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MIXED REALITY FRAMEWORK FOR ARCHITECTURAL DESIGN EDUCATION

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MIXED REALITY FRAMEWORK FOR ARCHITECTURAL DESIGN EDUCATION

Abstract

This study introduces a framework to build a new concept of architectural education based on the idea of Mixed Reality (MR) as a technique of merging real and virtual learning environment, studying its impact on the education curricular contents and the course outline especially in design studio courses to provide new possibilities for innovation design. the study aims to achieve strategies to design a model for architectural design education with the focus on the concept of design studio's evolution through the analysis of its basic components, between Mind (Think of the human factor), Reality (spatial factor for the design process), Media (tools used in Design) and the work organization in the studio between students and instructor/s and the Design Processes from the pre-design stage to design development stage.

Keywords

Mixed Reality; Augmented reality; Collaborative learning; Design studio; Educational technology.

MIXED REALITY FRAMEWORK FOR ARCHITECTURAL DESIGN EDUCATION

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ABSTRACT

This study introduces a framework to build a new concept of architectural education based on the idea of Mixed Reality (MR) as a technique of merging real and virtual learning environment, studying its impact on the education curricular contents and the course outline especially in design studio courses to provide new possibilities for innovation design.

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KEYWORDS

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1. INTRODUCTION

Bridging the gap between the virtual and the real world, Technology will change the way we see the world in relation to scientific discoveries and technical inventions. Digital technology has brought a series of major changes in the way we see and recognize the world, including our sense of space and body. While telecommunication technology has been influencing our notion of space and distance, digital imaging technology has blurred the boundary between the real, physical world and imaginary worlds.

Mixed Reality as a popular technique in Human-Computer Interaction (HCI), which deals with the interaction between the user and the computer, especially in the field of combining virtual and real-world elements (J. Young, E. Sharlin, & T. Igarashi, 2011), had an impact on the areas of human life, in particular the fields of architectural practice and education through design studio, which gave new opportunities for the development of architectural design and thinking process in relation with Studio Based Learning.

The design studio, as both a learning environment and a social place, is one of the major components of architectural education. Which consider as a Crucible to melt all design inputs from data, analysis, ideas and alternatives to solve the design problems, traditionally, the studio has been considered a place for individual design work and one-on-one mentoring between an instructor and a student. With the integration of new information and digital technologies, the nature of the design studio and the learning processes within it are being altered, this new landscape of the design studio offers opportunities for globally distributed collaborative work as well as new interpretations of design processes and studio practices. The technologies and the studio system are interwoven and their symbiotic relationships need to be understood (Yee, 2001).

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Therefore it's important to focus on the concept of design studio's evolution through the analysis of its basic components as an approach to achieve strategies to design a model for architectural design education.

2. THE ARCHITECTURAL DESIGN STUDIO

The term "studio" has a long and evolving history. It has meant many different things to many types of people. Today, the studio is seen as a place to learn, a place to work, a place to create, and a place to perform; it is even known as a domicile in which to live. As historic shifts occurred within the various fields and professions that the studio space served, the studio's uses became more specialized and its identity became more diversified. Starting with its beginnings as a non-defined location in which ancient "artifactual" art forms or architectural embellishments were created.

The design studio, is one of the major Components of architectural education and practice due to the main role in design thinking process, where the designer moves from the learning to the Practice through the design studio to create new architectural ideas influence the field of architectural education which makes it there a mutual impact between them. (As shown as Fig. 1)

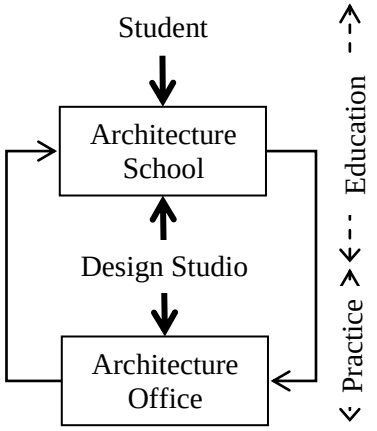


Fig. 1. Influences between architectural education & practice
Reference: - Author

Traditionally, it has been seen as the most important part of the educational curriculum in schools of architecture. The place where students are expected to grasp, present, and defend design ideas, and acquire new techniques and skills (Casakin, 2004) , Grounded by its formal origins in the Ecole des Beaux-Arts, the prestigious French design school.

3. DESIGN STUDIO COMPONENTS (M.R.M MODEL)

The design studio as the primary environment for learning and teaching design, which consider a Crucible to melt all design inputs from data, analysis, ideas and alternatives to solve the design problems, it can be analyzed to the main components Represent a design studio triangle-titled by the author- as **M.R.M MODEL** which contains **:-** (As shown as Fig. 2)

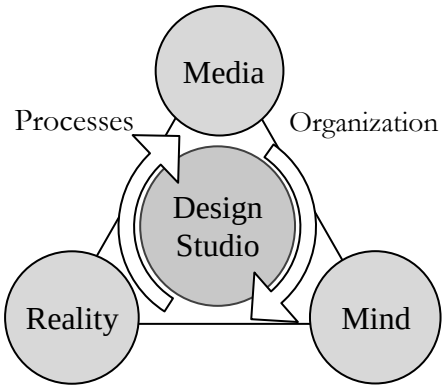


Fig. 2. Design studio components (M.R.M Model)
Reference: Author

1. Mind (Human Factor):

   All participants included in the studio through the specific roles, relations and interaction between them, including students and instructors in Education field, and including client, designer, team work and contractors in Practice field.

