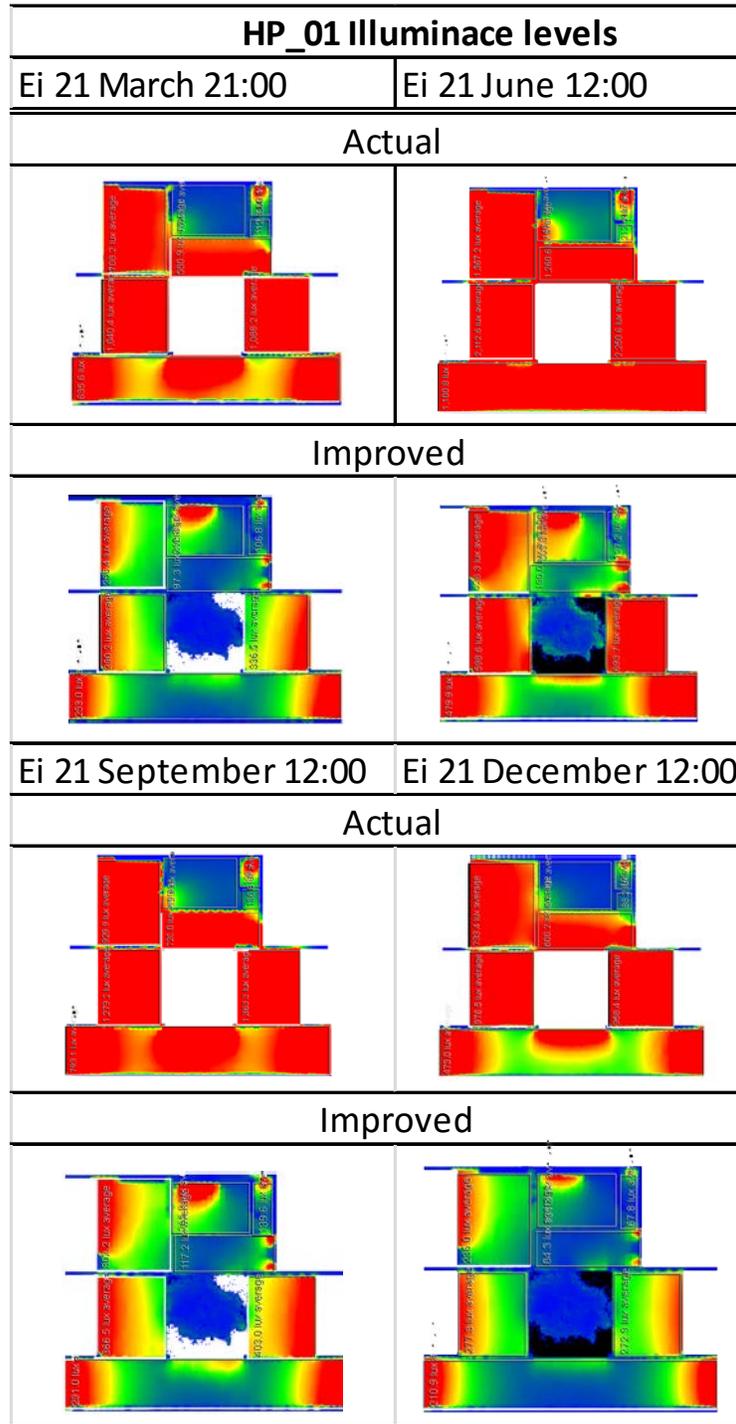
3. RESULTS&DISSCUSION

3.1 Daylight Performance.

3.1.1 Hp_01

Table 4. show the daylight performance of Hp_01 evaluated by simulating the illuminance levels in different parts of the house during March 21st, June 21st, September 21st and December 21st at 12:00 under a CIE intermediate sky. Each table shows the comparison of simulated luminance levels of the actual case and the improved scenario.

Table 4. Comparison of the simulated illuminance levels of HP_01.



Too bright spaces are evident on the base case of Hp_01 .The living area was found to have excessive heat and light. In June, it had 1367 lx whilst it should not overpass 500 lx and in December, 733 lx. Working areas shared the same problem. An atelier requires diffused and controlled light while the actual situation shows quite problematic, for this space had 2112 lux. The other workshop had the same problems. Even the art gallery was enormously lit in all four months that it was tested. The entrance hall also exceeded the standards, by having 923 lx in March while it normally should have around 80-100 lx. Too dim spaces include Kitchen which had little or no light with only 148 lx in June. This caused by the use of a blind façade that was chosen as a design strategy regarding privacy issues due to neighbor building located closely.

3.1.2 Improved situation of Hp_01

The continuation of the first floor slab on both north and south sides of the was used to provide shadow over lit spaces affecting living room and both workshops. Natural shading was also part of the improved scenario by including deciduous tree (or evergreen) in the courtyard which affects the intensity of light entering in the living spaces and working areas too. Furthermore, a careful selection of glazing transmittance (lower where needed) contribute reducing illuminance levels. Surely the kitchen needed an opening, this is done so being careful not to opening it somewhere where it would face the window of the neighbor building, to gain natural daylight through the day.

Figure 6 and *Figure 7* below show the simulated daylight factor for the Hp_01 and Hp_02 of the base case and improved scenario. The graphs show the Daylight factor measured at work plane height in the different rooms of the house for evaluating the light levels.

