IMPAQT

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**IMPAQT**
**Integrative Multidisciplinary People-centred Architectural Qualification & Training**

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# ICT & Virtual Reality support in Architectural Education

## Introduction

Building upon the advances that ICT offers, a crucial means not only for better visualization, but also for analysis, problem solving, and eventually for establishing an innovative shared learning environment in the actual and virtual world. This report is the deliverable of WP1.2; tools, equipment and ICT solutions; and considered one of the four deliverables of the preparation phase (WP1). It shows the approach developed on the utilization of ICT along the different streams of the integrative, multidisciplinary, people-centred program. It focuses on the tools and equipment that are most needed and useful for, 3-D visualization, documentation, analysis and integration to be utilized in understanding and defining design problems, formulating design objectives, design thinking, communication and evaluation of design solutions. Besides, exploring the maximum utilization of the Virtual Reality Theatre and VR studios, as well as potentials of 3D laser scanning of existing buildings and urban settings.

## Aims and objectives

This report reveals the strategies followed to integrate ICT and technology within the learning process and along the different educational courses as an outcome of WP11. Such outcome is highly coordinated with WP4, which develops the program core module in the form of educational courses. It also relates to WP12, which handles the capacity building activities and acquired resources for building an ICT and VR lab.

The interrelation between WP11 & WP12 ensures an optimum content of the courses (WP4) is being developed. The report also lists the requirements (tools, equipment and softwares) and activities for building the lab facility (WP12) to showcase its support optimum utilization along the learning process. The work plan for operating and sustaining the facility is utilized as part of the projects sustainability in WP18.

Moreover, the lab should facilitate and support the multidisciplinary people centered approach through technology along the multi disciplines. This ensures a learning environment that encounters the advancement of technology to evoke creative mindsets and flexible designers could be achieved. Such work is the used to disseminate how IMPAQT integrates technology into architectural and urban design education that is related to WP17.

<u>The main objectives are categorized as the following:</u>

a. Developing 3D models
    - 3d scanning of existing sites using photogrammetry
    - Photogrammetry tools and equipment
    - 3D scanning and photogrammetry tutorials for training
    - Collect VR case studies from online resources
b. Virtual Reality (VR) Architecture Studio
    - List and provide the VR tools and equipment
    - Allocate spatial requirements for all supplies of the facility
    - Develop end user product (i.e. VR demo desktop and mobile app) for learners to visualize 3D models
    - Provide guidance material for using the product
c. ICT integration in Architecture

- Integration strategy, pedagogy and guidelines
- List the resources (tools, hardware and software) required in each course
- Assure the implementation within the curriculum
- Evaluate influence of the technology on learners for future development

d. Blended Learning

- Identify material and courses that are to use the online platforms
- Facility for online classes (smart boards)
- Provide online content creation tools,
- Provide online content guidelines & procedures for future training

## Objectives

| | Influence on the learning process | Enquired tools & resources |
|---|---|---|
| a. ICT Integration in Architectural Education | ○ Feel the complexity of the design process at multiple scales.<br>○ Improve the communication between the architect and other engineers.<br>○ Feasible coordination between the different stakeholders within the building industry.<br>○ Create dynamic interaction between an individual and the built environment.<br>○ Integrate multidiscipline during the design evolution. | ○ Analysis softwares<br>○ Comp simulations<br>○ Digital sketching<br>○ 2D & 3D modeling softwares<br>○ BIM softwares |
| b. 3D Models (site scanning)<br><br>and<br><br>c. VR in Architectural Design Studio | ○ Visual synthesis.<br>○ Formalization of the design thinking process.<br>○ Enables dynamic behavioural studies Integrating multidiscipline in design.<br>○ Improve the practicum dimension in education.<br>○ Enhance collaboration between architects, mechanical engineers, structural engineers…etc.<br>○ Prepare students for future careers i.e. UTW program by ECG.<br>○ Improve multiple skills and visualization.<br>○ Create advancement in the teaching and learning pedagogy.<br>○ Enhance the implications due to further design experimentation.<br>○ Allow creating, perceiving, testing and improving the designs from a people centred approach.<br>○ Produce sensible architects and urban designers to human aspects.<br>○ Override 3D renders and animations that dissolves commercial designs eventually. | |
| d. Blended Learning | ○ Outreach knowledge beyond local environment.<br>○ Increase learning effectiveness. | ○ Forums & Platforms<br>○ Information bank |

| | | |
|---|---|---|
| | ○ Allow exposure and builds awareness, confidence…etc.<br>○ Engage Research and practice.<br>○ Faculty development.<br>○ Institutional progress. | ○ Cloud computing<br>○ Mobile apps |