2. Reality (Spatial factor):

   The physical environment where design activities is done, it can be located in architectural schools or firms.

3. Media (Technology factor):

   All design aided tools used in creating new possibilities for innovation design.

   These fundamental elements affecting the design studio needs for the existence of two additional factors to organize and process the activities through the design studio, as: - (Yee, 2001)

4. Organization:

   The work organization between students and instructor/s, It includes organizational, administrative structure within the design studio and the flow of information.

5. Processes:

   Learning and practice activities and operations within the design studio from the pre-design stage to design development stage.

There are a need to study the relationship between these basic components in education and practice fields to achieve strategies to design a model for architectural design education as follows:-

3.1 Mind –Reality Relation – Origin of the Design Studio

We can study the origins of the design studio in architecture before the digital era, through the study of the changing role of the architect in practice and education–as Human Factor (Mind) - in relation with The physical environment where design activities is done –as spatial factor (Reality), which can be divided into three Main Stages in architectural Practice and education (Lawson, 2005) as follows:-

a) The Vernacular or Craft Design Stage (The design studio was in real site)
   - The origins of the architectural practice began through designing by making or building, using the trial and error methods until the designer learned to solve the problems or the building is success then repetition of solution or design using local material and local methods of construction, the architect was called the master builder. (Lawson, 2005)
   - The informal architectural education began through learning by doing and training in real site, junior builder join the construction site In order to learn within observation, trial and error and tradition to be skilled and one day becomes a master builder.

b) The Design by Drawing Stage (The design studio was in Architectural firm)
   - In architectural practice, the separation of the designer from making results in a central role for the drawing. “This separation imply the split between handicrafts and design. This was associated with the transformation of the building from technical crafts to liberal arts, from bricklaying to mathematics, and from architecture as a practical profession to a learned field of study. This transition had effects on the professional practice, drawings became more necessary and gradually replaced models” (Salama, 1995), if the designer is no longer a craftsman actually making the object, then he must instead communicate instructions to those who will make it. Primarily and traditionally the drawing has been the most popular way of giving such instructions (Lawson, 2005), Drawing and design was done in real place within the Architectural office or firm ,this place called the Drafting /Design Studio, the term of Architect was began to use under Professionalism Standards.
   - The architectural education was by sending juniors to the Architectural offices to train under supervision of Professional Architects.

c) The Design as a science Stage (The traditional design studio-formal Education)
   - With the increase in the number of students, it originated the idea of formal schools from Ecole des Beaux-Arts in France -Ateliers Model (Yee, 2001), and later Bauhaus in Germany-Workshop model, that established the architectural concepts of education, formed the traditional design studio in architectural education and practice. (Salama, 1995)

3.2 Media–Reality Relation – Mixed Reality

"The infusion of digital media into the practice of architecture is changing how we design as well as what we design, digital media has altered the process of design and the culture of design education" (Norman, 2001), led to emergence of new areas of design such as - Computer Aided Architectural Design –C.A.A.D, and Computer Aided Manufacturing-C.A.M which had an impact on the Transformation to Digitalization from Traditional Design Studio –T.D.S to Digital Design Studio-D.D.S in the fields of architectural practice and education.

Mixed Reality as a popular technique in Human-Computer Interaction (HCI), which deals with the interaction between the user and the computer, especially in the field of combining virtual and real-world elements.

In 1994, Paul Milgram and Fumio Kishino defined a Mixed Reality as "...anywhere between the extrema of the virtuality continuum." (Milgram & F. Kishino, 1994) , where the virtuality continuum extends from the completely real through to the completely virtual environment with Augmented Reality and Augmented Virtuality ranging between, to produce new environments and visualizations where physical and digital objects co-exist and interact in real time through four main environments, as follows:- (As shown as Fig. 3)

a) Real Environment (RE)

It is the environment where we live and interact through real objects and stuff, and this is the environment in Real Design Studio.

b) Augmented Reality (AR)

It merges the virtual Elements with the real actual environment that the participant can see the actual surrounding environment combined with computer generated imagery. (Yuen, S, Yaoyuneyong, G, & Johnson, E, 2011)

c) Augmented Virtuality (AV)

A situation in which a virtual world is augmented with real-world objects or information, augmentation of a Virtual Environment with real objects. (SCHNABEL, 2009)

d) Virtual Environment (VE)

It is a complete virtual environment does not exist out of the real world and also called Cyberspace which is "An infinite Artificial World where humans navigate an information