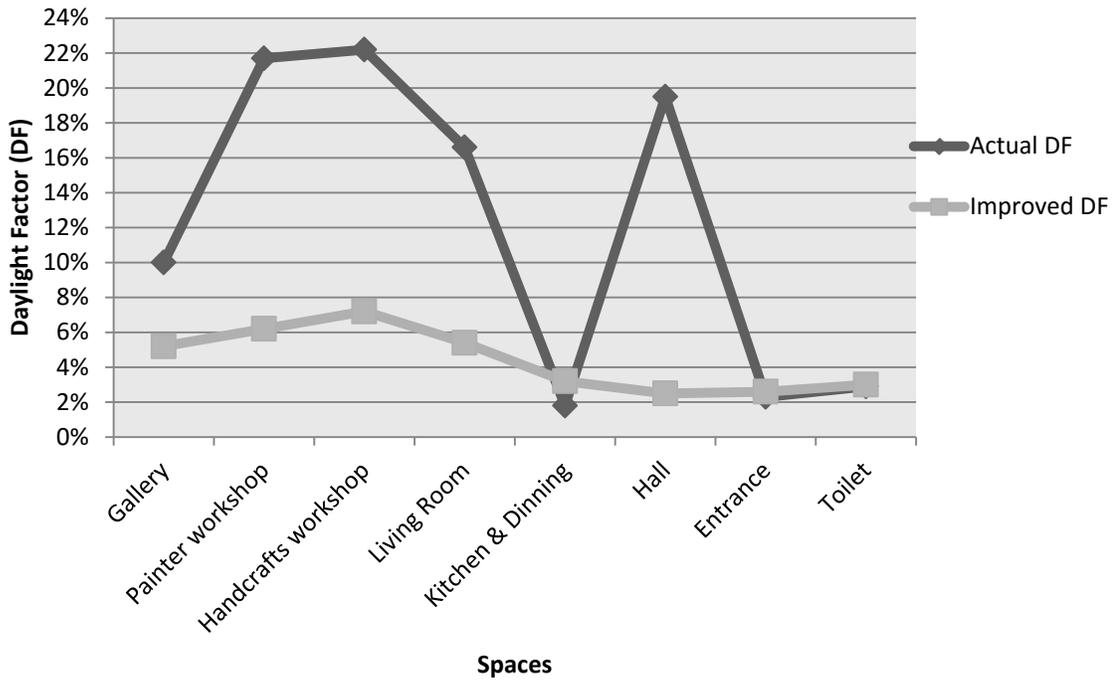


Figure 6. Comparison of the simulated daylight factor of HP_01

The main element that contributed to lower the level of light entering the building was the natural shading tool: the tree. Positioned in such a way that it would not become an obstacle for circulation, it lowered the number of lx in living area to 526 lx in June, 598 lx and 693 lx in two workshops, 480 lx in the gallery and 130 lx in the corridor. The extra opening in the kitchen increased the lux, with this space now having 305 lx. Table 5 represents the daylight factor improvements for each space, respectively it varied from 2% to 5%, only exceeding to 7% to workshops, where detailed work was produced, and therefore more light was needed.

3.1.3 Hp_02

Table 5 and *Table 6* show the daylight performance of Hp_02 evaluated by simulating the illuminance levels in different parts of the house during March 21st, June 21st, September 21st and December 21st at 12:00 under a CIE intermediate sky. Each table shows the comparison of simulated luminance levels of the actual case and the improved scenario. First Floor, where the more commonly used spaces as living and dining areas are positioned, represents a very high illuminance values in all the spaces as a result of glass facades located on East in front of the lake side. Nearly the same problem were faced also in the second floor spaces where are found the sleeping areas.

Table 5. Comparison of the simulated illuminance levels of ground floor, HP_02

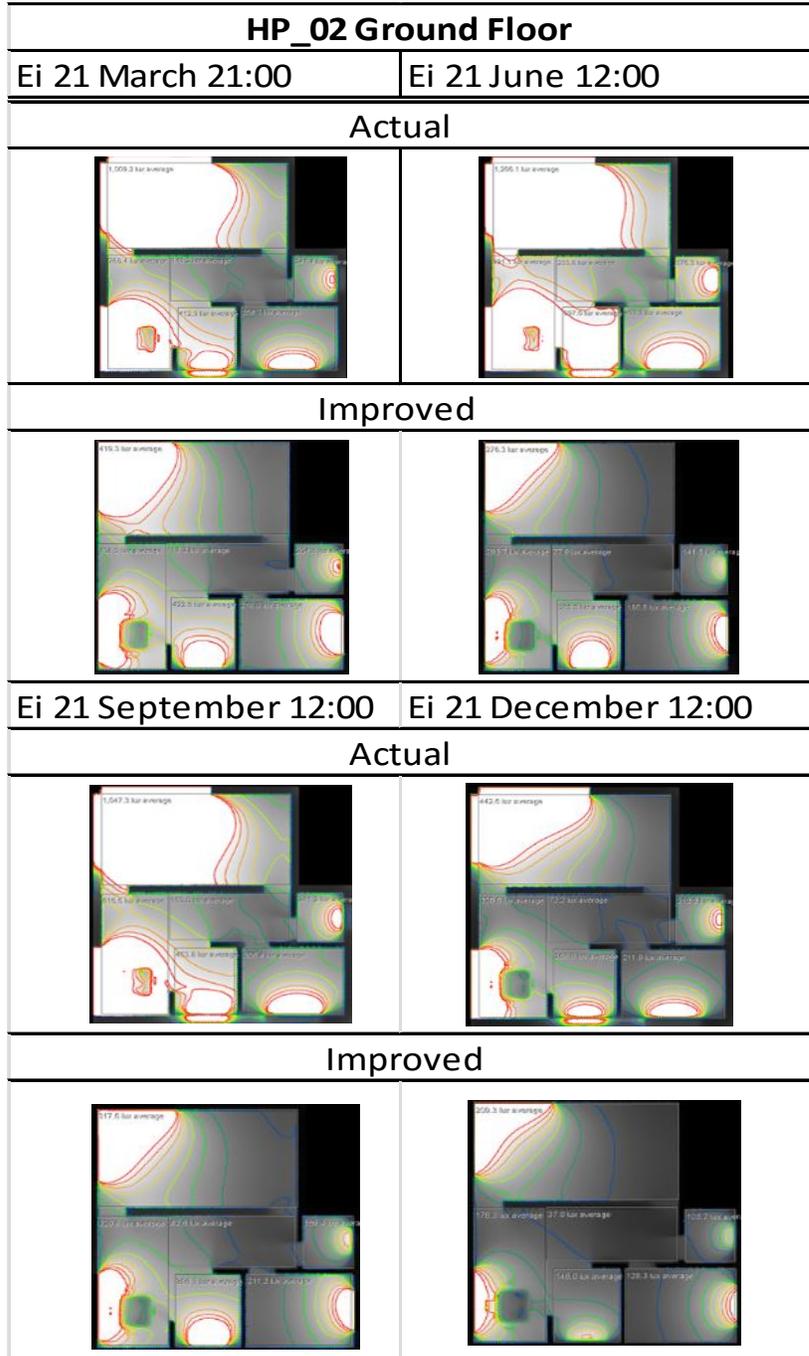
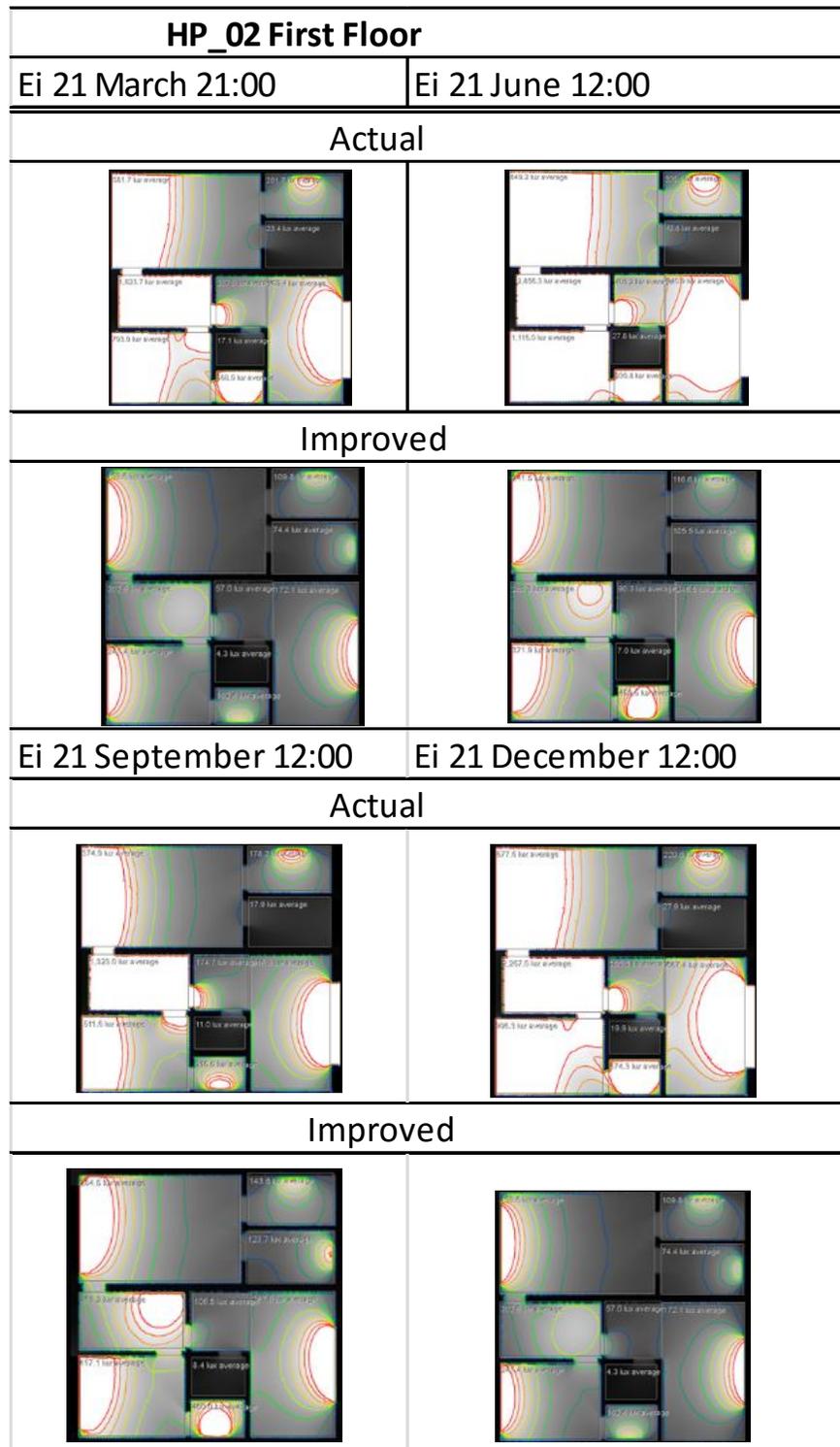


