Erasmus+ KA-2 Project ARCHISTEAM
"Greening the Skills of Architecture Students via STEAM Education".

Project Report

O3 - ADAPTATION OF DEVELOPED STEAM MODULES IN EXISTING CURRICULA

This Project is granted by the European Commission under the Erasmus+ Programme (Lifelong Learning or Youth Programme), implemented by The Turkish Republic Ministry of European Union and the Center for European Union Education and Youth Programmes (Turkish National Agency/http://www.ua.gov.tr)

PROJECT INFORMATION

Project acronym:	ARCHISTEAM
Project title:	Greening the Skills of Architecture Students via STEAM Education
Project number:	2016-1-TR01-KA203-034962
Project website:	http://www.archisteam.com
Report name:	O2: ADAPTATION OF DEVELOPED STEAM MODULES IN EXISTING CURRICULA
Date of preparation:	April 2018
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1. INTRODUCTION : MODULE DEVELOPMENT FOR ARCHITECTURAL EDUCATION

It is a long and controversial debate "how design education should be" and "what is designerly way of thinking". In all these discussions, what is consented is "design is one of the most advanced thinking skills" for which constructivist learning becomes the core. Constructivist learning is the way for the mind to transform data into knowledge based on experience. Dewey (as cited in Bhattacharjee, 2015) argued that human thought is practical problem solving, which proceeds by testing rival hypotheses (p.68). These problem-solving experiences occur in a social context, such as a classroom, where students join together in manipulating materials and observing outcomes. (Dewey, as cited in Bhattacharjee, 2015) Since it is relying on student-centered approach, students are encouraged to use active techniques (experiments, real-world problem solving) to construct more knowledge. By designing and performing a number of teaching practices for well-planned learning environment, the students learn how acquire knowledge and learn.

It should be highlighted that constructivism is not a teaching model but it is a frame of thought, an ideology based on three main learning strategies: experiential learning, problem-based learning and project-based learning for which learners are actively engaged i.e. it is learner-centered. Detailed explanation of Problem Based and Project Based learning can be accessed from Appendix 1.

When design education in the focus of studios are considered, either project based or problem based, experiences will serve in developing such a constructivist mindset. In this process, the role of instructor/mentor is crucial.

Unlike traditional approaches, constructivism modifies the role of teacher by changing from active to guide role for helping student to construct knowledge. Constructivism requires active participation of students in the learning process rather than being passive recipient of information as well as the guidance of teachers to construct students' knowledge instead of causing mechanically ingesting knowledge by them.

In this process, it is evident that each individual has a different learning style. Kolb (1974) says that "knowledge results from the combination of grasping experience and transforming it." (p. 9) and accordingly, in this learning process, four main phases namely; experience, reflection, conceptualization and experimentation take place.

Successful experiential learning requires that each stage being mutually supportive of and feeding into the next. Hence controlling the learning process, properly designing the "learning environment" by the instructor/mentor starting from the assignment of the problem to the assessment, objectives and outcomes become the key issues as well as the skill sets to be conveyed during the education and thereafter.

Hence, revisiting design education with this perspective will help to restructure design education regarding skill sets that are referred in this project.

The role of STEAM model for achieving a better experiential learning strategy is explained below:

STEAM is an educational approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking (Catterall, 2017). It is forwarding ahead as a positive movement to truly meet the needs of a 21st century learning. Key principles of 21th Century Learning are:

- Learning is active vs. passive
- Outcome based vs. time-based
- What children know, can do vs. memorization of disjointed facts
- Student-centered vs. teacher-centered
- Integrated interdisciplinary curriculum vs. fragmented curriculum

True STEAM experiences involve two or more standards from Science, Technology, Engineering, Math and the Arts to be taught and evaluated through each other. On the other hand, students' understanding of how things work can be increased and their use of technologies can be developed by a true STEM education (Bybee, 2010). STEAM approach centralizes on inquiry, collaboration, and an emphasis on process-based learning. STEAM provides more real life connections to students and teachers and through it a powerful combination of topics and techniques for educating our society is aroused.

STEAM approach centralizes on inquiry, collaboration, and an emphasis on process-based learning aiming for exploring new and creative ways of problem-solving, displaying data, innovating, and linking multiple fields.

A successful STEAM approach enhancing constructivist learning and thus design education require a well-designed curriculum and well-defined and clearly outlined skills as it is briefly introduced above. In this regard, this part of the project is focused on the expected skill sets and the design of a proper curriculum.

The generic skills and the complementary module presented in the O2 is revisited regarding the partieculiarities and specific requirements of architectural education. Although there is a great diversity in teaching approaches in architectural education as it is discussed in the previous reports (O1 and O2), the following expectations which are regulated by DIRECTIVE 85/384/EEC should be achieved in the course of education in order to be an entitled professional architect.

Table 1: Architect's SKILLS according to current European legislation

"Such studies shall be balanced between the theoretical and practical aspects of architectural training and shall ensure the acquisition of:		
1	an **ability** to create architectural designs that satisfy both aesthetic and technical requirements,	COMPETENCE
2	an adequate **knowledge** of the history and theories of architecture and the related arts, technologies and human sciences,	KNOWLEDGE
3	a **knowledge** of the fine arts as an influence on the quality of architectural design,	KNOWLEDGE
4	an adequate **knowledge** of urban design, planning and the **skills** involved in the planning process,	KNOWLEDGE / SKILLS
5	an **understanding** of the relationship between people and buildings, and between buildings and their environment, and of the need to relate buildings and the spaces between them to human needs and scale,	KNOWLEDGE
6	an **understanding** of the profession of architecture and the role of the architect in society, in particular in preparing briefs that take account of social factors,	KNOWLEDGE
7	an **understanding** of the methods of investigation and preparation of the brief for a design project,	KNOWLEDGE / COMPETENCES
8	an **understanding** of the structural design, constructional and engineering problems associated with building design,	KNOWLEDGE / COMPETENCES
9	an **adequate knowledge** of physical problems and technologies and of the function of buildings so as to provide them with internal conditions of comfort and protection against the climate,	KNOWLEDGE / COMPENTENCE
10	the necessary design **skills** to meet building users' requirements within the constraints imposed by cost factors and building regulations,	SKILLS
11	an adequate **knowledge** of the industries, organizations, regulations and procedures involved in translating design concepts into buildings and integrating plans into overall planning."	KNOWLEDGE / COMPENTENCE

What the European legislation requires is then declined in particular programs of various schools, which detail the training offer by specifying the skills that students are supposed to acquire at the end of their studies. In particular the formal descriptive card of the architectural degree at the University of Bologna, declines the interests previously described in the 26 abilities listed below:

1. ability to design the architectural structure
2. ability to design at different scales,
3. ability to conceive, plan, design and manage systems and processes in the construction sector;
4. ability to design and manage the construction process phases;
5. ability to verify the possibilities of transformation and configuration of urban spaces;
6. knowledge of the architectural representation methods and main building blocks and themes of the building process;
7. ability to historically recognize and critically evaluate architectures;
8. ability to critically detect an artifact;
9. knowledge of materials, semi-finished products and components for the construction of the architectural structure and capacity of evaluating their conditions of application according to the properties and performance characteristics
10. ability to verify the relations between buildings, theoretical resolution of the constructive system and choice of technological procedures
11. knowledge of concepts related to structural mechanics and ability to perform structural calculations;
12. ability to control and manage building processes, considering the relationship between buildings, environment and available resources;
13. ability to define and manage building maintenance plans;
14. knowledge relating to thermodynamics, heat transmission and environmental control
15. ability to apply the methodological foundations of the technical physics for the energetic analysis of the building and the control of the microclimate and indoor comfort ;
16. ability to analyze the conservation status of an architectural artifact;
17. ability to design conservation and restoration interventions;
18. ability to evaluate the problems related to plant adaptation and consolidation;
19. ability to evaluate the compatibility of new uses in an existing building;
20. knowledge of real estate estimation principle and knowledge of procedures aimed at estimating the value of architectural and urban planning activities and of the evaluation techniques useful for expressing the judgment of convenience in the comparison of multiple design alternatives;
21. understand the application of the mathematical and physical principles underlying the architecture and engineering sector;
22. knowledge of tools for the management of technical information;
23. ability to work independently and in a team;
24. communicate in written and spoken English;
25. ability to identify, formulate and solve complex problems that require an interdisciplinary approach;
26. communicate the results of your work graphically, through presentations and technical reports."

The list above highlights the expected competency of an architect at the end of his/her education in relation with skills. It is fair to claim that all these abilities advance each and every year to fulfill the overall goal of the education.

The fulfillment of these skills and abilities can be achieved by encapsulating the three fold generic skills as Ground Skills, PBL Skills and ICT Skills (which may vary from year to year and/or across different university definitions of baselines) and with a properly designed instruction and evaluation schemas.