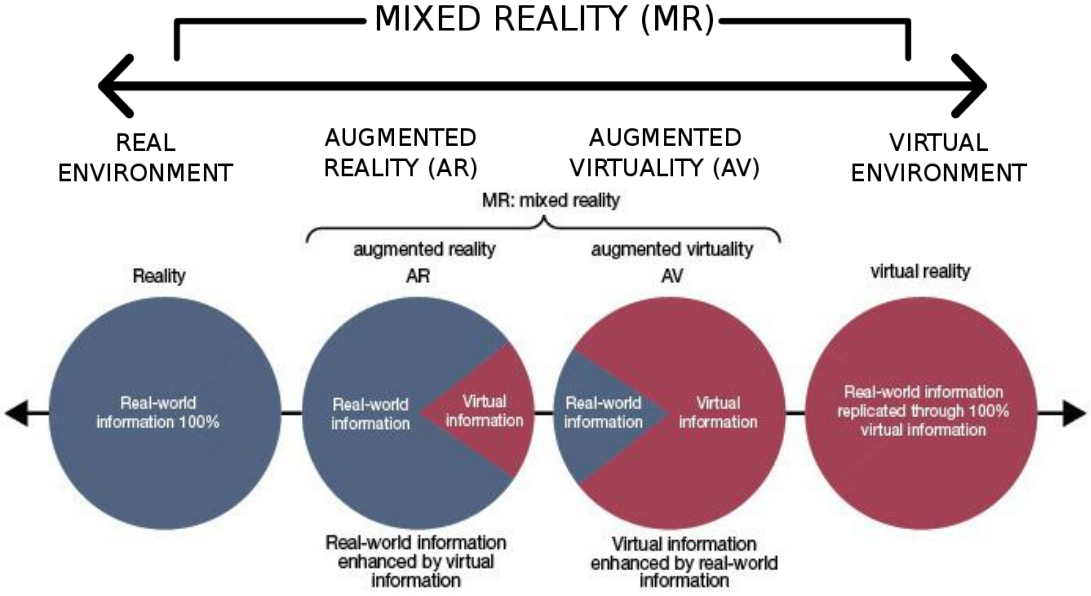


Fig. 3. Reality-Virtuality Continuum – Mixed Reality
Reference: (Milgram & F. Kishino, 1994)

based spaces." (Bertol & Foell, 1997)

3.3 Mind – Media Relation – Multi-design worlds

This part according to the study of (Cerovšek, Zupančič, & Kilar, 2010) which presents the competency management approach for design in physical and virtual worlds, the approach divides worlds of design to 4 types which must be developed and refined in design education, and these themes is between: (as shown as Fig. 4)

A. Human & Computer:

The relationship between mental thinking of the designer, and the uses of digital technology in design processes.

B. Intangible & Tangible:

The relationship between all that is tangible (physical), & intangible (virtual).

This gives us four main worlds where architectural education and practice processes done, and influences on each other through the work environment and the using of the design models. (As shown as Fig. 5)

1. The Imaginary World:

   The intangible human world - using the cognitive abilities, through the imaginary environment to produce mental models in the form of creative design ideas, it could be called also the mantel world.

2. The Real World:

   The tangible (physical) human world - the physical environment exists without computers to produce physical models, providing a context for real collaborative architectural design.

3. The Mixed World:

   The tangible computer world between the real and virtual world which consider as mixed environment to produce mixed models using Augmented reality and Virtuality (AR ,AV) models , it could be called also Mixed Reality World.

4. The Virtual World:

   The intangible computer world – the virtual environments which uses computers representations to produce virtual models, providing a new context for remote collaborative architectural design.

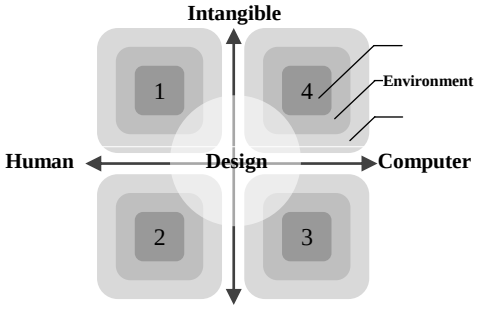


Fig. 4. Division of design worlds between Human & computer, intangible& tangible
Reference: (Cerovšek, Zupančič, & Kilar, 2010)