Table 6. Comparison of the simulated illuminance levels of first floor, HP_02



3.1.4 Improved situation of Hp_02

Intruding the windows 30 cm in order to create shading was used in order to optimize the illuminance levels in the living room, then by slightly changing the sizes of the windows and adjusting glass transmittance, to reduce the entering of the light in the spaces. In the space number 4 which is the guest room, was changed the window position to South in order to get better lighting through the day. For archiving light in Space number 3 which represents the closet for the master bedroom had no window so an opening was created.

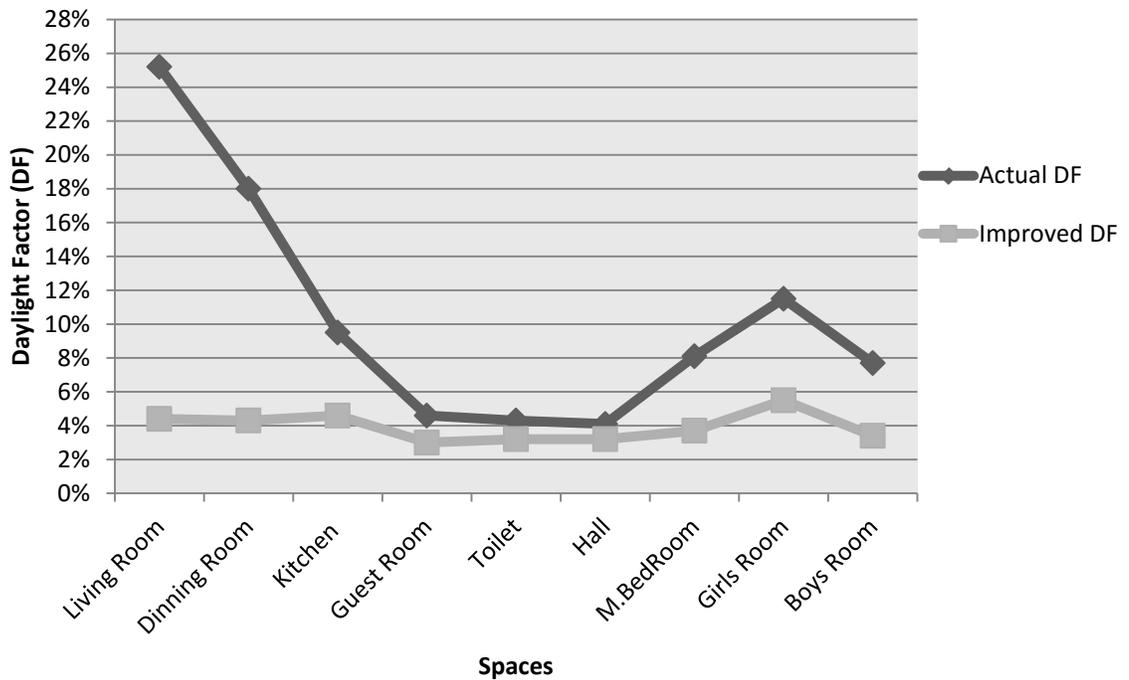


Figure 7. Comparison of the simulated daylight factor of HP_02

The integration of adequate Natural lighting levels into aHp_02 can be seen in the table 6. It reflects improved daylight factor of the base case and improved scenario. It clearly shows the effectiveness of the implemented strategies within a space. By adding openings at the right locations when values are below standard values, and reducing their number (one of the strategies) when the values are above standard values. But not only size plays an abundant role in progression, but also transmittance of the windows, shading systems, exterior/interior shutters etc.