## Gap Analysis

Three types of surveys were conducted to investigate the influence of ICT and technology on the existing architectural and urban design education aiming to find the drawbacks and challenges of such integration. First are the online surveys, which included questionnaires for young architects. Second included questionnaires to the specialized partners the Desk review and surveys included questionnaires of focus groups and specialized partners were conducted to investigate the advantages/disadvantages of incorporating Design-aid tools in Architecture Education. ICT and technology allow interdisciplinary teamwork between different parties and engineers which saves time and money. It enables the designer to create organic complex forms and forms that emerge from certain parameters.

### a. Interviews with academics

Most responses highlighted the significance of ICT tools and technology for visualization, representation, analysis, digital fabrication and impact assessment. However, it is advised that learners should be aware not to become dependent upon such tools solely for tackling design problems. Few challenges were revealed by the students interviewed who emphasized the complexity of the learning process for many software and tools. They added that many software and tools depended on their prior knowledge to other skills that they may not always possess, which limits their equal opportunities and design innovation.

### b. Interviews with practitioners

Few responses recommended the importance of utilizing ICT and technology during the design thinking and not just to represent the end result due to its informative outcomes which could guide the design decisions efficiently by implementing quick changes. Other recommendations highlighted the use of ICT for helping the professional practice and methodologies innovation yet necessitating the need for verification. Also, suggestions were made to not allow computer modelling to take over physical models due to their influence on improving creativity. Specialized partners assured the importance of developing mindsets that are capable of utilizing the tools and technology to serve their goals. Besides the need to conduct actual measurements to analyze buildings performances through computer simulations that are reliable and validated to contribute to better understanding of the design implications.

## Drawbacks and risks

Some limitations and draw backs have been revealed from the literature that has been reviewed. Studies that documented the implementation of ICT and technology in higher education are limited, in particular those for the field of architectural and urban design education. However, the following limitations and challenges have been conducted and listed below:

<u>Added to the educational content rather than integrated:</u>

- Due to the lack of trained faculty where the tool requires more time and work load to use and not benefit from the time it saves and advancement it provides to the content.

Overriding essential architectural skills:

- Students escape the need to draw, sketch and model.
- Changes in cognitive ability and creativity overtime.

Capacity building:

- Consistent training of faculty which requires cost and time
- Learning support trainers
- Require flexible mindsets that adapt to rapid changes.

Cost and budget:

- Adding extracurricular content for students i.e. programming workshops, trainings, learning support …etc.
- Coping with the rate of the technological updates such as equipment and softwares
- Continuous capacity building and turnover of staff.

Lack of sufficient knowledge:

- Lack of material, resources and data in many fields related to the built environment
- Lack of reliable tools and instruments to be used to fill the gap of knowledge
- Lack of validated architectural and urban design curriculum integrating technology immensely between all fields, thus, drawbacks remain doubtful.

Effect on the personal skills of the architect:

- Using modelling and drafting softwares during the early design stages of the project limits the mental skills and creativity of students. This is due to the poor coordination between mind and hand when using A tendency to create 'clip thinking' phenomenon disabling students from perceiving long non-linear text
- Reduces concentration overtime
- Challenge to ensure equal opportunities for students due to the need for high resources
- Need for consistent high-quality guidance and technical IT support
- Remain technology as a tool to design, construct and improve the built environment.
- Create methodology to clarify aim and objectives before using any tool to avoid drawback
- Wrong bridging between different softwares or tools to achieve design goals.
- Misinterpretation of outcomes
- Generalization of outcomes from created scenarios with lack of awareness to its impact
- Depending on the VR experience for the practicum of the theoretical content and override actual site visits.