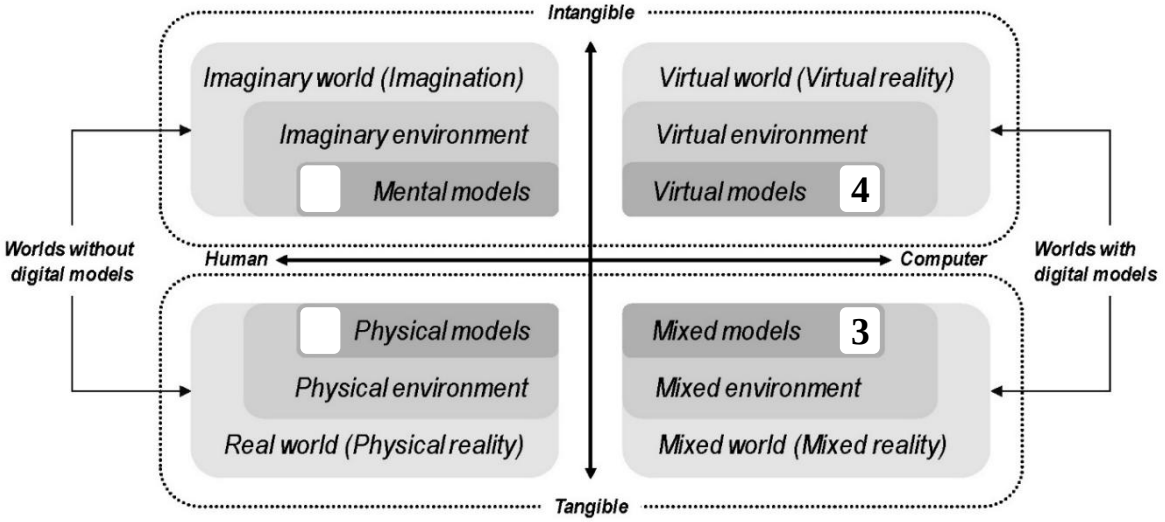


Fig. 5. Multi-design worlds, environments and models
Reference: (Cerovšek, Zupančič, & Kilar, 2010)

We can trace the design processes inside the digital design studio- D.D.S through Multi-design worlds to find problems as design inputs and solve it as design outputs, the design process begin as an Idea in *The Imaginary World* in designer mind, it can be represented in the form of digital models in *The Virtual World* and then to *The Real World* to be construct as a Physical model or represent as mixed reality model through *The Mixed Reality World*. . (As shown as Fig. 6)

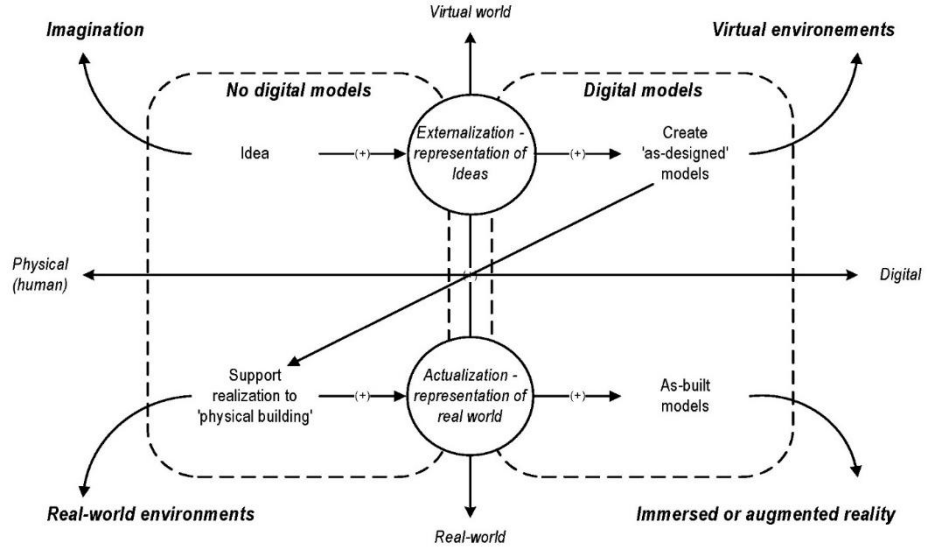


Fig. 6. Design Processes through Multi-design worlds
Reference: (Cerovšek, Zupančič, & Kilar, 2010)

4. OBJECTIVES & STRATEGIES

To design a learning design studio model to apply digital technology in the field of architectural education, through the relationship between Mind, Reality and Media (M.R.M Model),the study take the concept of digital design studio-D.D.S as a vision to design An integrated study plan for architectural design education In order to refine the student's skills and increase his experience design through individual or collective common design in the same place or remotely in multiple design environments, ranging from the real to virtual environment.

This design environment is considering as an integrated environment separate from constrains of place and time, it has many advantages in combining Real & Virtual Design Environment , Traditional & Digital Design Processes , Practice & Education Design Processes, Individual & Participatory Design and Digital design and fabrication.

Building architectural thought through integrated educational process in continuous way to a specific goal during the years of the study, using different design methods with focus on the concept of Studio-based learning.

this goal based on a Vision of dealing with Multi-dimensions worlds including the relationship between Multi-design worlds, Design & Construction Worlds, Design Education & Practice Worlds and Design & Different Scientific Worlds, this vision titled as "Multiverse Design Studio-M.D.S".

5. MULTIVERSE DESIGN STUDIO-M.D.S VISION

A design studio, which its operations done between multiple different worlds, and through several images, such as:

5.1 Multi Design Worlds

Design can be done through multi-worlds between the main components of the design studio (Mind, Reality and Media), the M.D.S aims to develop and support architectural students to gain four design levels through the learning process into the design studio, these levels are: - (As shown as Fig. 7)

5.1.1 Mental Level (1st Level)

Represent the main base and the basis for the design education as *Introductory design education* which includes the development and refinement of intellectual and cognitive skills of students and the design thinking skills and other skills that support the mental operations performed inside the studio during the design work.

Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom in order to promote higher forms of thinking in education, identified three of learning domains (Bloom, Krathwohl, & Masia, 1984) , including :-

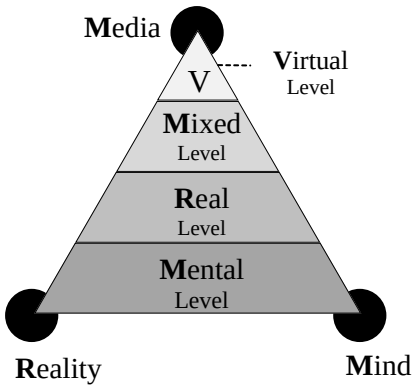


Fig. 7 Division of design Levels through the learning process
Reference: Author

a) Cognitive domain (Mental & intellectual capability, ie., knowledge, or 'think')
b) Affective domain (feelings, emotions and behavior, ie., attitude, or 'feel')
c) Psychomotor domain (manual and physical skills, ie., skills, or 'do')

5.1.2 Real Level (2nd Level)

The second level of the Design education is called *Real Design education* which concern with the relationship of human mental thinking with real Environment, this level include three of learning domains ,as follows:-

a) Design Studies I:

It is divided into two parts, the first part is the *Craft Design Studio* in order to learn design by doing, and to identify ways and building materials through the local architecture with doing a practical project using a design similar methods,

and learn to build Physical Model, the second part is the *Traditional Design Studio* in order to learn design by drawing and to learn traditional design methods.

b) Environmental Studies I:

It includes the study of Physical Environment elements affecting the architectural design studies, such as climate and the wind and the movement of the sun and site studies.

c) Technology Studies I:

It includes Physical Technology Studies between different construction technologies and design communication media.

5.1.3 Mixed Level (3rd Level)

The third level of the Design education is called *Mixed Design education* which concern with the relationship of human mental thinking - Mind with the digital Media , this level include three of learning domains ,as follows:-

a) Design Studies II:

It includes the use of digital technology in architectural design processes between traditional and digital design, real and virtual , this studies divided to two parts , the first part is the *Integrated Design Studio* in order to develop students skills in using Computer Aided Design- CAD and Building Information systems-BIM , the second part is the *Mixed Design Studio* in order to use Augmented Reality-AR and Augmented Virtuality-AV technologies in design process with support with Remote design Collaboration.

b) Environmental Studies II:

It includes the study of mixed environment between real and virtual and its effect on architectural design.

c) Technology Studies II:

It includes Mixed Reality technology to build digital models using the 3d and Mixed reality Programs.

5.1.4 Virtual Level (4th Level)

The fourth level of the Design education is called *Virtual Design education* which concern with the Digital Media in order to change design from Traditional to Virtual Design methods, this level include three of learning domains ,as follows:-

a) Design Studies III:

It deals with virtual design environments in architectural design to open new horizons for the design away from the restrictions of space and time through Virtual Design Studio –VDS and Virtual Worlds using Remote design Collaboration.

b) Environmental Studies III:

It includes the study of Virtual environment and its effect on architectural design.

c) Technology Studies III:

It includes Virtual Reality technology to build digital models using the Virtual reality Programs.

5.2 Design & Construction Worlds

Multiverse Design Studio-MDS Connects between architectural design and Construction Worlds, through the link between the fields of Architectural, Engineering and Construction,

although that the architectural practice processes is a collaboration and cooperation between these fields, but in architectural education the study of these fields is almost separate especially the relationship with the engineering branches as Civil, Mechanical and Electrical engineering.

With the evolution of B.I.M Technologies as an approach to develop the fields of architectural education and practice through the combining the fields of Architectural, Engineering and Construction in one field called A.E.C Industry, it can be through four levels as follows :- (As shown as Fig. 8)

a) Mental Level (1st Level):

Study the principles of each of the three fields separately to get to know the most important theories and learn the skills of drawing and modeling and solving various design problems.

b) Real Level (2nd Level):

Study in practical the A.E.C Industry through construction real site visit and building small physical models in order to learn engineering methods for construction.

c) Mixed Level (3rd Level):

To identify the principles of Building Information Modeling – B.I.M technology as a tool to facilitate the exchange of technological information in digital form between the parties of design process , in order to build a digital model contains the architectural , Civil , Mechanical and Electrical information.