2. MODULE DEVELOPMENT

2.1. What is a Teaching Module

A curriculum usually refers to a number of courses offered by an educational institution. But, defining "what is a curriculum" has always been a controversial issue because it means different thing to different people. The curriculum of a school is the formal and informal content and process by which learners gain knowledge and understanding, develop skills and alter attitudes,appreciations, and values under the auspices of that school (Doll, 1995). In educational institutions, knowledge, skills and attitudes that students are expected to gain are delivered through a series of courses. Thus, a curriculum is an arrangement of several different courses to have students gain necessary knowledge, skills and attitudes.

Teaching modules are usually conceptualized as self-contained "units" of content. Multiple modules constitute an instructional course or training program. A unit can cover just one class or more. Modules are to teach techniques. A course may contain variety of modules whereas a module teaches a complete skill or a meaningful content. It usually covers just one subject and is assessed independently of other modules in order to enable flexible/adaptable course design.

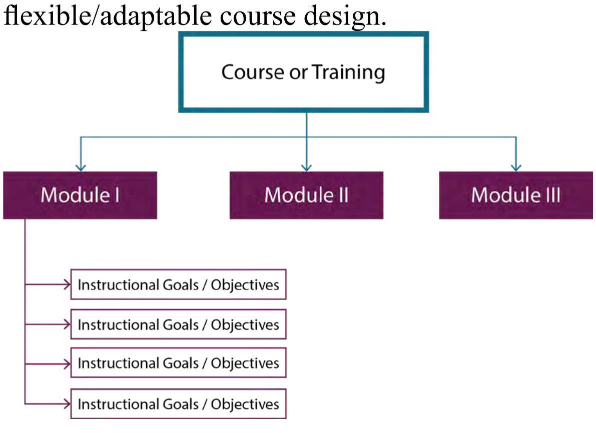

Figure 1: Course /Training and Module Diagram

2.2. Components of a Teaching Module

Module development is an application of the instructional design process. Instructional design is the systematic practice of creating learning experiences through which learners gain new skills and competencies under the guidance of learning and teaching theories. There are different approaches to instructional design, and these approaches are commonly used in developing teaching modules.

The ADDIE Model is a framework that lists generic processes used by instructional designers and training developers. It represents a prescriptive guideline for building effective training and performance support tools in five phases: (source; Kurt, S. "ADDIE Model: Instructional Design," in Educational Technology, August 29, 2017. Retrieved from https://educationaltechnology.net/the-addie-model-instructional-design/)

Analysis:

Analysis phase includes several concerns to better understand the real instructional problem and the needs of the students.

Design:

In this stage, major concern is the instructional goals & objectives, instructional content, and assessment criteria and tolls.

Development

In this phase, the whole concern is to put all in action. This phase usually achieves three tasks: drafting, production and evaluation.

Implementation

Implementation phases focuses on the collection of continuous feedback pertaining to the instructional design and the product. Thus, instructional

Table 2: : Teaching Module Example

Instructional Objectives	Content	Teaching/Learning Activities	Assessment
State your instructional objectives in SMART format	List Facts, Concepts, Principles and Skills related to the instructional objectives	Define the teaching activities (presentation, group discussion, project based learning, demonstration)	Define on the measurement type in accordance with learning objectives (Rating Scales and/or Checklist)

designers and learners are the source of feedback at his stage.

Evaluation

Finally, evaluation stage requires summative and formative assessment of the instruction and the learning process.

The ADDIE model is one of the most commonly used models because of its prescriptive guidelines for developing an effective instruction.

According to Yelon (1996, p: 109) Teaching modules are composed of 4 main components. Those are (1) Instructional Goals/Objectives, (2) Content, (3) Teaching/Learning Activities, (4) Evaluation.

2.2.1. INSTRUCTIONAL GOALS AND OBJECTIVES:

Instructional goals can be viewed as outcomes of the instruction. In other words, instructional goals are the description of the knowledge and skills that we want students to gain during the instruction. Providing instructional goals to students before the instruction enables students become mentally and physically ready for the content to be learned. Students should connect instructional goals with real world performance so that students will have a meaningful learning experience. Additionally, instructional goals also provide directions for assessment. Thus, based on the instructional goals, the instructor can determine the function and the type of assessment.

How to Write Instructional Objectives:

One of the most common methods of writing effective instructional objectives is called S.M.A.R.T. The acronym stands for:

1. Specific: Make sure that objectives make the same sense for all including students and instructors.

2. Measurable: Remember that unless you define observable outcomes, you cannot know whether learners gained necessary knowledge and skill at the end of the instruction. Thus, student's performance must be measurable by both quantitative and qualitative criteria.

3. Action-oriented: make sure that you use action verbs in your objectives so that student's performance can be evaluated.

4. Realistic: Make sure that expectations from the students are realistic in terms of conditions and time given.

5. Time-Based: Make sure that students are given proper time to attain objectives.

Example of an SMART objective:

After successful completion of this ICT skills module **(time-based)**, students will be able to collect relevant information and explain **(action-oriented)** its relevance to the given problem **(specific, measurable, realistic)**

Bloom's Taxonomy: The Cognitive Domain:

In the mid-1950s, the American educational psychologist Benjamin Bloom made one of the most significant contributions to the classification of educational objectives, and described several categories for cognitive learning. The table 3 is a brief review of these.

Table 3: Brief overview of Bloom's Taxonomy (Source: http://www.personal.psu.edu/bxb11/Objectives/ActionVerbsforObjectives.pdf)

Category	Description
Knowledge	Ability to recall previously learned material
Comprehension	Ability to grasp meaning, explain, restate ideas
Application	Ability to use learned material in new situations
Analysis	Ability to separate material into component parts and show relationships between parts
Synthesis	Ability to put together the separate ideas to form new wholes, establish new relationships
Evaluation	Ability to judge the worth of material against stated criteria

According to the Bloom's Taxonomy, Table 4 which is the list of action verbs can be used in writing instructional objectives.

Table 4: List of action verbs to use in writing instructional objectives

Cognitive Learning Level	Action Verbs
Knowledge	define, describe, state, list, name, write, recall, recognize, label, underline, select, reproduce, outline, match
Comprehension	identify, justify, select, indicate, illustrate, represent, name, formulate, explain, judge, contrast, classify
Application	predict, select, assess, explain, choose, find, show, demonstrate, construct, compute, use, perform
Analysis	identify, conclude, differentiate, select, separate, compare, contrast, justify, resolve, break down, criticize
Synthesis	combine, restate, summarize, precise, argue, discuss, organize, derive, select, relate, generalize, conclude
Evaluation	judge, evaluate, determine, recognize, support, defend, attack, criticize, identify, avoid, select, choose

2.2.2. CONTENT:

In his instructional design model, Yelon (1996) links content directly with the instructional goals, methods and assessment. It means, you have to teach your students related content that will help them gain necessary knowledge and skills to achieve learning outcomes and to perform successfully on the assessment. The content should be relevant, appropriate to the students' background and their learning styles and structured to provide meaningful learning experience.

Yelon (ibid., p: 108) refers to content as "essential content to teach" and claims that essential content has 4 sub-categories (or types of knowledge to be taught): (1) Facts (2) Concepts (3) Principles (4) Skills. The basic assumption behind categorizing content under 4 themes is that each type of content requires different mental processes and efforts to be learned. Thus, instructional interventions – which are the means of carrying content to the learner – should be developed accordingly. In the following table, Yelon (1996, p: 109) describes each essential content and proper intervention to teach it.

2.2.3. TEACHING/LEARNING ACTIVITIES (METHOD):

Throughout history, mankind has developed and used several teaching methods to transfer knowledge and experience to the next generation. In their work, Joyce, Weil & Calhoun (2013) categorized teaching methods under 4 main themes.

Social Interaction Family- Emphasizes the relationship of the individual to society or to other persons. Gives priority to the individual's ability to relate to others.

- Partner and Group Collaboration
- Role Playing
- Jurisprudential Inquiry

Information Processing Family- Emphasizes the information processing capability of students. Gives priority to the ways students handle stimuli from their environment, organize data, generate concepts and solve problems.

- Inductive Investigation & Inquiry
- Deductive Investigation & Inquiry

Table 5: 4 sub-categories (themes) of the module

	Facts	Concepts	Principles	Skills
Ideas	Organized set of facts	Definition of the Category	Definition relating variables	Ordered simplified steps
Examples	Vividly illustrated substantiation	Typical Example – Non-example pairs	Evidence showing relationship of variables	Demonstration

- Memorization
- Synectics (Techniques for Creativity)
- Design and Problem Solving
- Projects & Reports

Personal Family- Emphasizes the development of individuals, their emotional life and selfhood. Gives priority to self-awareness.