## Activities Implementation

The content of each of these courses has been developed by multiple IMPAQT partners aiming to consolidate several disciplines and backgrounds.

### A. Developing 3D models

Using current technology of laser scanning or photogrammetry has recorded tremendous success in the digital archiving of cultural heritage worldwide. The same technology shall be implemented in the current work package to map existing architectural buildings and urban settings representing different typologies for two reasons:

1. To provide students in the developed program to be immersed in the architecture and urban space models, learning from, and correlating to their own work different contextual factors and experiential aspects.
2. Utilize these existing models to build on, learn how to think and design in 3D while maintaining the cultural landscape.

- The team from ASU have been working together in scanning heritage sites in EG in a former TEMPUS project (VIRCULT). They have developed significant expertise in this area and shall capitalize on that in the current work.
- Necessary tools, hardware and software for the scanning mission shall be acquired from the equipment budget building on the existing ones from the TEMPUS project.
- The ASU team shall extend their expertise to NU to spread the technology for any future requirements.
- The sites to scan and what to scan shall be prescribed by the architecture and urban planning teams (NU/ETSAB/KU).

### B. Virtual Reality (VR) Architecture Studio:

The planned virtual reality architecture studio is intended to accommodate all features and requirements in any traditional studio, however it is integrating stereoscopic virtual space and digital media technologies to compliment the human architecture design talents and expertise acquired during the studio sessions in the program. This shall include VR headsets and screens equipped with ALL design tools for the students integrated in a virtual environment allowing to carry out the architecture design process, while being able to share progress, communicate, immerse and walkthrough in stereoscopic virtual 3D models (WP11.1) and even have their tutorials at the virtual site in a near-real form brought to them into the shared learning virtual environment developed. This shall be carried out in virtual cubicles allowing both concentration environment and at the same time permitting sharing-for-learning atmosphere.

### C. ICT integration in Architecture:

The use of ICT is an important component in architecture and urban design education. Given the multidisciplinary nature of the developed program, ICT will play an essential role in integrating the multiple disciplines in the curriculum. Computer-Aided Design (CAD) and Building Information Modelling (BIM) have become essential tools for architects in several aspects including design, analysis, simulation, sketching, visualization in 2d and 3D as well as information sharing. Geographic Information Systems (GIS) are used to study, analyze, and visualize any

phenomenon that has a spatial component. This is particularly useful in the areas of urban design, community planning, and site selection process. GIS can also be used in conjunction with other visualization tools, CAD, to create dynamic and complex models. The tasks performed in WP4-WP9 would involve identifying what, when, and how the abovementioned ICT tools are to be used in the different courses and modules. These ICT-based components will be designed and integrated in the respective courses accordingly.

**D. Blended Learning:**

The incorporation of the blended learning model in education exploits the capabilities of digital content and internet-based platforms to enhance the learning experiences for students and instructors by enabling them to engage in ways that would not normally be available or effective in their usual environment. It offers different online modes of delivery, versatile models of teaching and styles of learning which when combined with the traditional face- to-face mode yield a more effective learning experience. Recorded lectures, webcasts, online virtual classrooms, discussion forums are used to extend the learning experience beyond the typical classroom experience. It provides off- campus access in an asynchronous form where students have online self-paced activities. The tasks performed in WP4-WP9 will identify the courses and contents that benefit from the blended learning delivery model and develop e-content.

Blended learning changes the role of the teachers to being coaches and the students from being just recipients to be in charge and decide in which direction to move and at which pace. The advancement of technology and blended learning creates a more effective way of learning were instructors are no longer the source of knowledge. This copes with the openness of information and globalization for mutual learning between instructors and students.

## ICT & VR lab

**How could the facility support the learning process that aims to integrate a multidisciplinary-people centred approach?**

It gives the students – future architects and urban designers – the potential to test his or her design based on other users' needs, comfort and/or perception to allow them to modify their product repetitively. The tool allows the students to explore the profound details they are taught within other courses and alter their designs according to the contextual conditions of each project. Furthermore, the level of experimenting using VR could eliminate design scenarios that they had deemed viable and while open others that had been out of their league. This could be verified in computational methodologies such as VR, AR and MR by testing dependant and independent variables, which could not be conducted in field investigations. Therefore, enabling students to access the immersed environments for investigating aspects that are related to people and their behaviours provide a leap for architects and urban designers. The time limitation put on any design proposals enquiry is responsible for the producing an unpleasant built environment that does not satisfy the user's needs. Such provision promotes a breed of mindsets are sensible and centred around to the users.