By doing this study, we have come to a conclusion that by applying all the aforesaid ways, the values of Illuminance and Daylight Factor have achieved quite immense improvements. Since in the Actual Situation the overall estimated rates were higher than the normal conditions, the Improved Scenarios show a much developed design in terms of lighting issues.

3.2 Thermal Performance

Figure 8 and *Figure 9* illustrate the comparison of the simulated heating loads for all scenarios of the two villas Hp_01 and Hp_02.

The actual value of the energy consumption for Hp_01 per m² was 66.88 W/m², according to the European Union This value should be Albania is about 50-55w/m² [European Union., 2016]. Energy consumption is directly related to the comfort of the inhabitants, which is one of the main objectives of architecture and also with the economy of the design.

Figure 8 shows different approaches in order to decrease the value referring to the scenarios by making some changes in the materials used in Ecotect. Each scenario shows the process attempts from S1 in which increasing the insulation in the walls and

in the ceiling from 5cm to 10 cm and changing the glazing from double to triple reveals slightly changes in the value. The report proved that a triple glazing would be more effective for HP_01 than a double one. Also the right U-values gives better results. The increase in wall insulation seemed to decrease the value of consumption; meanwhile the results prove that an increase in Ceiling insulation was not necessary. Meanwhile after checking the results I saw that an increase in ceiling insulation was not necessary.

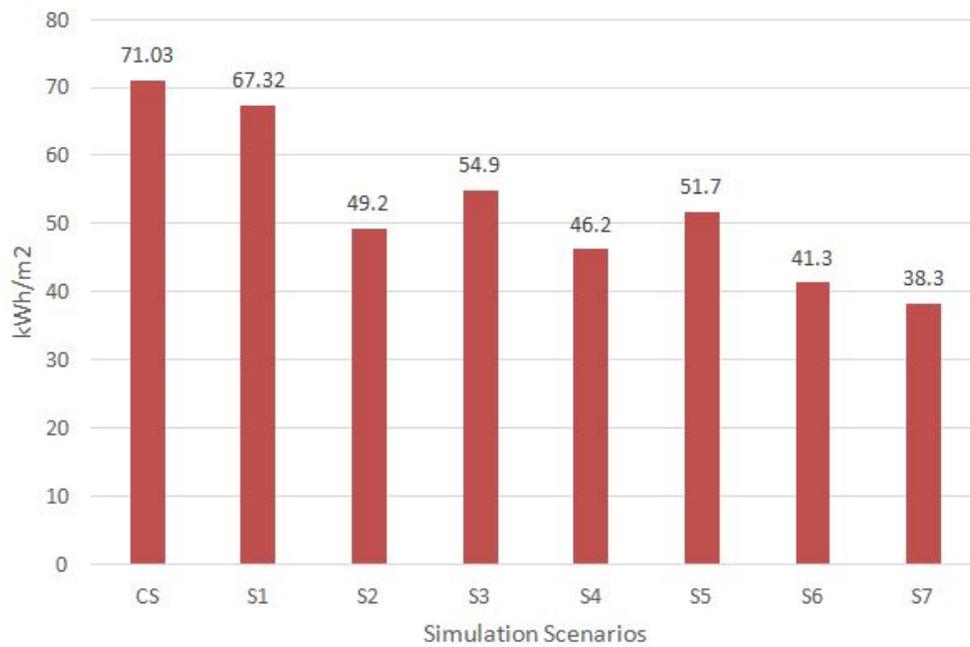


Figure 8. Comparison of the Simulated Heating Loads for all scenarios HP_01

After providing different options for the materials and layers and simulating through Ecotect the achieved graph that shows the consumption of energy/ m² for Hp_02 as shown in the (Figure 9).

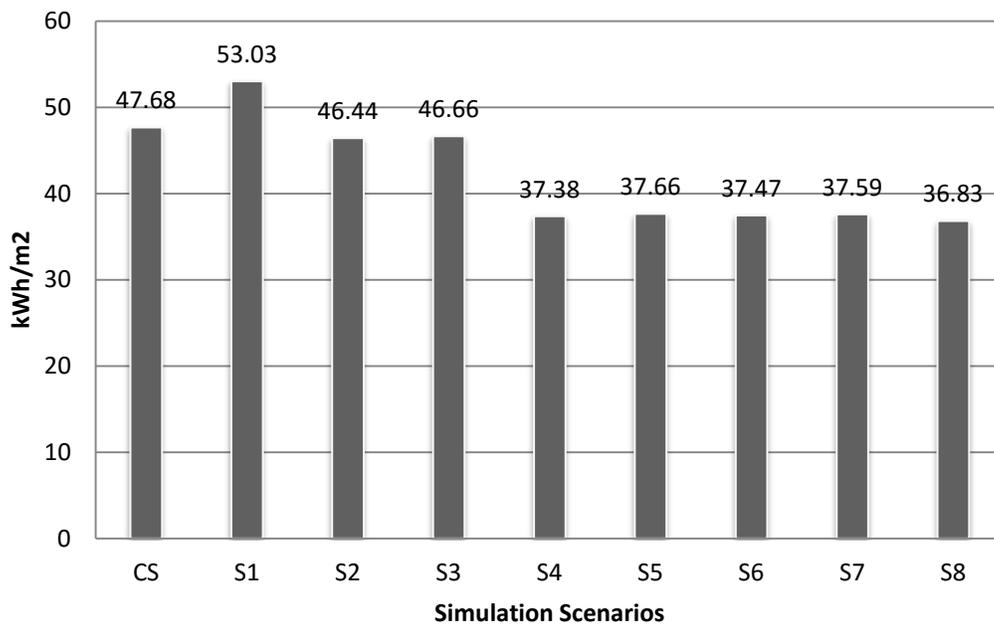


Figure 9. Comparison of the Simulated Heating Loads for all scenarios of HP_02

The graph reflects changes that are made in eight different scenarios. It's evident from the graph that if triple glazing is used instead of double glazing the change is really small but the difference in price is high so it suggest as a better option double glazed instead of triple. When it comes to insulation, the difference between 5 cm to 10 cm is very high and the cost is higher also, but if it is considered in long terms the economical savings throughout the years is a preferable choice. The lowest value is accomplished by combining the three

options, but the cost in this case tend to be very high and the difference of energy consumption low. In both cases, the scenario 7 shows the best option reducing the heating loads up to 32.7 % and 10.8 % for Hp_01 and HP_02 respectively.