- Indirect Teaching
- Awareness Training & Values Clarification
- Role Modeling
- Self-Reflection

Behavioral Modification Family- Emphasizes the development of efficient systems for sequencing learning tasks and shaping behavior. Gives priority to the observable behavior of students.

- Direct Instruction (Demonstrations & Presentations)
- Anxiety Reduction Programmed instruction
- Simulations

Choosing an appropriate teaching model depends on several conditions. First of all, the teaching model should lead students to the instructional goals. Secondly, learning environment and instructional resources should be appropriate for the teaching method. Finally, the instructor should be capable of successfully applying the model.

2.2.4. ASSESSMENT & EVALUATION

Assessment is the most important component of an instructional model due to its nature. Assessment requires collecting systematic data about the students' progress in the learning environment. This data serves for several instructional purposes. First, assessment provides evidence about how instructional goals are realistic or attainable by students. Second, assessment also indicates how effective the teaching method is, so teacher can modify the method. Finally, assessment provides evidence to make a judgement about the students' performance.

Due to its multiple functions, there are several assessment types and assessment tools listed in the literature. One of the best classifications is provided by Miller, Linn & Gronlund in their book "Measurement & Assessment in Teaching" (2013). The following table is extracted from this book (page 43).

Measurement of Complex Cognitive Outcomes: Performance Based Assessment:

In the context of learning, objective test items (e.g. True/False questions, Multiple Choice Items and Fill in the Blanks items) are the most commonly used test items. It's not because these types can measure all learning outcomes but they are convenient for instructors since each item type possesses one single right answer. On the other hand, most learning environments require students to gain and master more complex skills and behaviors which are mostly demonstrated in the authentic learning environments.

Performance assessments provide instructors to a base for evaluating the "process" and the "product" of the learning outcome. Performance-based assessment is also referred to as "authentic assessment" or "alternative assessment" (Miller & Linn & Gronlund 2013, p: 255). The most important advantage which performance-based assessment provides is that this type of measurement allows to measure complex learning outcomes that cannot be measured through other types of measurement. Especially, in academic fields like Architecture, critical and creative thinking skills of students are keys to success. And those skills cannot be measured unless performance-based assessment methods are employed.

There are also some limitations that should be linked to performance-based assessment. First, sometimes judgmental scoring might be inevitable in this type of measurement, because different observers may rate the same performance differently. Second, this type of measurement is always too time consuming. But, there are always solutions to overcome these problems.

Rating Scales

Numerical rating scales are some of the simplest types of assessment and are most commonly used in assessment. The following is an example for the numeric rating scale.

Example: Numerical Rating Scale

Directions: Rate the degree to which student contributed to the group project report.

4. Consistently and effectively contributed
3. Mostly and effectively contributed
2. Seldom and ineffectively contributed
1. Never or little contributed

To which extent does student contribute to the group project report?

Graphic rating scales are commonly used for performance appraisal. If student performance can be divided into observable sequential pieces, Then graphic rating scales can be an effective assessment tools in the learning environment. The following is an example of a graphic rating scale.

Example: Graphic Rating Scale

Directions: Rate the degree to which student contributed to the group project report.

To which extent does student contribute to the group project report?

Example: Descriptive Graphic Rating Scale

Directions: Rate the degree to which student contributed to the group project report.

To which extent does student contribute to the group project report?

Check Lists

Checklists are quite similar to rating scales. On rating scales, you can indicate the degree of competency or behavior whereas on checklist you can make a "Yes/No" or "Observed/Unobserved" judgements. The following is an example for the checklist type of assessment.

Example: Checklist

Directions: Circle YES or NO to indicate if competencies are demonstrated.

YES	NO	1. Open the application
YES	NO	2. Go to the "File" from the Menu
YES	NO	3. Choose "A new Document"
YES	NO	4. Save the document

3. SKILLS

As it is stated in the O1 and O2 reports of the project, and "Part 1 : Introduction" of this report, the modules proposed in the scope of this project provides complementary skills for students of architecture schools. Although there is a great diversity in teaching approaches of architecture as it is discussed previously, professional skills aimed to be gained during the architectural education are regulated by DIRECTIVE 85/384/EEC. In this project, it is aimed to prosper architecture students with green skills enabling them to adapt into changing environment, conditions, technology, and demands.

In this regard, three modules are developed with various skill sets focusing on a specific direction of adaptability of individuals. As the first one is … The second one, …. Finally, a complementary module addressing Information and Communication Technologies is proposed to enrich the capability of students not only to use rapidly developing technologies, but also to prompt to develop and challenge the technological development.

These skill sets should be renewed each and every year in coherence with the objectives of education and in pace with current technologies. Hence education technologies and methodologies are also subjected to be revised/modified/altered in time. In this regard, any skill set such as provided here should be revised whenever necessary.

The framework presented herein should be perceived as a guide reflecting contemporary needs and approaches. Moreover, it exemplifies the general rules of thumbs and principles of content and module design in a broader perspective. Hence, the schema presented within the scope of this project acts as guideline and exemplary application of how to develop a framework for aforementioned goals.

3.1. Ground Skills

The general approach which derives from the above mentioned european directive, occurs in the single degree courses that specify their teaching objectives with the skills that will be obtained by their graduates.

It is important to underline that the degree course in architecture offered by the University of Bologna is a five-year course without interruption. In short, it does not admit the "three plus two" system which is known in the general university environment as the "Bologna process".

Considering the list of 26 skills described in the abovementioned Chart of the Architecture degree at the University of Bologna, it is possible to recognize groups of alike skills.

Skills are mentioned in order of adherence to the professional profile that an architect is supposed to fulfill. It is then possible to subdivide the above mentioned competences in a macroscopic subdivision:

1 - 8 : skills concerning the designing process;

9 - 21: technical knowledge related to the control of structural and technological components, of the construction sites, management of problems related to the maintenance and restoration of existing buildings; basic knowledge of real estate market and esteem.

22 - 27: already described "ground skills".

The stratification of these skills favors courses constituted by integrated modules between the various scientific sectors in which research is organized.

3.1.1. TWO EXAMPLES OF STEAM INTEGRATED COURSES AT THE UNIVERSITY OF BOLOGNA

The Archisteam project has been the framework to "measure" and implement the STEAM quality of two integrated courses already offered within the educational offer of the five-year master degree in architecture above mentioned and described.

In the comparison of different educational experiences in different Countries and cultural traditions, also the nomenclature has its own importance. Thus, for example, in Italy, the whole course of studies leading to a master degree is called "Course", as is called the single teaching activity by which each course of studies is composed, whether it is semi-annual or annual. Within spoken language, where "course of study" is not always specified, it is therefore the context that allows to understand whether one refers to a single teaching or rather to the whole cycle of studies leading to a master degree.

Just as the course of studies consists of several courses or teaching activities, each course can be composed of different training modules, sometime conducted by different teachers, sometime by the same, in any case differentiated according to specific themes and training objectives.

The following examples are courses in the meaning of teaching activities, in turn made up of training modules.

The first integrated course, "Lab-based Course on Building and Architecture (Integrated Course)

(Laboratorio di Costruzione dell'Architettura, Corso Integrato)" is a second year course and (Laboratorio di Costruzione dell'Architettura, Corso Integrato)" is a second year course and implicates an integration between Technological Planning (module A) and Environmental Planning (module B).

The second integrated course, "Detail design for Energy Efficiency (Integrated Course)" (Progettazione esecutiva dell'architettura per l'efficienza energetica, Corso Integrato) is a third year course which is constituted by two different modules: Detailed design for Energy Efficiency (Module A) and Environmental Technical Physics (module B).

Here below is shown the detailed descriptions of the two courses according to official teaching plans.