The VR technology compensates the lack of dynamic indices and simulations softwares that test behavioural patterns and movements of BOT's (users) at particular scenarios. All investigations

and theories related to this discipline have been tested using static indices where outcomes are then combined with a factor to counterweigh motion, yet, depending on the design. The VR environment enables multiple users to access the designed scene, where live and dynamic observations could be made. Also, the tool focuses the designer's vision towards the built environment from their eye-view level, which could…..

**How could the technology integration into the curriculum be developed further in the future?**

Methods and tools utilized at any stage of the courses should be assessed before and after its use to evaluate its outcomes. Such method reveals the effectiveness and support the technological tools provide to calibrate the tracks followed by the learners. Also, this should achieve the balance between abusing digital tools and computational designs and between marginalization of technology.

## Integration Methodology

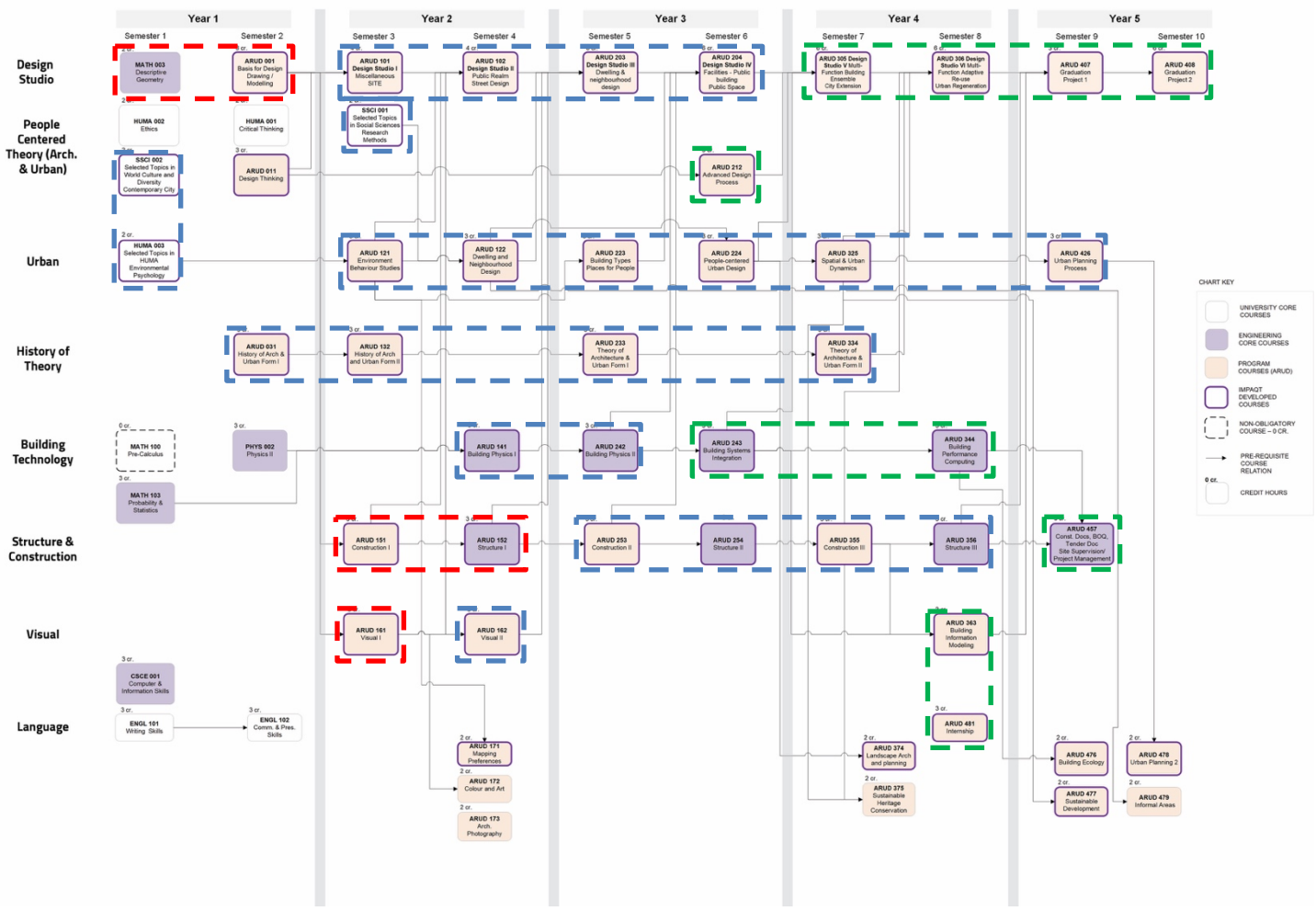
Formerly, architectural and urban designs could only be represented through physical modeling, which was time and cost inefficient. With the presence of modeling and simulation software and technological tools designers could not only communicate their ideas clearly, but also assess their designs before they are actually built. Furthermore, such tools advanced immensely enabling architects and urban designers to analyze the influence of numerous parameters within the built environment in any context and within any scenario. Therefore, the contribution of ICT and technology in architectural and urban design institutions became significantly inevitable.