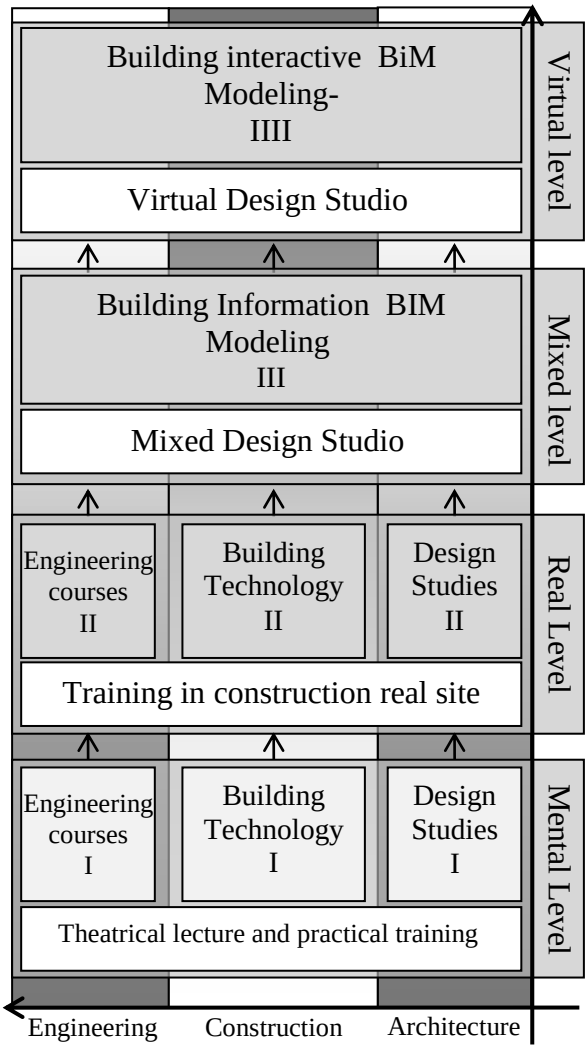


Fig. 8. Division of A.E.C studies levels through the learning process
Reference: - Author

d) Virtual Level (4th Level)

This level focuses on the use of virtual worlds as an environment to learn construction process using the functions of simulation systems instead of the traditional ways of learning through classroom, these simulation systems are through models Building Information BIM capabilities with social interaction and exchange of information supplied by virtual worlds, which can be described as " Building interactive Modeling- BiM ". (Ku & Mahabaleshwarkar, 2011)

5.3 Design Education & Practice Worlds

A design studio, which connects between the worlds of architecture practice and Education, through Participatory design, whether in the same location or remotely, allowing

test of the new design and construction methods, as well as to support the training of students in the field of practice it can be through four levels as follows :-

a) Mental Level (1st Level):

The study of the evolution history of the architectural practice, whether locally or internationally in order to Support the cultural dimension, the criticism process and the acquisition of various design experiences to the students.

b) Real Level (2nd Level):

Understanding the profession of architecture as practiced in real context by linking architectural design education within the real design studio and the requirements of professional practice to make educational programs more responsive to the needs of practical life.

c) Mixed Level (3rd Level):

Supporting the entry of digital technology in the learning processes of design, especially using Mixed Reality technology to provide tools of communication between the architectural practice and education.

d) Virtual Level (4th Level):

The use of virtual worlds in collaboration design beyond all temporal and spatial boundaries of the link between the fields of architectural practice and education, with a possibility for students from different cultures to participate in the operations of professional practice across the world.

5.4 Design & Different Scientific Worlds

Multiverse Design Studio-MDS Connects between architectural design and Different Scientific Worlds that are related to design, through four basic themes (Dilan, 2015), which are :- (As shown as Fig. 9)

a) Human - Human Science:

The study and interpretation of the experiences, activities, constructs, and artifacts associated with human as social science, Arts, History and Language.

b) Technology - Applied science:

A discipline of science that applies existing scientific knowledge to develop more practical applications, like new technologies ,Computer and Engineering science.

c) Tangible - Natural science:

A branch of science concerned with the description, and understanding of natural phenomena, as Ecology, Physics and Chemistry.

d) Intangible- Formal science:

They are disciplines concerned with formal systems, such as logic (as Logical thinking and Solving Problems) and Mathematics (as Calculus, Trigonometry & Descriptive Geometry).