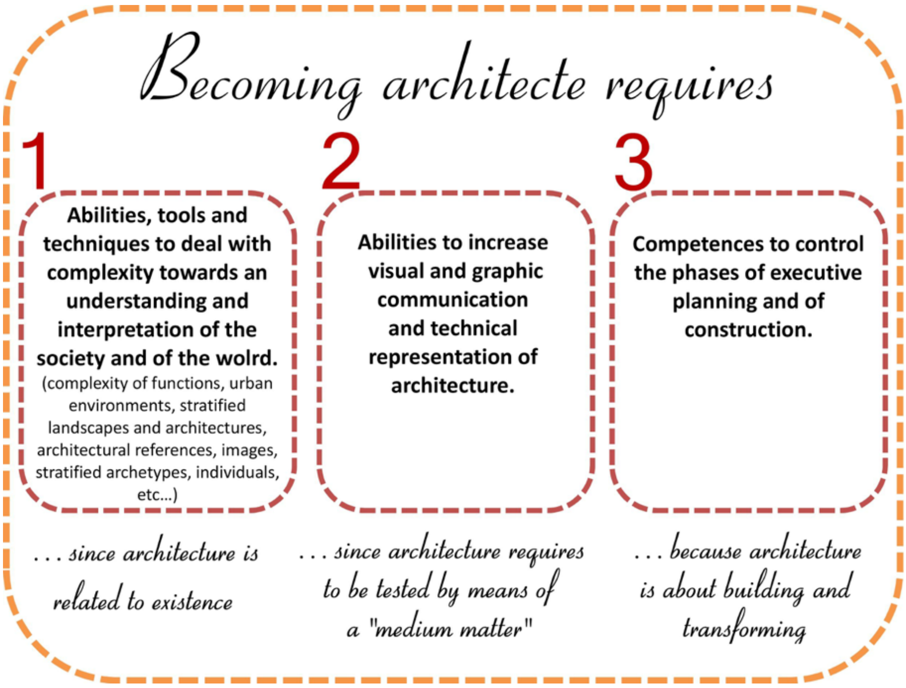

Figure 2: Requirements of becoming an architect

Lab-based Course on Building and Architecture (Integrated Course)

(Laboratorio di Costruzione dell'Architettura, Corso Integrato)
Teaching language: Italian.
School: Engineering and Architecture - Campus of Cesena
Single cycle degree programme (LMCU) in Architecture (cod. 0881)

Module A: **TECHNOLOGICAL PLANNING** (8 credits)	
Instructional Goals /Objectives	The training program of this subject consists in the study and the control of relationships among building structure, theoretical resolution of construction plant and selection of technological procedures depending on the functional optimization of spaces. The study of construction techniques evolution completes the cognitive goal. Students will be able to apply their knowledge and skills in relation to defined architectural construction design.
Content	The laboratory aims at investigating thoroughly the relationship between project and architecture construction by dealing with the phases of building process and by acquiring awareness of the links existing among spaces, activities, technical solutions and realization methodologies. The laboratory focuses on the relationship between project and construction system, and provides for the development of a complete project for a building unit by means of sequential phases for the definition of typological and technological choices corresponding to specific ex-tempora developed in classroom. The definition of planning choices is based on the critical survey of needs and generally speaking on the principle of the approach as a function of need and performances. Planning shall consider the complexity and articulation affecting the planning/construction process of a building structure: relationships with the environment and with the historic and socio-cultural context, safety and comfort needs, available resources, conditionings of organization and management forms of building process, regulatory instruments in force, productive context (dimensions and structure of the company and of industries in the field), updating of techniques and of technological innovation. These goals include the intention of helping students to acquire an appropriate knowledge of technical elements and their aggregation criteria through the awareness of the link generated between features of activities and spaces and functions of technical solutions adopted, so that the determination and planning of fundamental technical elements and their assemblies are carried out while controlling the role of materials, products and building procedures in the architecture project as a function of immediate housing needs and of the use of building over time.

Module A:

TECHNOLOGICAL PLANNING (8 credits)

Teaching / Learning Activities	**Teaching Methods** Laboratory activities consist of lessons, long practice, short practices (ex-tempora), talks and tests, and end up with the final examination. The long practice (examination topic) regards the definition of a building typology to be inserted into a preset context with integration of traditional construction systems and dry technologies. The short ones (ex-tempora) focus on specific aspects of the long practice and ending with an assessment: they are structured in order to be advance phases in the development of the final project. Work organization aims at a complete development of the project within the end of the laboratory. **Teaching Tools** The laboratory foresees the presence of students in classroom for the gradual elaboration of the architectural construction project. All phases will be followed and backed by the professor, tutors and didactic collaborators. The Department library is a useful support for specific documentation and investigation. Department of Architecture and School of Engineering and Architecture equipments will be used (overhead projectors, videoprojectors, electronic media).
Assessment	It is foreseen to carry out a series of practices in classroom as gradual occasions to check the learning and elaboration of the project. A constant check of the theoretical preparation at the base of the selection of construction systems and technologies takes place during laboratory activity. Each ex-tempore is a check of specific aspects of the program. The final project is based on the reprocessing and systematizing of aspects gradually dealt with in laboratory. The individual examination consists in the description and discussion of project works produced during the course. Moreover, it includes the theoretical check of aspects relating to the theme assigned and to topics dealt with in laboratory.

Module B:

ENVIRONMENTAL PLANNING (8 credits

Instructional Goals / Objectives	At the end of this module, students are supposed to have acquired basic knowledge related to fundamental problems in the relationship between buildings, environment and available resources, deepening tools and strategies of resource management, in the framework of strategies for control and management of building processes.
Content	The question of the role and significance given to techniques and materials in the process of formation of architectural periods is a much discussed one. The question has arisen especially in the contemporary age, when the increasingly marked distinction between the design process (preliminary project), the production of working drawings/specifications/bills of quantities, and the actual construction stage has led to a high fragmentation of the traditionally unitary architectural process. The laboratory course aims to address, in particular, the knowledge requirements that derive from an anthropic reality, like the Italian one, which is highly historicised. What are our ancient buildings made of? Which materials were used? And which traditional techniques were employed? Many archival sources exist, but their use has never sufficiently taken into consideration aspects of material culture that underline contracts, tender specifications, bills of quantities, etc.. The same applies to manuals: Vitruvius, Alberti and Palladio, for example, are rich in knowledge about construction methods which have never been fully analysed and interpreted. Moreover, there is a yet unexplored area consisting of the oral testimonies of contractors, masons and carpenters that can provide valuable information about dying trades and skills. The course aims to provide students approaching the construction sector with the keys necessary to enter the fascinating world of materials which form our historical architecture: from wood, stone, tiles, mortar and concretes, to reinforced concrete and steel. The analysis of traditional building sites, from antiquity to present times, will enable students to learn about the acquisition, preparation and use of each material according to different production needs. For the sake of clarity, the course makes explicit reference to real experiences acquired in some Italian regions; in other words, to the immense living archive of building cultures and craftsmanship that are hidden in our city centres and rural buildings. In particular, the course will focus on the properties, the selection criteria and the manufacturing of natural building materials found in architectural elements and structures. The aim is to provide students with the necessary analysis and evaluation skills for design and construction stages, with particular emphasis on identifying the causes of deterioration in ancient and modern artefacts. Besides theoretical lectures, the course includes some guided visits to the production sites of some of the most commonly used materials in construction, as well as to some building sites exemplifying the topics discussed.
Teaching / Learning Activities	**Teaching Methods** Classroom lessons and visits to construction sites or to companies working in construction sector. **Teaching Tools** Bibliography that can be found in libraries specialized in architecture and in the faculty library.
Assessment	Classroom interviews are scheduled after lectures and a final interview is scheduled before the examination of the Laboratory of Construction of Architecture I.

Detail design for Energy Efficiency (Integrated Course)

(PROGETTAZIONE ESECUTIVA DELL'ARCHITETTURA
PER L'EFFICIENZA ENERGETICA - C.I.)
School: Engineering and Architecture - Campus of Cesena
Single cycle degree programme (LMCU) in Architecture

Module A: **DETAIL DESIGN FOR ENERGY EFFICIENCY**	
Instructional Goals / Objectives	At the end of the course, the student should have developed a knowledge of theoretical principles, methodologies and operational criteria for constructive, technological and structural solutions and the ability to organized their executive definition. In particular, the student should be able to apply this knowledge to the reading and interpretation of architectural projects.
Content	The learning path includes the analysis of building elements and technologies with reference to work execution issues and from the perspective of process sustainability. The issues of environmental protection and quality of living are increasing their importance in contemporary design. Specific interrelations between the changing of users' behavior and the evolution of new concepts of living are outlined at brief level, design approach and execution and management level: a very close connection links technological innovation to environment and living conception, therefore an integrated approach is essential. The exercises to be developed during the course are aimed at exploring the different options related to the characteristics of construction materials and to the expected performance of the system, at assessing the implications of different design choices in relation to energy balance, at checking the interaction between the different design parameters and at understanding how complexity can be managed through an efficient construction process. The course will cover some of the main technological issues that affect the contemporary architecture and specific tools, phases and methods of operational design will be described. Particular attention will be paid to the understanding of the technological choices about energy efficiency from project design to its construction, from its exercise to its maintenance. The keywords for the development of the main issues are: building system, complex process, integrated design, life cycle, energy efficiency.
Teaching / Learning Activities	**Teaching methods** The activities of the course will include seminar, lectures and tutorials and will conclude with the final examination. The exercises, to be agreed with the teacher, will consist in the executive planning of a part of a building under study, developing the architectural elements on a detailed scale. Work progress steps will be supervised in the lecture hall, in order to complete the project within the end of the course. **Teaching tools** Design phases will be supervised and backed by the lecturer. Faculty equipments will be used (overhead projectors, video projectors, data carriers, laboratories). For in-depth studies a specific bibliography will be provide during the course. Part of the teaching material to carry out the design exercises will be available on the Faculty server