IMPAQT, aims to develop an integrative, multidisciplinary, people-centred educational program, which incorporates ICT and technological tools to facilitate the learners design thinking. However, it is necessary to enlighten the learners consistently to set their design goals and intended outcomes before integrating technology to retain their control over such tools. This is not only to avoid producing inappropriate design solutions driven by computational forces, but, rather to maximize the architect's sensibility to the human aspects in the built environment. Yet, the rationality of softwares, simulations and modelling tools in providing outputs should remain within the designers control to derive conclusions and interpretations of less subjectivity, disputability and considerate to other factors such as the behavioral and psychological influences. Furthermore, learner's ought to take full advantage and control of the tool at hand aiming to enhance their design than depending on it to drive their design decisions. This will retain the technology from leading to misconceptions, decisive interpretations or even limiting the learner's creativity.

**Classify courses into three categories:**

1. Non-integrative
   Courses that are hard to learn using computers, as they build formalized knowledge and skills, which are directly transferred to students i.e. free-hand drawing and model making.
2. Partially integrative
   Courses where the technology and tools facilitate the learning process due to the higher transfer of knowledge and engagement between the instructors and students.
3. Integrative

Courses that evolved dramatically with the intervention of softwares or tools. The curriculum and course planning depend on the tool and software intervention.




non-integrative  partially integrative  integrative

**Applications and tools integrated within the study streams:**

<u>Design studio stream, People centred theory stream and Urban stream</u>

- Creates motivation, passion and competitiveness that improves student's performance
- Will create changes in behavioural studies and enable students to contextualize the material
- Reflect context, site and culture in designs
- Progress in design evolution due to a better visualization, minimize errors and fatal mistakes due to poor realization of confusion
- Construct new ideas based on existing design
- Receive more effective feedback from tutors
- Represent dynamic concepts and ideas
- Enables to design projects that are futuristic yet human centred
- Work on design ideas outside dedicated learning spaces

History stream

- Connecting history to other courses and disciplines.
- Allow students to understand heritage beyond the geometrical form.
- Engages students to theory.
- Engage students in analysis of historical building systems and recreating lost data enables creative solutions.
- Raising architects able to improve touristic facilities.
- Converting existing buildings into smart buildings improves the students design skills.