3.3 Questionnaire

Based on the responses to the questions in Table1 to 10shows the main interview results of the questionnaire. The questions were based on a five-point Likers scale.(Figure 10 - 19)

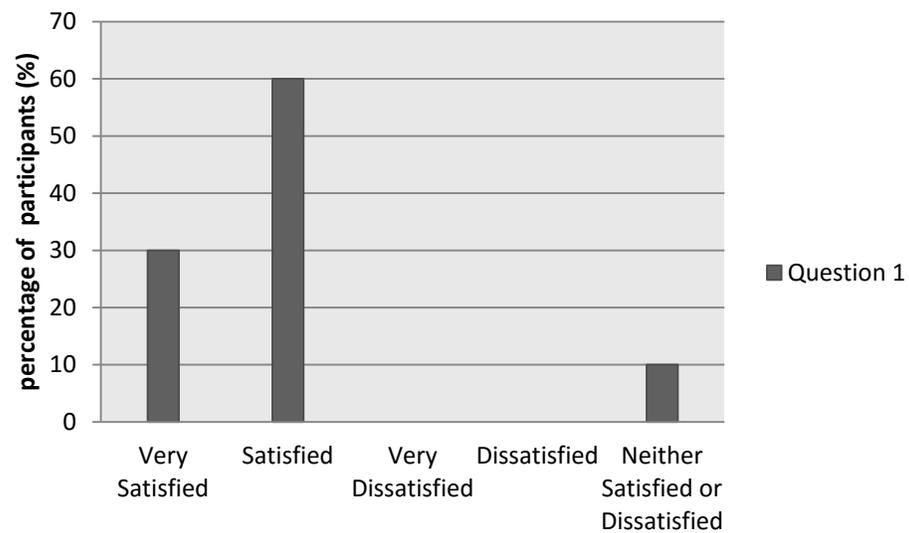


Figure 10. Question 1: The stimulation programs were easy to work with.

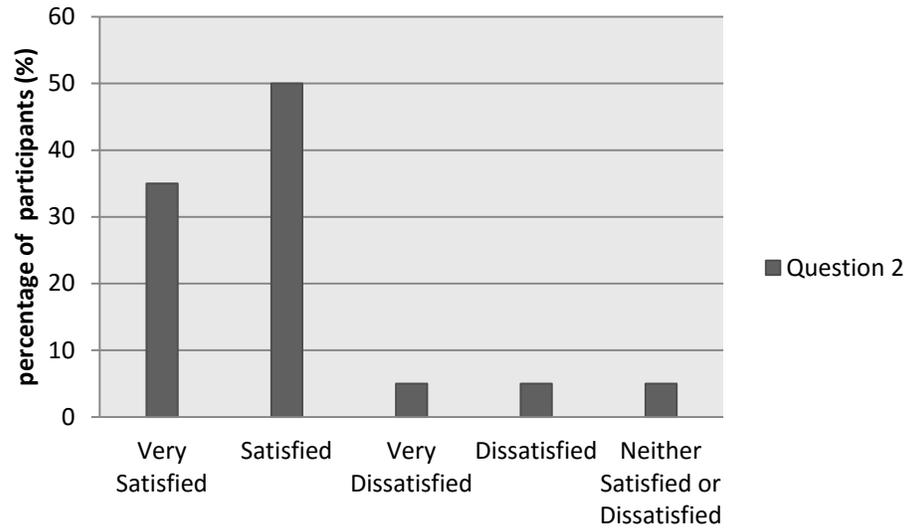


Figure 11. Question 2: I can easily create geometries.

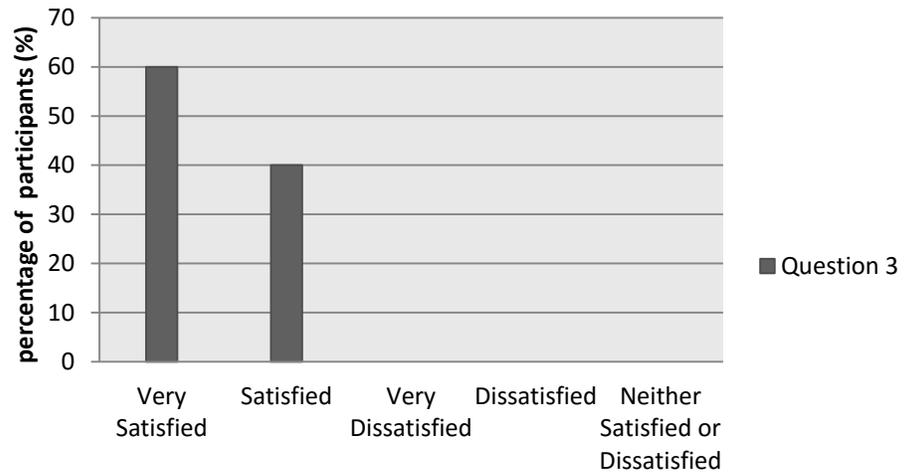


Figure 12. Question 3: The simulation test/results helped me to create a better idea about building performance

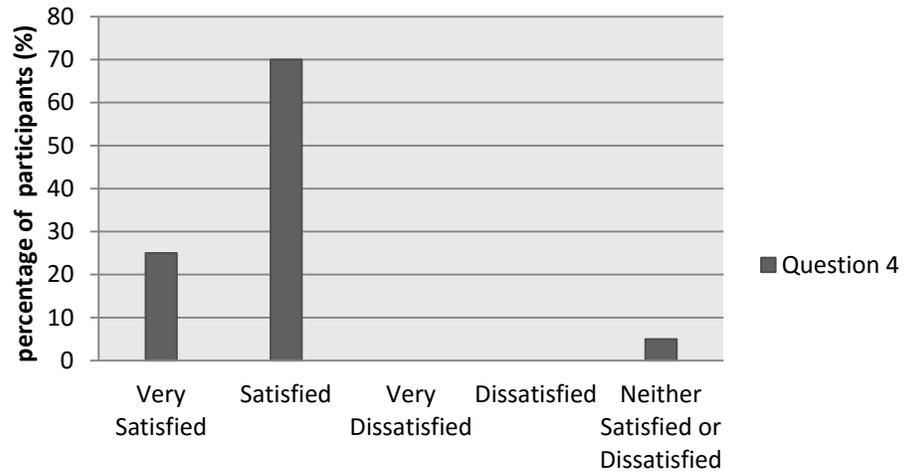


Figure 13. Question 4: Simulation programs are proficient tool to evaluate design strategies.