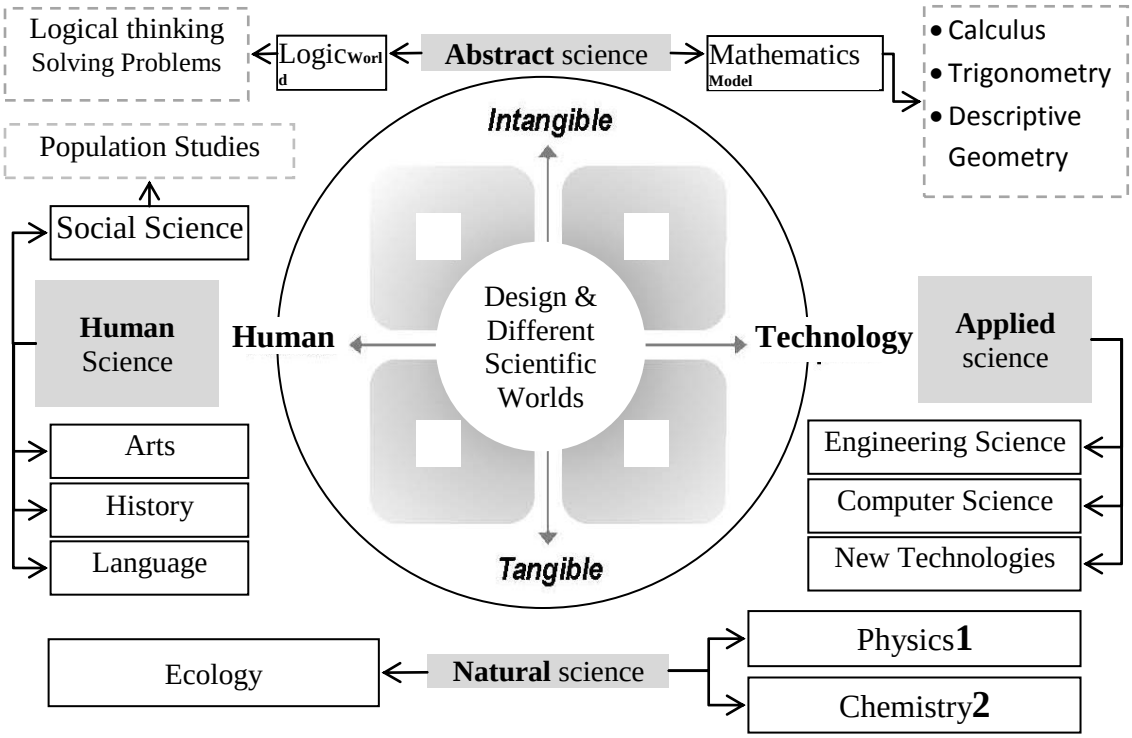


Fig. 9. Design & Different Scientific Worlds
Reference: - AuthorFig. 8. Division of A.E.C studies levels through the learning

6. EDUCATIONAL FRAMEWORK FOR M.D.S

Based on the previous studies, the researcher trying to reach the Multiverse Design Studio –M.D.S proposal as educational program, it aims to achieve a positive support to the influence of the different worlds of the architectural field and represented by four basic worlds, as follows :- Design Worlds, Construction Worlds, Practice Worlds and Scientific Worlds.

This architectural educational program will be through studio based learning over 5 years of study, divided to ten (10) semesters including a set of general studies and specialized covered courses which supports educational and design processes within Comprehensive Design Studios–C.D.S in order to provide basic knowledge, Design Experiences and Skills for the student to solve design problems creatively, therefore the proposed educational program mainly divided into two parts:-

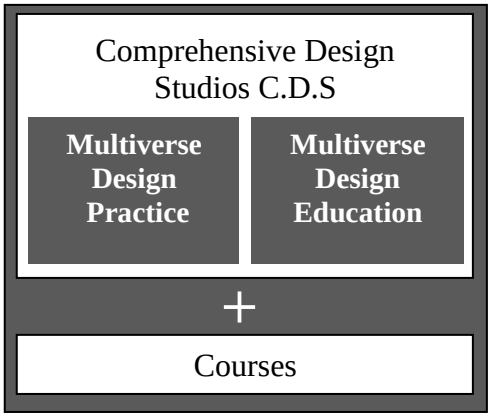


Fig. 10. Multiverse Design Studio educational program
Reference: - Author

6.1 Comprehensive Design Studios–C.D.S

Which Include ten (10) design studios divided over the five years of the study, as the basis of the architectural study, divided into two parts :-

a) Multiverse Design Education:

Included eight (8) design studios in order to develop the student learning levels from mental level to the virtual level through four years of architectural study with its relationship with the multi-design worlds.

b) Multiverse Design Practice:

Included in the last year of study through two (2) design studios, in order to Practice for the design, construction and participation with the practice field (training location or architect office) to refine the design skills through the design standards and practice, then the final Graduation Project work to apply different design levels to find unconventional solutions to the problems of design.

6.2 Courses

To support the previous design studios divided into general and professional studies according to the proposed educational model of the Multiverse Design Studio.

a) General Studies:

Including the study of science-related to architecture field, such as formal sciences such as mathematics (calculus and trigonometry and geometry descriptive, Parametric design), and the humanities and social (community and art studies, population studies and real and virtual environments), applied sciences (engineering sciences, and computer science) and natural sciences (environmental sciences, physics and chemistry as properties of building materials)