Building technology stream and Structure and Construction stream

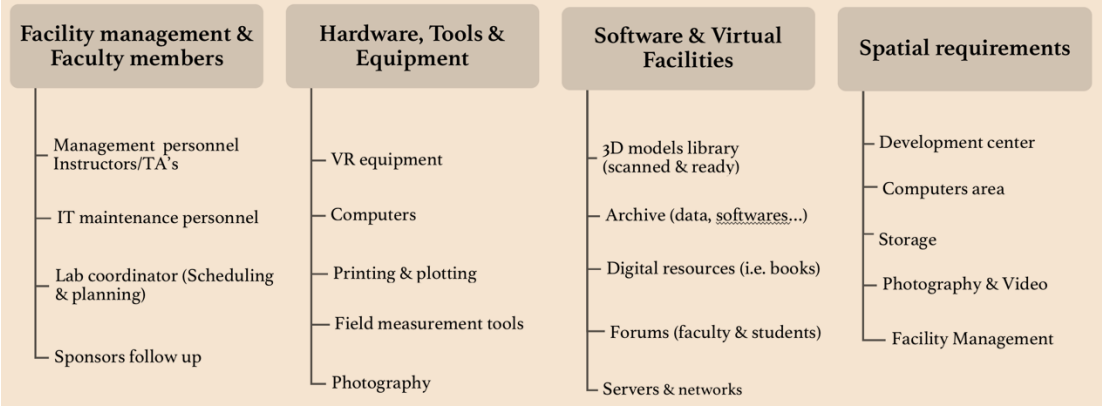
- Connecting history to other courses and disciplines.
- Allow students to understand heritage beyond the geometrical form.
- Actual site visits complemented by VR experience strikes a balance between when achieving the practicum.

Visual stream

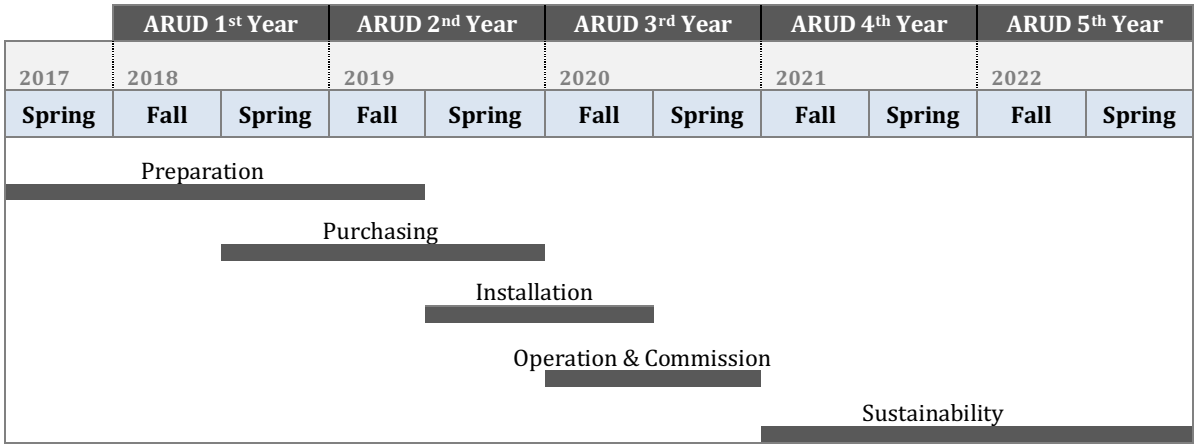
- Allow students to foresee their designs closer to reality.
- Enhances their senses of light, enclosure, morphological characteristics…etc.
- Experiencing the design from multiple user's perception.
- Enhances imagination at the early design stages.
- Stimulate other design challenges.
- Enable more realistic designs that are human centered.
- Tests the user's perception to the proposed designs.
- VR & AR should be integrative utilized within the course.
- Requires faculty training.
- Faculty would support research.

## Lab requirements

The goal is to establish a computer lab at NU that is used by the students, instructors and researchers during their learning or investigations at ARUD program. A brief feasibility study was conducted to identify the needs and requirements of the facility. Later, a management plan and time schedule were put according to the projects deadlines and ARUD study plan.