Module A:

DETAIL DESIGN FOR ENERGY EFFICIENCY

Assessment	The access to the examination is subject to verification of the work carried out during the revisions. The individual exam includes the theoretical verification of the topics dealt with in the lessons and the discussion of the design projects produced during the course. The assessment of the design exercise and the exam on the theoretical part will be carried out in a single test divided into two parts: • the first one will focus on the final presentation of the surveys carried out during the year. On that occasion each candidate must demonstrate his / her own preparation on the basis of the illustration and the discussion of the project; • the second part will be aimed at verifying the knowledge on the topics covered during the lessons with reference to the texts indicated and the supplementary documents. The works to be delivered on the day of the exam include: analysis card in A3 format; • ppt files for the presentation of the case study; • 2 tables in A1 format; • a reduced copy of the tables in A3 format; • a copy of the organized collection of the Product Technical Data Sheets (STP) relating to the selected technological-functional unit; • a CD collection of the dwg, doc, pdf, dwg and ppt files of the works and presentations carried out during the year (in particular the dwg, jpg and eps for each image are requested). Each student will receive a folder (windows) containing specifications on the cataloging of the material. The delivery of tables, reductions and CD is to be considered mandatory to take the exam. The results of the design exercise and the oral examination will be used to determine the exam grade.

Module B: ENVIRONMENTAL TECHNICAL PHYSICS	
Instructional Goals / Objectives	The aim of the course is to study energy performance of buildings, with particular reference to the design and technologies choices related to energy efficiency and plant-system, with aim to obtain comfort condition in indoor space: thermo-hygrometric, acoustic, daylight, and indoor air quality. Students will be requested to adopt and to verify the environmental technical physics aspect related to building design, technologies and materials, in order to increase energy efficiency and comfort condition.
Content	Recall of Environmental Technical Physics: thermodynamics and thermokinetics. PSYCHROMETRY Mixtures of air and water vapor and psychrometric transformations. WELLNESS AND COMFORT Thermohygrometric wellbeing, Fanger equation, PMV (Predicted Mean Vote) and PPD (Predicted Mean Vote) comfort indicators. LOCAL DISCOMFORT Indoor air quality (Indoor Air Quality - IAQ) pollutants and reduction of the concentration of pollutants in indoor environments. THERMO-PHYSICAL CHARACTERISTICS Thermo-physical characteristics of building materials and components, thermal transmittance and dynamic behavior of the building envelope, transparent opaque elements. Characteristics and criteria for calculating thermal bridges (atlas of thermal bridges and finite element model) Thermo hygrometry of building structures and Glaser Diagram, interstitial and superficial condensation verification. ENERGY PERFORMANCE OF BUILDINGS. Procedure for calculating the energy performance of the building in winter and summer (thermal energy needs useful for heating and cooling according to UNITS 11300 part 1): sizes, definitions, characteristics of building closures, global coefficient of heat exchange and thermal contributions . Calculation of the energy performance index of the building (EP index) expressed in primary energy, thermal plant yields and renewable energy sources (outline). Energy performance of buildings: legislative framework and technical standards. TECHNICAL INSTALLATIONS FOR BUILDING Features and subsystems of technical installations in buildings. Characteristics of winter and summer air conditioning systems in confined spaces, plant subsystems (generation, distribution, regulation and emission), minimum dimensional criteria, rooms and technical rooms, distribution and plant terminals. APPLICATION OF THE NOTIONS TO A CASE STUDY The didactic module provides for the application of the concepts acquired in the lectures to a case study among those identified for the Executive Design Module. Specifically, the thermophysical performances (transmittance and Glaser diagram) and the layout of the system must be calculated. The graphic elaboration can be written in a group, according to the same criteria of the executive planning module. Lighting Engineering notions: fundamentals of illumination and photometric quantities, physical phenomenon and perceptual phenomenon visual comfort requirements.
Teaching / Learning Activities	The course includes two modalities: LESSONS, related to the topics and contents of the program, and collective or single IN-CLASS REVISIONS regarding the graphic elaboration inherent to the teaching content application to the case study. The two methods have to be considered equal to the evaluation. In relation to the application of the case study, the teaching method would like the students to develop their skills through her/his independent search for sources (technical magazines, design studio, etc.) in order to identify the existing plant layout, or (in the case it would not be possible) to find sources or references related to the specific case study, with the definition of possible system solutions. The reviews are designed to clarify doubts common to all students and solve specific cases. The Environmental Technical Physics Module 2 is carried out in synergy and collaboration with the Executive Design Module and the case study is the same.

Module B: ENVIRONMENTAL TECHNICAL PHYSICS	
Assessment	The end-of-course exam aims to evaluate the achievement of the teaching objectives and skills acquired by the student. The verification procedure takes place in two phases: the drafting and delivery of the graphic elaboration related to the case study and the oral interview, together with the Executive Design Module. The graphic, in A1 horizontal format, must report the thermophysical data of the main building closures, the Glaser diagram of at least one opaque closure and the layout and diagram of the heating system. The delivery of the graphic design takes place at the end of the course, in a date proposed by the students and agreed with the teacher. It is not possible to deliver beyond this date, subject to specific and timely exceptions. The assessment is carried out independently by the teacher and the results are communicated via the web and / or posted at the studio. The oral interview consists of answering to one or more questions posed by the teacher, related to the contents addressed during the course. The verification provides an answer, in the first instance, written (formulas, schemes, etc.) and, at the same time, an interview with the teacher to clarify the written answer with any further information.

Now presenting an analysis, the two courses present an effective integration of STEAM skills. Apparently, with regard to the letters of which the acronym is constituted, it seems that the integration concerns more “STE” than “AM”. The properly creative component remains hidden in the description of the courses, although our reader should take into account the proper element of the didactic activity, because architecture is a concept that expresses itself through a body of technologies and techniques without which it would not be. The creative component “A” must therefore be considered the implicit background of the whole course.

Otherwise, the math component “M” is a prerequisite for the evaluation of the thermodynamic components that measure the efficiency of the technological solutions which has been selected and then adopted.

Let’s now turn to detailed considerations regarding the two integrated courses we took into account. The evaluation of the modalities with which each field is completed, will allow to plan an improvement in the description of the training offer itself, and therefore of the teacher’s awareness of the different commitments to which his / her role competes.

There is a strong discrepancy between the English description of these courses and the descriptions offered in Italian language. All the above reported cells have been filled from the English language program, where present, and translating the italian one, where corresponding informations were missing in the English version. It is important to underline that the entire educational offer of these courses is guaranteed in Italian only.

1. **Instructional Goals /Objectives:** For all courses we considered, this entry is filled in generically. It rather describes the general context to which the course is addressed, without including a SMART description of its training objectives. In relation to this last consideration, we cannot fail to point out that this approach is also a consequence of a culture of university teaching that still consider unseemly going into too concrete details, as if culture and knowledge would be measured or quantified. Background to this approach is a certain elitism of knowledge, as well as, once again, a certain discrimination between subjects and approaches involving thought alone on the one side, and criteria and approaches that admit concrete implications in time and space on the other. In this way each module objectives tend to coincide with a summary of its related contents. The practical and measurable

information provided to students remains only the one relating to the modalities of the final examination.

2. **Contents.** With regard to this compilation field, different compilation methods can be observed beyond and within the examples we have shown. Subjects with greater humanistic implications tend to adopt discursive approaches, whereas technological and scientific subjects analytical and point-by-point approaches, as the last module does among the examples we mentioned. Nevertheless, one can easily see that the formulation of the field "contents" does not follow a standard scheme, and it is also sometimes difficult to separate the aspects that Yelon (1996, p.109) clearly recognizes.
3. **Teaching/learning activities (Method):** with the only exception of the last module we analyzed, all modules distinguish "teaching methods" and "teaching tools". Teaching methods strictly identify different ways by means of which contents are delivered (ie lessons, extemporaneous exercises, training on a single case study, on-site visits, personal research). "Teaching tools" strictly concerns materials and tools through which training contents become accessible. Much of the teaching method remains obviously unknown up to the start of the course, or it remains anchored to the personality and the relational modalities of the teacher.
4. **Assessment.** From the courses we analyzed, it can be concluded, first of all, that the exam remains a recognizable and formal moment that does not pertain to the single module, but to the entire course of which each module is a part. In the above mentioned integrated courses the exam is presented as a punctual test and not as a continuous verification of the learning contents. All modules foresee a double assessment: on the one hand, the personal verification of the theoretical knowledge is scheduled by means of oral test or written questionnaire. On the other, performance based assessment intervenes in the evaluation of a tangible learning outcome as a design-project has to be considered. No form specifies whether the judgment is reserved to the lecturer or to a commission specifically appointed. No didactic module provides a self-evaluation of students with respect to entry and exit skills. Self-evaluation processes makes the students feel responsible for the respect to learning issues so that they no longer study to achieve an external or exogenous objective, but an internal or endogenous one, such as the improvement in gaps or weaknesses that they can autonomously detect in their own training.