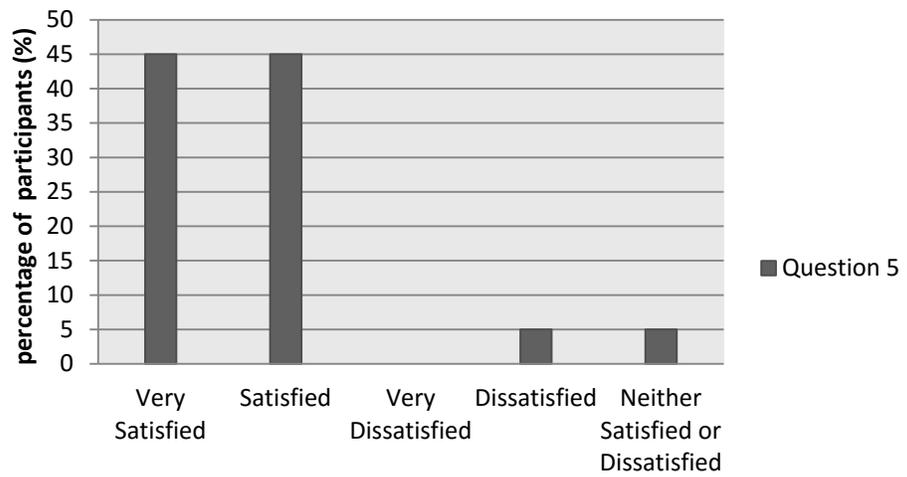


Figure 14. Question 5: I can understand properly the steps of the process.

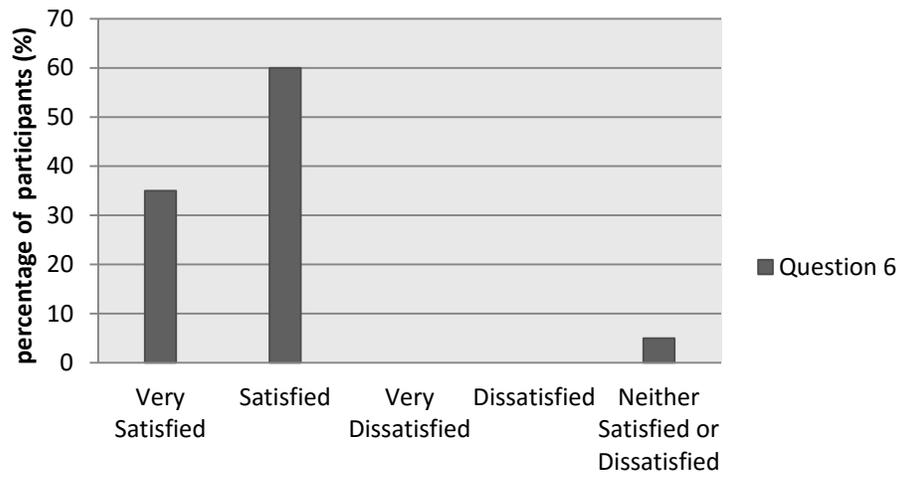


Figure 15. Question 6: I can follow instructor-the interface of the program was user friendly.

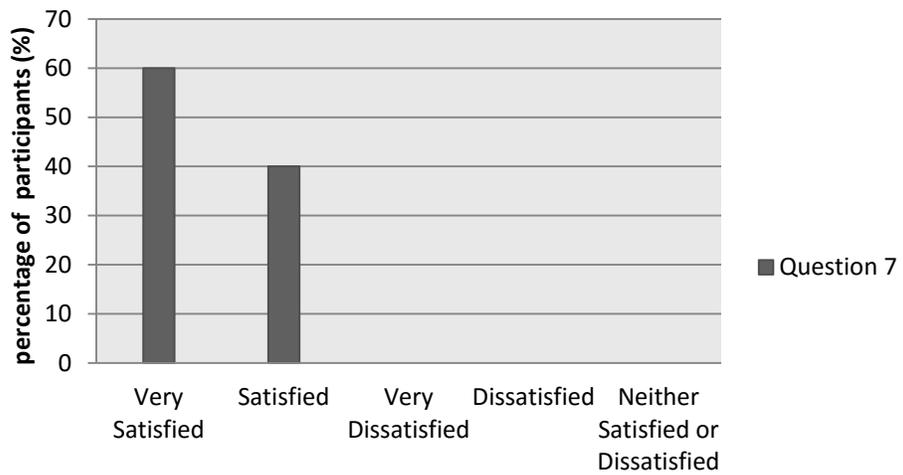


Figure 16. Question 7: The use of the simulation tool helps me to create a better understanding about daylighting.

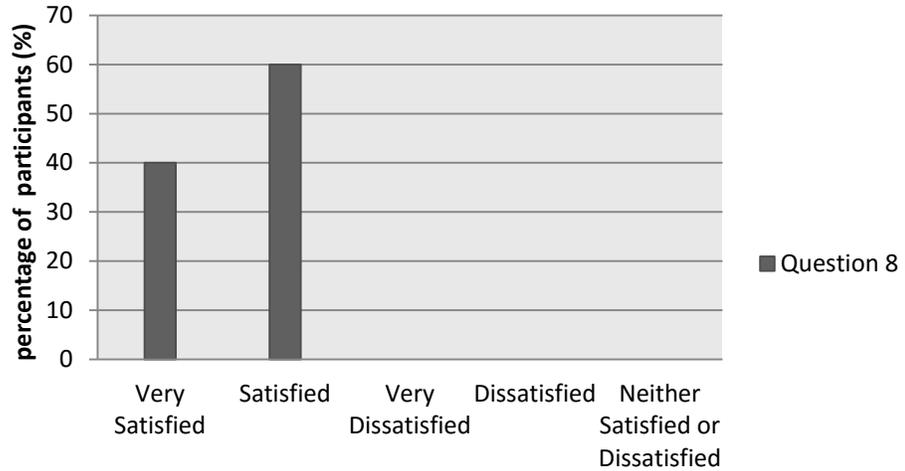


Figure 17. Question 8: The use of the simulation tool helps me to create a better understanding about thermal performance.