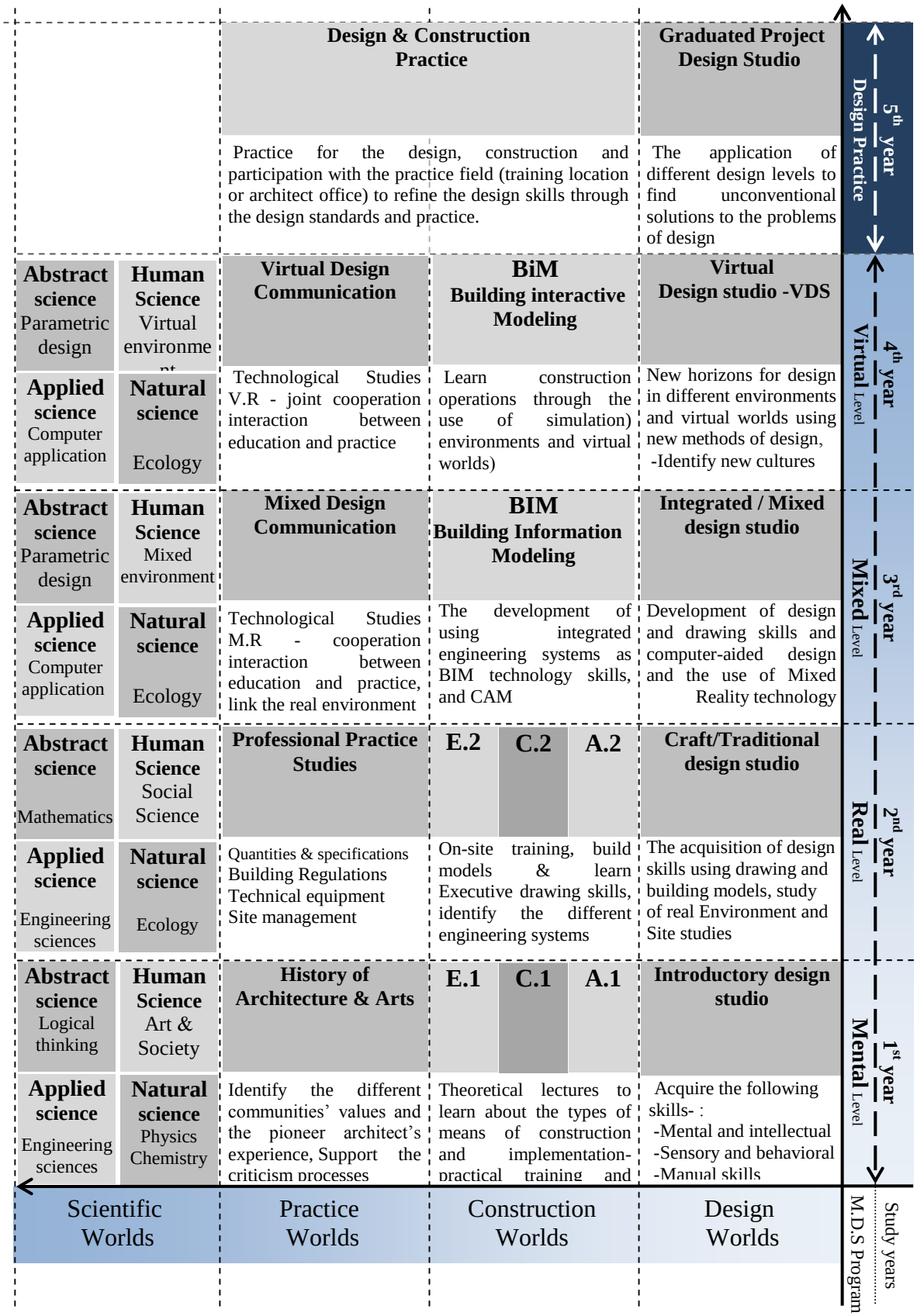
b) Professional Studies:

Including the study of the history of art and architecture, professional practice studies (material quantities and specifications, regulations, technical equipment of buildings, site work), theories of architecture, Building technology and environmental technology…etc.

The following Table (1) reflects the proposed framework to design a model of architectural education “through 5 years of study.

Table 1. Architectural education framework

Reference: The author


Design & Construction Practice
Graduated Project Design Studio
5th year Design Practice
Practice for the design, construction and participation with the practice field (training location or architect office) to refine the design skills through the design standards and practice.
The application of different design levels to find unconventional solutions to the problems of design
Abstract science Parametric design
Human Science Virtual environment
Virtual Design Communication
BiM Building interactive Modeling
Virtual Design studio -VDS
Applied science Computer application
Natural science Ecology
Technological Studies V.R - joint cooperation interaction between education and practice
Learn construction operations through the use of simulation) environments and virtual worlds)
New horizons for design in different environments and virtual worlds using new methods of design, -Identify new cultures
4th year Virtual Level
Abstract science Parametric design
Human Science Mixed environment
Mixed Design Communication
BIM Building Information Modeling
Integrated / Mixed design studio
Applied science Computer application
Natural science Ecology
Technological Studies M.R - cooperation interaction between education and practice, link the real environment
The development of using integrated engineering systems as BIM technology skills, and CAM
Development of design and drawing skills and computer-aided design and the use of Mixed Reality technology
3rd year Mixed Level
Abstract science Mathematics
Human Science Social Science
Professional Practice Studies
E.2 C.2 A.2
Craft/Traditional design studio
Applied science Engineering sciences
Natural science Ecology
Quantities & specifications Building Regulations Technical equipment Site management
On-site training, build models & learn Executive drawing skills, identify the different engineering systems
The acquisition of design skills using drawing and building models, study of real Environment and Site studies
2nd year Real Level
Abstract science Logical thinking
Human Science Art & Society
History of Architecture & Arts
E.1 C.1 A.1
Introductory design studio
Applied science Engineering sciences
Natural science Physics Chemistry
Identify the different communities' values and the pioneer architect's experience, Support the criticism processes
Theoretical lectures to learn about the types of means of construction and implementation-practical training and
Acquire the following skills- : -Mental and intellectual -Sensory and behavioral -Manual skills
1st year Mental Level
Scientific Worlds
Practice Worlds
Construction Worlds
Design Worlds
Study years
M.D.S Program

7. CONCLUSIONS

A. The design studio, is one of the major Components of architectural education and practice due to the main role in design thinking process.

B. It must pay attention to architectural education through Studio-Based Learning principle, because it is important in the transfer of design expertise through training and practice and design with an interactive dialogue between professors and students.

C. The design of an integrated educational model for the digital design studio requires positive support for the relationship between the different Design worlds, in order to develop the student's architectural thought.

D. The architectural education should concern with the increasing in digital technology especially in the field of combining between Real and Virtual environment (Mixed Reality Technology).

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