Table 6: Ground Skills and respective Learning Outcomes, Content, Teaching Materials, Teaching/Learning Activities and Assessment Methods

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
GROUND SKILLS				
G-A Design Process				
G-A1	Being able to design the architectural structure in relation to the character of the places and the size of contemporary cities	**Facts:** What are the aspects of architectural and urban design, structure, management and construction? **Concepts:** Enable to define structural relations, different scales, processes Enable to conceive the aspects of construction sector Enable to assess the transformation and configuration of urban spaces Enable to develop a critical point of view to evaluate existing architectures **Principles:** How to approach architectural and urban design, structure, management and construction? **Skills:** Designing the architectural structure in relation to the character of the places and the size of contemporary cities Designing at different scales, from urban dimension to technological detail Conceiving, planning, designing and managing systems and processes in the construction sector Designing and managing the construction process phases Verifying the possibilities of transformation and configuration of urban spaces Recognizing historically and critically evaluate architectures	Hands-on practice via studio education Guided practice Demonstrating how to criticize existing architectures Descriptive information with best practices from the field	Numerical Rating Scale
G-A2	Being able to design at different scales, from urban dimension to technological detail			Numerical Rating Scale
G-A3	Being able to conceive, plan, design and manage systems and processes in the construction sector			Graphical Rating Scale
G-A4	Being able to design and manage the construction process phases			Numerical Rating Scale
G-A5	Being able to verify the possibilities of transformation and configuration of urban spaces			Graphical Rating Scale
G-A6	Being able to historically recognize and critically evaluate architectures			Numerical Rating Scale
G-B technical skills related to the control of structural and technological components, of the construction sites, management of problems related to the maintenance and restoration of existing buildings; basic skills for real estate market and esteem				
G-B1	Being able to critically detect an artifact	**Facts:** What are the criteria to detect, relate, define and analyze an artifact in terms of theoretical resolution, technological procedures, maintenance, building physics, conservation, and usage **Concepts:** Enable to distinguish good and bad practices in terms of criteria Enable to critically analyze existing artifacts	Descriptive information about the building physics Demonstrating conservation and restoration examples Case study demonstrations	Numerical Rating Scale
G-B2	Being able to verify the relations between buildings, the theoretical resolution of the constructive system and choice of technological procedures			Numerical Rating Scale

<table>
<tr><th>Skill Indicator</th><th>Learning Outcomes</th><th>Content & Teaching Materials</th><th>Teaching Learning Activities</th><th>Assessment</th></tr>
<tr><td>G-B3</td><td>Being able to control and manage building processes, considering the relationship between buildings, environment and available resources</td><td rowspan="7">Principles:
How to assess the criteria of detecting, relating, defining and analyzing an artifact in terms of theoretical resolution, technological procedures, maintenance, physics, conservation, and usage
Skills:
Critically detecting an artifact
Verifying the relations between buildings, the theoretical resolution of the constructive system and choice of technological procedures
Controlling and managing building processes, considering the relationship between buildings, environment and available resources
Defining and managing building maintenance plans
Applying the methodological foundations of the technical physics for the energetic analysis of the building and the control of the microclimate and indoor comfort
Analyzing the conservation status of an architectural artifact
Designing conservation and restoration interventions
Evaluating the problems related to plant adaptation and consolidation
Evaluating the compatibility of new uses in an existing building</td><td rowspan="7"></td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B4</td><td>Being able to define and manage building maintenance plans</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B5</td><td>Being able to apply the methodological foundations of the technical physics for the energetic analysis of the building and the control of the microclimate and indoor comfort</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B6</td><td>Being able to analyze the conservation status of an architectural artifact</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B7</td><td>Being able to design conservation and restoration interventions</td><td>Graphical Rating Scale</td></tr>
<tr><td>G-B8</td><td>Being able to evaluate the problems related to plant adaptation and consolidation</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B9</td><td>Being able to evaluate the compatibility of new uses in an existing building</td><td>Numerical Rating Scale</td></tr>
<tr><td colspan="5">GC Ground Skills</td></tr>
<tr><td>G-C1</td><td>Being able to understand the application of the mathematical and physical principles underlying the architecture and engineering sector</td><td rowspan="5">Facts:
What is the relation between mathematics and physics with architecture and engineering
What are the key aspects of verbal and graphical communication?
Concepts:
Enable to communicate with other disciplines
Enable to communicate verbally and graphically
Enable to comprehend the role of mathematics and physics in architecture and engineering
Principles:
How to relate mathematics and physics with the architecture and engineering
Skills:
Understanding the application of the mathematical and physical principles underlying the architecture and engineering sector
Communicating in written and spoken English
Identifying, formulating and solving complex problems that require an interdisciplinary approach
Communicating the results of your work graphically, through presentations and technical reports</td><td rowspan="5">Descriptive information on graphical communication
Demonstrating verbal communication with colleagues from other disciplines
Case study demonstrating the role of mathematics and physics in architecture and engineering</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-C2</td><td>Being able to work independently and in a team</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-C3</td><td>Being able to communicate in written and spoken English</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-C4</td><td>Being able to identify, formulate and solve complex problems that require an interdisciplinary approach</td><td>Graphical Rating Scale</td></tr>
<tr><td>G-C5</td><td>Being able to communicate the results of your work graphically, through presentations and technical reports</td><td>Graphical Rating Scale</td></tr>
</table>

3.2. Baseline Skills in a PBL University Setting

Studying architecture and design in a problem-based learning university requires different skill-sets, some of which are general to university-level studies, some are more specific to problem-based learning (PBL), and yet others are more specific to studying architecture and design. While general university skills are typically present in freshmen to some degree, problem-based learning skills are typically more rare. As architecture and design requires skills which are to a large degree specific to the field, those skills are typically even more rare in students who have just entered university.

In the following, the different baseline skills which are important when studying architecture and design in a PBL university setting are presented according to how general or specific they are to studying at university, to studying in a PBL-setting, and to studying architecture and design respectively. Only few of these baseline skills may be unequivocally relegated to only one of these realms. In practice most skills are relevant in higher education across pedagogical models and fields of study. Yet it is fair to claim, that within these three domains, some skills are more critical than others. As the presented skills may be relevant across the different realms, they are also presented graphically in a diagram showing where they reside (Figure 3).

The listing below must be regarded as a continuum rather than separate skill-sets. Within the three groupings, skills are organized with regard to their specificity. More specific skills are presented first, gradually followed by more general or pervasive skills. Hence, the more specific skills are relevant only to particular learning processes while the more general skills relate more to the student's approach or attitude towards learning in general.

The skills discussed here have been defined empirically. They are not discussed in the context of particular theoretical paradigms. And while it is probably not exhaustive, it does include what is considered to be the most crucial skills for studying architecture and design in a PBL university.

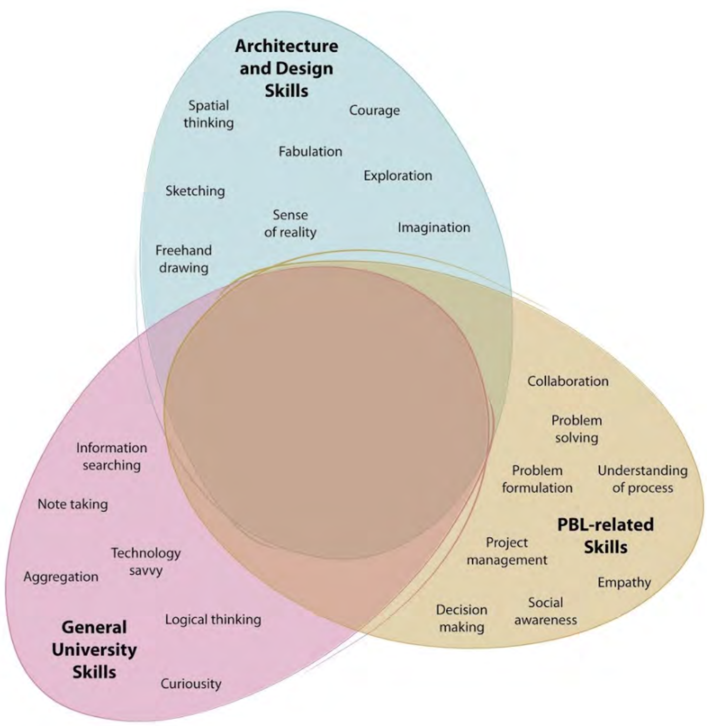

Figure 3: General university, PBL and architecture and design-related baseline skills.