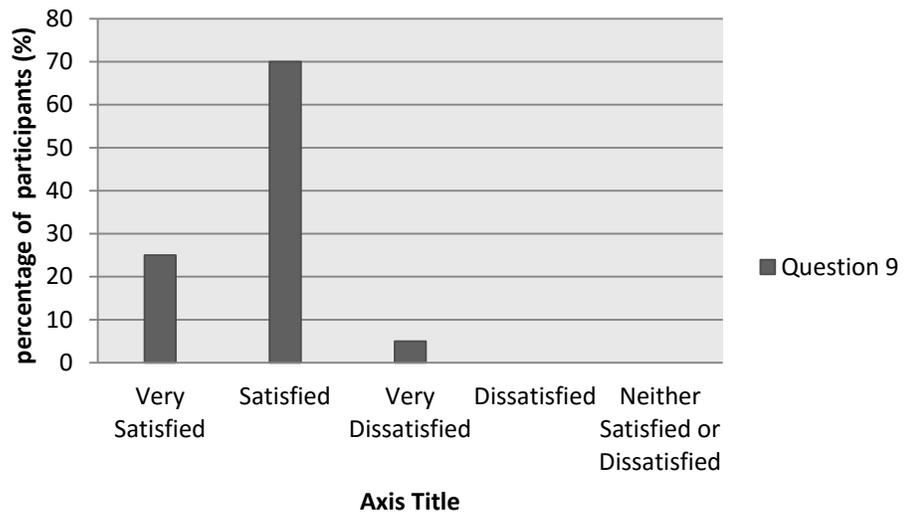


Figure 18. Question 9 : After the course I find simulation programs as an important tool to a archive qualitative design.

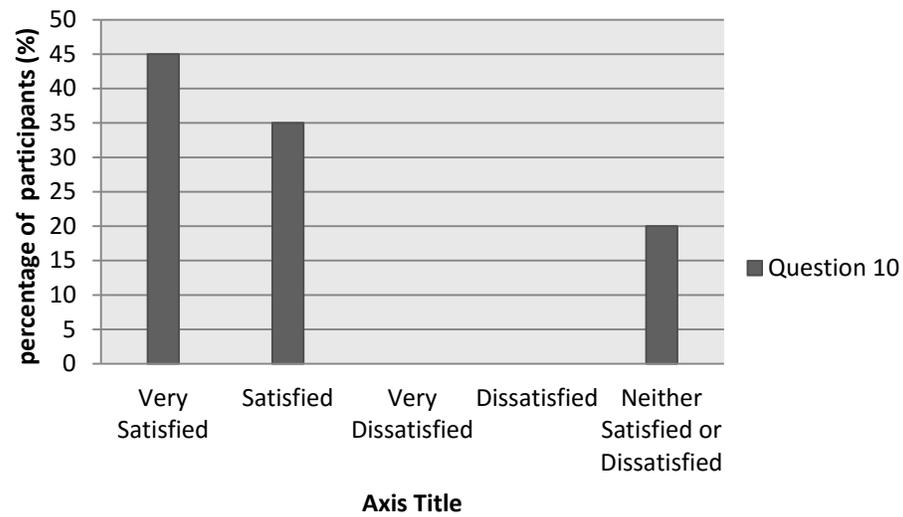


Figure 19. Question 10: I think that simulation programs should be used in early stage design

The review of the responses from the questionnaires leads to a number of observations.

- More than 90 % of the students were able to work simulation programs without any major impediment. (*Figure 10.*)
- A considerable fraction of the students perceived the role of the simulation tools and performance assessment as integral tool to the design process.*Figure 12. and (Figure. 14)*
- By the use of the simulation tools students show to create a better understanding regarding building performance.

- To the question if the use of the simulation tools helped them to create a better understanding the answer were, respectively; 60 % very satisfied and 40 % regarding the importance of daylight in the design process while in thermal performance the results were :40% very satisfied and 60 satisfied. *Figure. 16* and (*Figure. 17*) respectively.
- Based on the results the students found the interface of the program and the instructor elucidation as proficient user-friendly at usage of the simulation programs. (*Figure. 15*)
- The questionnaire demonstrated that the 80% of the users found relevant the use of the simulation program in the early stage design. Thus, the general view is positive, because it does not only creates a new path of professional competence on the side of architects, but also because it ameliorate the preliminary stage of design (with its importance for the performance) with the benefit of timely performance analysis feedback such as in the early design stage performance. Hence, efforts to disseminate building performance assessment and the respective tools in the design development phase should be encouraged. (*Figure .19*)

CHAPTER 4

4. CONCLUSION

This paper describes the contextual framework approach for introduction of simulation as both support decision tool and design teaching resource at the undergraduate Environmental Control Studio architecture course at Epoka University, Albania. Based on the thermal and daylighting performance simulation work of the students, critically reflects the achievements and challenges faced while applying simulation in the design projects. Further thought the questionnaire output, this paper has highlighted the challenges faced at the undergraduate level while using simulation in the context of teaching design. Due to these details, simulation of the real world through different software as this thesis presents affects practitioners into understanding the process to its complexity. Dynamic environmental forces and processes lead the architect to many strategies or different solutions for the design. Students develop architectural understandings within a dynamic, responsive and adaptive ecological context.

The use of Velux result quite helpful in giving us detailed information on an important aspect of design like daylight. As elaborated in the students' work, students' output - the usage of simulating programs such as Velux reflects their understanding of the software and their learning outcomes. Since light have a huge impact on design strategies, daylight simulation contributed to the students' knowledge regarding certain decisions about glazing, orientation, shading and the role of the vegetation in controlling direct sunlight. Being aware of the decisions about daylight during the early stages of design simulation tool helped to elaborate more the project based on scientific data and have correctly designed spaces. Students work and outcome clearly demonstrates that

students adopted software like successfully at archiving adequate lighting levels and also enforced more the importance of natural daylight thought critical thinking to come up with a fully completed design. Even though it result bit problematic when it comes to creating complicated geometries straight out from Velux referring to the questionnaire response, still it did not show problems with importing the 3D files from other sources.