The consecutive phases are: starting from the preliminary phase of listing and purchasing, passing through the installation phase of the software licencing and installation, networking and space planning to be ready by the end of the first semester, then the operational phase were the facility operates at its full efficiency after one year from its establishment and before the end of the project. In addition to the commissioning phase proposed for the first 5 years where the lab operates smoothly at its full capacity. A sustainability plan is also proposed to maintain the facility




and ensure its quality.

| Preparation phase | Implementation phase | | | Commission phase |
|---|---|---|---|---|
| | Purchasing | Installation | Operational | |
| Gap analysis + Utilizing framework + curriculum integration methods + lab space planning | Specifications + Hardware & software list + Purchasing & tendering | Software purchase/licencing + installation + server & networks + 3D scanning + capacity building | Management plan + hiring + MOU + coordination and troubleshooting + installing new tools | Maintenance and updates + QC & QA + sustainability plan |

Deliverables:

List of equipment needed for phase 1 (software and hardware)

Technical specifications and licensing mode suitable

There are many tools, equipment and expertise required to build an ICT and VR Lab for students to utilize in an academic environment of architectural and urban design education. Above all time is required.

Establishing the 3D library, i.e. models of buildings, objects or urban areas using modeling softwares

Laser scanning of buildings, objects or urban areas using photogrammetry

Tools and equipment:

GPS for positioning and orientation of the camera, resolution pixel counts and 3D points for tying. calculation of a sparse point cloud by a trigonometric algorithm using the tie points and camera locations and the lens data. calculation of the dense point cloud were the fitness of this algorithm makes a significant difference between programs.

Hardware: memory, cpu cores and high levels of graphics processing units. The amount of memory is a major factor especially for PhotoScan and ContextCapture

Software:

Expertise:

to ensure photo alignment, stability of capturing technique, color matching, weather conditions. Very light or dark surfaces may cause problems and over- or underexposed photos should be omitted, since details are essential in the 3D model creation process

**Architectural visualization and urban modelling**

Create photorealistic 3D models of the nearby buildings, roads and nature, to add architectural designs. When architects design new buildings, they try to present those 3D models as they would appear in the actual building location. this is through creating simplistic 3D block mockups of the surrounding area, or by producing a 3D still image of the building and combining that with a photograph from the location using digital photo manipulation.

**Urban Modelling**

Cities and other urban areas have been aerially photographed for city planning and other modeling purposes for decades, but now this photography data has a new usage in photogrammetric 3D modeling. Creating 3D models of cities is carried out all around the world, and it is easy to see in Google Earth, where new photogrammetric 3D cities are being built every day. These photogrammetric 3D models are much more useful than regular 2D photographs, namely because of the ease of combining them with Geographic Information System (GIS) data, which then allows for visualizing of important infrastructure information in three dimensions.

**Recording of Cultural Heritage**

Photogrammetric 3D Modeling provides archaeologists a way to preserve existing 3D structures as virtual models for future generations. Reconstructions have been created even out of tourist photos, namely crowd-sourced data. Museums all over the world share the same problem of

constantly rising number of exhibits, while storage capacity is not keeping pace. Only a small share of museum exhibits may be visible for the public at a time. Exhibits may be photographed, converted into 3D virtual objects and shown to the public online by 3D photogrammetry.

## Tools, Software and methods adopted

There are numerous tools, software, simulations and instruments that could be adopted within the architectural and urban design education. The current report categorizes the tools that will be incorporated within the 5-year program based upon their main use among architects and practitioners. The wide range of tools and facilities of ICT necessitates the urge to set a regulatory boundary to categorize the technological tools and methods. Such process depends mainly upon the complexity of each tool/facility, time it consumes, and the resources required. This is to set the threshold and expectation for the course instructors and professors to play within. Besides setting a benchmark that would assure the quality of the outcomes, to eliminate individual knowledge of the tools and methods and not to let the utilization depend upon the capabilities of the students.

The technological and ICT tools are categorized as follows:

- Representation, Realization, modelling
- Analysis and simulation
- Live interaction with the built environment

**Drafting and modelling:** Autocad, sketchup, photoshop, **BIM:** Revit, Rhino, Grasshopper

Instruments, microclimatic softwares, CDF

**Virtual Reality:**

**Augmented Reality:** Programming and gaming, coding,

**Digital fabrication, 3D printing,** Laser cutting,

**3D scanning and photogrammetry** 3D MODELING ReCap Pro

Digital library for case studies, ALICA and ECG