3.2.1. GENERAL UNIVERSITY SKILLS

Information Searching

Regarding information searching, students are expected to address this in different phases throughout the entire design process to help support a problem-oriented and integrated approach. First, as an overall desktop/library search on relevant literature to study and understand historical, contextual and societal issues affecting the chosen problem framework, but also to outline and unfold relevant theories, methods and tactics for analysis and ideas development. Finally, as empirical information mapping out relevant site-based conditions, unfolding user perspectives, as well as framing structural/technical and environmental constraints.

Note-taking

Note-taking is key for recording information and capturing valuable empirical input, especially when working together with others in large PBLoriented groups. Typically, students address this by using computers/tablets to write down notes during lectures, class instructions and supervision meetings. In addition, more traditional tools as notebooks, post-its, pen and paper are used to write and sketch/draw maps, capture conceptual ideas and develop diagrams, which can be valuable visual inputs when sharing and communicating information throughout the entire design process.

Technology savvy

The study form of a modern university education includes high levels of understanding and experience when it comes to technology and digital solutions. Reading plans, scheduling, the search for academic sources and even social life are all tied up on online solutions, which have made it virtually impossible to complete an education successfully without obtaining the necessary knowledge about digital platforms like Facebook, online libraries, and even physical solutions like plugging in a projector.

Aggregation

For a student to create an understanding of a given subject, he or she must practice the ability to see the sum of parts. This is true, not only in order to cope with the high level of complexity of some reading material, but typically also for grasping the purpose of courses and lectures. In order to understand a given subject, the student must often research several areas/sub-topics in order to get the full picture, and in order to obtain a complete understanding at the end. This does not only apply to specific areas of study but also to education itself. The student must learn every independent aspect of the field of study in order to understand the final function and purpose of his/her education. As an example, a medical student must study several different subjects like biology, communication, economics, and ethics in order to truly understand what it means to be a doctor.

Logical thinking

This term is rather self-explanatory as it deals with the cognitive reasoning used by the students in their work and perception of academic materiel and subjects as opposed to an emotionally driven thinking. Every person admitted to a university will have a cultural or even religious understanding of various matters, and it is of most importance that every student leaves these "beliefs" at the doorstep in the search for knowledge and understanding in the academic fields. The student must practice his or hers ability to use reasoning and logic to obtain, understand, and utilize knowledge in order to succeed and prosper within their field.

Curiosity

Curiosity is a central skill in both PBL-thinking but also in architecture and design education. Therefore, students are expected to use this as a driving force in individually seeking out and gaining new knowledge, skills and competencies. In addition critically investigate and explore historical and state-of-the-art knowledge both theoretically, methodologically and technically to unfold and solve the problem.

3.2.2. PBL-RELATED SKILLS

In problem-based learning (PBL), students are expected to not only demonstrate theoretical understandings but also to apply theories and methodologies to real life problem-solving. This is typically done collaboratively with other students. This means that baseline skills relating to problem-solving and collaboration are central to problem-based learning.

Collaboration

When working together with others, collaborative skills are obviously of paramount importance. Depending on educational culture and tradition, collaborative skills are trained to varying degrees in K12 education. The general trend in Western Europe however, seems to go towards increasing degrees of collaborative learning in K12 education. Therefore, collaborative skills are increasingly present in students at entry level. Nonetheless, collaborative skills may vary among students, and must typically be developed and even stimulated.

Problem Formulation

An important part of the PBL pedagogy is that students themselves must formulate the problems which they work on. Therefore, the capacity to formulate problems is central. As initial problem statements (particularly in architecture and design) are based on imperfect knowledge and incomplete understandings of the nature of the problem, problem formulation involves constant problem reformulation throughout the process of problem-solving. As problems should increase in complexity with the levels of study, problem formulation and reformulation skills must develop continuously.

Problem Solving

Apart from being able to formulate a problem, students subject to problem-based learning must also be able to solve problems. This involves being able to judge which knowledge and methodologies must be applied in order to achieve a successful result. Some problem solving strategies may be proposed or even required as part of formalized learning. But as students should be able to devise their own approaches, problem solving is also very much a baseline skill.

Decision Making

Part of problem solving is being able to make decisions as to which choices to make. As design problems are ill-defined by nature, decision-making skills are required not only on a weekly basis but on a daily and even hourly basis when dealing with architecture and design problems. Decision making implies the normative capacity to evaluate which choices are the best, which, in turn, depends on both experience and attitude. Some decisions may be individual while others may be collaborative. While individual decision making may be hard, collaborative decision making maybe even harder, as experience and attitudes may differ among individuals. Developing collaborative decision making skills is therefore crucial.

Project Management

Project development involves different tasks, some well-known and simple, others unknown and complex, from start to finish. Being able to judge what to do when, and how much time to allocate for different tasks is important in order to reach a successful result. It involves being able to evaluate the skills, tools, techniques and methodologies which are appropriate to apply. When working with others, it also involves knowing the skills of team members and being able to distribute tasks, resolve conflicts, and coordinate work processes.

Understanding of Process

As an underlying condition of PBL, the learning and development process can be difficult and frustrating to navigate. Therefore it requires a deeper knowledge of open-ended processes and process navigation than typical project management. This also includes the awareness of how learning processes correspond and work together with the overall progression of the problem-based project.

Social Awareness

Collaborative problem solving is a social process. Beyond mere professional skills, it therefore also requires social skills. These include an awareness of other people, their wishes, needs and desires, and an understanding of their interests and capacities. Social skills is the oil which makes the engine run in collaborative processes. They encompass the non-instrumental aspects of collaboration such as aid, encouragement and praise, but also constructive criticism.

Empathy

While empathy is a prerequisite for social skills, it is more universal as it constitutes the persona. Empathy is the capacity to put oneself in other persons' shoes and see things from perspectives other than one's own. This capacity is fundamental to building trust, establishing a comforting work environment and good working relations. Conversely, lack of empathy among collaboration partners may lead to fear and distrust, hidden agendas and covert strategies, all of which are counterproductive to collaborative work processes.

3.2.3. ARCHITECTURE AND DESIGN-RELATED SKILLS

Freehand Drawing

The ability to draw in freehand is rarely taught in K12 outside specialized programs. Nonetheless, it is an important prerequisite for design development. While rarely taught systematically in architecture and design programs either – apart from in occasional nude drawing classes which are often elective or extracurricular – this must ironically be considered a baseline skill. Many architecture and design programs seem to rely on a learning-by-doing approach to freehand drawing as applied in observation drawing and sketching during design project development. While most students realize its importance, they seem to pursue freehand drawing skills to very varying degrees.

Sketching

Although sketching often involves freehand drawing – and is mostly related to this – it also involves the use of a host of other design media, such as physical model-making and CAD. Sketching, fundamentally, is design development through iterative cycles of design testing in a trial and error fashion. As the most fundamental element of the design process, sketching to a large degree is designing. While model-making and CAD software may be formally introduced, using these tools for sketching is very much a tacit process by which sketching skills develop in the students individually.

Spatial Thinking

Spatial thinking is the capacity to analyse and to organise volumes and voids in space. While no person could survive in the physical world without spatial thinking capacities, they may vary significantly from one individual to another. In architecture and design, spatial thinking capacity determines the level of complexity in three-dimensional space which the designer is able to understand, as well as to conceive of. While spatial thinking is crucial in architecture and design and may be trained implicitly through design work and other design exercises, it is hard to measure directly and thus to teach explicitly in a well-defined way.

Sense of Reality

While the capacity to fabulate (see below) is important in architecture and design, it is equally important to be able to relate design ideas to different aspects of reality, such as the laws of physics, social systems, and economy. In order to be viable in the real world, designs must be buildable, usable and feasible. As very many real world factors may determine the success of a design, a broad sense of reality can be pivotal for the designer's ability to create a successful design.

Explorative Spirit

In design, good solutions rarely come easy, but are the result of repeated cycles of design exploration. Rather than settling for the first solution which might fulfill a design brief or challenge, this requires an explorative spirit. Having an explorative spirit means that you think you may reach an even better result if you try harder and spend more time trying to solve design problems. Perseverance and curiosity are components of an explorative spirit, as well as the eager to gain new insights, even if you are not sure what you may use them for.