Based on the analysis via Ecotect, Simulation tools show to be quite helpful to determine the problematic that the building may have before it comes to life. So the choice of the materials is very important and in close relation to the location and orientation also. As in the case of Hp_01 and Hp_2 , where the change of the window layers had a significant influence in the performance of the villa, by settling its energy consumption value very close to the standards. Regarding the usage of simulation program was realized that different thickness of insulation and different materials change the thermal performance of a building and also affects the final cost of the construction .Simulation model was used to parametrically explore building features and operational options that could be that could be beneficial both energetically and environmentally. Specifically, certain combination of improvement measures improve the thermal performance of the building in the climatic situation of Tirana ,Albania and it is evident that the design and orientation play the most important role in the thermal performance of a building. Still, simulation tools are quite helpful to determine the problems that the building may have before it is built. So materials selection is of great use in this stage of the whole process. As in the case of Hp_02, where the change of the typology of the wall had a significant influence in the performance of the villa, by settling its energy consumption value very close to the standards set by EU.Although 'Ecotect' had some difficulties in creating the spaces because they would overlap, the program was much helpful in understanding better the inside of a space and the treatment and the effect of materials in decreasing or increasing the cooling/heating values. Also it is clear that sometimes the usage of much more costly resources is better because that investment is taken back throughout the years. Sustainable design is more

important than ever. Building information modeling solutions make sustainable design practices easier by enabling architects and engineers to more accurately visualize, simulate, and analyze building performance earlier in the design process. The intelligent objects in the building information model enable the advanced functionality of the desktop and web-based tools that are included with Autodesk Ecotect Analysis software. Using Autodesk Ecotect Analysis, architects and designers can gain better insight into building performance earlier in the process, helping to achieve more sustainable designs, faster time to market, and lower project costs.

Moving on to the survey, there was a questionnaire-based interview of 20 students giving their feedback about use of the simulation tools. The main purpose of this survey is to understand the feasibility of different simulation tools, such as Velux visualiser and Ecotect, and importance during training sessions. Ecotect as a tool that evaluates buildings during different stages, while Velux deals with daylight comfort. More than 80% of the users found it relevant the use of these programs to improve their design. As a result undergraduate students found it appropriate use the simulation tools and the theoretical background behind them as useful strategy in as an important factor to the design concept and building comfort. Despite that they agreed that these tools were very useful to understand the design concept and building comfort. These types of tools should be more integrated in architectural education, thus to increase the level of conceptualization and take design skills to another step.

Nevertheless, the design process shouldn't be limited by the use of the software in a way or another, despite its powerful capabilities. He use the software should be in best benefit, not to let it overrun the process. It's important to evident that architectural education constitutes both the sociocultural and professional challenge of the contemporary world. Students should be able to conceptualize, design, understand and realize the act of building within a context of the practice of architecture which balances the tensions between emotion, reason and intuition and which gives physical form to the need of society and the person itself Nevertheless, we must keep in mind that user

friendly and less complicated software will makes it easier for students to digest the information. The conclusion is that simulation tools are very useful for students and should be implemented in order to increase the professional competence of future architects and engineers to increase the performance in everyday work and projects.

CHAPTER 5

PAST RESEARCH

Nowadays, most of the architecture schools are in a turning point to transform the contents of their programs towards sustainable design and energy efficiency. In some schools, the process runs swiftly as the other ones have some difficulties in altering their teaching methods and their contents. It is not easy to change an entire education program at once, but it is possible to transform it smoothly through time with different interventions. Lectures, seminars, workshops, elective courses and such single attempts are very important as they might be the starting point for the alteration of the whole program. Such attempts have to vary and increase in numbers in time. To prevent the impression that those attempts are single and inefficient implementations, they have to be followed and supported by different activities in the curriculum. On the other hand, academies have the mission of being the reference point of the profession in their field of interest. In this case, architecture schools are the first and one of the most important places where the students meet the discipline of architecture and also the place where the shape of the architectural tendencies in the future take form. The school might not only reflect the realities of genuine professional world the students will encounter after they have graduated, but also feed the architecture discipline with new approaches and solutions evolved in researches conducted by its members. Consequently it is a fact that the energy efficiency and sustainability issues will get into the contents of architecture school sooner or later, as it is approved that the energy and resources problems in the world are permanent for the rest of the time. The important point here is that the transformation process of the schools cannot be too long as the energy and resources problems are getting bigger every day. Architecture schools should prepare their strategy to embed energy efficiency and sustainable design principles into their programs and perform the strategy swiftly. The schools which do not fulfill this process

in a sufficient period of time might face the danger of being out of date and inadequate compared to the rest of the schools in the world. To deliver low impact buildings and fill the gap for architects to deliver the design, the loop between building design, operation and performance must be closed. This will be especially important and useful at the early stage of the design process, where major decisions that affect the building usually take place. This can only be achieved by developing tools that follow the integrated design process. It should fit into architects' way of design decision making. The tools developers should realize that to develop architects friendly tools, decisions are broad, at the early design stages and there is minimal concern for detail. Tools for this stage, should allow the description and simulation of building in fewer minutes without substantial training on the part of architects. The results from such output should be in a form that can be understood even by non-experts and be able to give architects a quick and accurate output with minimum input. This is because, at this stage of the preparatory studies, the focus is mainly on the differences between different design alternatives, therefore, computations and all simulations should be performed quickly and effectively. Characteristics, such as degree in the pliability, precision, data input, among others, should be taken into consideration when developing software tools for this stage. Consequently, enough flexibility and low input information schema, amongst other requirements, are identified as being necessary in BPES tools for the early phase of the design process. As the project progresses, decisions become more refined as the focus is on very detailed aspects of the design. In general, data exchange at this stage needs to become more sophisticated, innovative, credible and less error prone, so that practitioners can integrate these tools more smoothly into practice. Requirements of BPES tools targeted for It is not impossible for an architect to improve himself and advance in knowledge about new technologies by his/her own, but the more appropriate way is that the architectural institution which educates architects equips its students with the necessary knowledge and consciousness about the actual circumstances of the world.

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