Courage

The very definition of design is to create artifacts that do not already exist. This requires venturing into the unknown. And this, in turn, requires courage. If you are afraid of going where no-one else has gone before you, you are likely to be a poor designer. The confidence that you may come up with something new and useful, even if you do not resort to convention, established methods, or tested techniques is required in order to transgress beyond the realm of the existing. When venturing into uncharted territory, you must have the courage of not knowing what is coming to you.

Imagination

Being able to get ideas and to get inspired is linked to imagination. Imagination is the capacity to form mental images of things which are not present to the senses or cannot be perceived in the real world. Imagination is fed by experience and curiosity. While experience builds over time, however, it may both sharpen and dull imagination. Curiosity may reside in individuals to varying degrees, irrespective of age. Hence, while imagination may either grow or diminish with age, it may exist in young people. Imagination must be nurtured and encouraged to stay alive.

Fabulation

The design process rarely follows a straight path of reasoning, nor is it warranted by adhering to clear formulas or procedures. As opposed to many engineering problems, design problems cannot necessarily be broken down deductively or in rational ways. Conversely, allowing yourself to fabulate – to stray along irregular and inconspicuous paths of thinking – may be what takes you to the right solution. To fabulate is to allow your thoughts to wander and to change direction, triggered by whatever comes to your mind or to your attention.

Creativity

While often hailed as the most important skill for designers, it is also one of the most intangible and ill-defined. Creativity may be defined and fostered by many different sub-skills, such as the ones listed here. But there are countless ways in which to be creative. However, creativity seems to require a combination of both mind-sets and skill-sets. To formulate a design idea you must both be able to imagine it and to visualize it. This requires both imagination and visualisation skills. To conceive of new forms, you must be able to think spatially as well as to dare exploring into the unknown. Rather than a skill in itself, we therefore prefer to think of creativity as the sum of all the skills it takes to be a good architect or designer.

3.2.4. CONCLUSION

Baseline skills in a PBL university setting, by the nature of things, are only subject to limited formalized teaching, if at all. In part because baseline skills are expected to exist – at least to some degree – in students when they enter the program. And in part because the nature of many baseline skills makes them unsubjectable to formalized teaching. How, for instance would you teach curiosity, empathy or courage? This does not mean, however, that the presence of these skills in students cannot be evaluated. Rather, however, it means that they can be encouraged or stimulated through other learning processes. In a sense, therefore, you may say that baseline skills is what happens to you, when you are busy doing other things.

Even if not taught, the development of baseline skills are still important in order to become a qualified professional. It is desirable, therefore, to slip them in wherever possible, even if they are not explicit learning goals of formalized teaching. In order to do so, it is important to know the characteristics of each skill – what it takes to able to, say, aggregate or understand process. It is also important to know the types of content and material, and teaching and learning activities which are likely to stimulate the building of baseline skills.

In the table below, the baseline skills presented in this chapter are listed with regard to their characteristics – formulated as 'learning goals', and with examples of the types of content and material, and teaching and learning activities which are likely to stimulate the building of those skills. Were they to be taught, the general university skills would cluster mainly in the social interaction and behavioral modification families of relevant teaching methods. Not surprisingly, the PBL-related skills would cluster mainly in the social interaction and personal families of relevant teaching methods, while the architecture and design -related skills would cluster mainly in the information processing and personal families of relevant teaching methods.

As baseline skills are predominantly soft (qualitative) skills, they cannot be evaluated against hard (quantitative) criteria. Therefore, baseline skills can only meaningfully be evaluated by way of performance-based assessment. In practice this means that assessment should take place predominantly through dialogue, i.e. oral assessment.

Table 7: PBL Skills and respective Learning Outcomes, Content, Teaching Materials, Teaching/Learning Activities and Assessment Methods

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
PROBLEM BASED LEARNING SKILLS				
PBL-A General University Skills				
PBLA1	Being able to identify and define search terms	**Fact:** Handbooks and primers introducing basic knowledge, such as note-taking techniques. **Concept:** General concepts of knowledge, studying and learning, such as critical thinking. **Principle:** Basic frameworks for understanding the world, such as principles of reasoning (inductive, deductive and abductive reasoning). **Skill:** Basic study skills, such as information searching, note-taking etc.	Inductive investigation and inquiry Deductive investigation and inquiry Memorization Synectics Design and problem solving Projects and reports Direct Instruction Anxiety reduction programmed instruction Simulations	Numerical Rating Scale
PBLA2	Be able to select the proper sources for the search			Graphical Rating Scale
PBLA3	Being able to summarize and conclude the search			Numerical Rating Scale
PBLA4	Being able to understand the purpose of taking notes			Graphical Rating Scale
PBLA5	Being able to use note-taking techniques			Numerical Rating Scale
PBLA6	Being able to sort and use notes for writing			Numerical Rating Scale
PBLA7	Having a general understanding of the purpose and use of different technologies			Graphical Rating Scale
PBLA8	Having specific knowledge of concrete technologies			Numerical Rating Scale
PBLA9	Being able to use specific technologies to relevant tasks			Numerical Rating Scale
PBLA10	Being able to understand the professional relevance of specific facts, concepts, principles and skills			Graphical Rating Scale
PBLA11	Being able to explain the relation between the sum and parts of specific concepts			Numerical Rating Scale
PBLA12	Being able to proportionally evaluate the significance of elements relative to each other			Graphical Rating Scale
PBLA13	Being able to understand systems and principles			Numerical Rating Scale
PBLA14	Being able to apply systems and principles to concrete tasks			Numerical Rating Scale
PBLA15	Being able to synthesize systems and principles from observed phenomena			Numerical Rating Scale
PBLA16	Being able to see learning as a goal in itself			Numerical Rating Scale
PBLA17	Being motivated to seek information out of one's own initiative			Numerical Rating Scale
PBLA18	Allowing oneself to delve into new knowledge without a specific purpose			Numerical Rating Scale

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
PBLB PBL-related skills				
PBL-B1	Being able to establish a common understanding of a certain task	**Fact:** Instructions and guidelines to group work, such as collaboration agreements and project management charts. **Concept:** Basic PBL concepts, such as definitions of problem formulation, project delimitation and process evaluation. **Principle:** Principles of different project planning paradigms, such as defined vs empirical process control. **Skill:** Basic PBL skills such as problem formulation and problem solving.	Partner and group collaboration Role playing Jurisprudential inquiry Indirect teaching Awareness training and values clarification Role modeling Self-reflection	Graphical Rating Scale
PBL-B2	Being able to organize work between multiple individuals in order to solve a certain task			Graphical Rating Scale
PBL-B3	Being able to optimize own and others work by sharing individual work to a common result			Graphical Rating Scale
PBL-B4	Being able to understand the dualism between a problem and solution space			Graphical Rating Scale
PBL-B5	Being able to identify a problem			Numerical Rating Scale
PBL-B6	Being able to clearly formulate the problem			Graphical Rating Scale
PBL-B7	Being able to iterate the problem formulation in order to narrow the solution space			Numerical Rating Scale
PBL-B8	Being able to define criteria for a viable solution			Graphical Rating Scale
PBL-B9	Being able to develop proposals that corresponds with the criteria for solving the problem			Graphical Rating Scale
PBL-B10	Being able to evaluate concepts and solutions that solves specific problems			Graphical Rating Scale
PBL-B11	Being able to decide upon what solution to choose based on systematic evaluation			Graphical Rating Scale
PBL-B12	Being able to count in attitudes and experience from both individuals and as a group			Numerical Rating Scale
PBL-B13	Being able to identify project goals and project limitations			Graphical Rating Scale
PBL-B14	Being able to manage the scope, timing and quality of a project			Numerical Rating Scale
PBL-B15	Being able to continuously adapt the project to the current situation			Graphical Rating Scale
PBL-B16	Understanding the open-ended and iterative nature of a problem-based project			Numerical Rating Scale
PBL-B17	Being able to navigate the process in order to achieve the needed knowledge			Graphical Rating Scale
PBL-B18	Knowing basic social rules and behavior			Numerical Rating Scale
PBL-B19	Being able to understand and comprehend a social situation effectively			Numerical Rating Scale
PBL-B20	Being able to adapt to and navigate in a situation with a social insight and sensitivity			Numerical Rating Scale
PBL-B21	Being able to sense others' feelings and perspectives			Numerical Rating Scale
PBL-B22	Being able to take an active interest in others' concerns			Numerical Rating Scale

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
PBL-C Architecture and design-related skills				
PBL-C1	Knowing basic drawing tools	**Fact:** Text books and tutorials introducing knowledge, such as building construction and 3D rendering techniques. **Concept:** Notions specific to architecture and design, such as aesthetic quality, model representation and space. **Principle:** Drawing and sketching related principles, such as perspective, section, scale and golden ratio. **Skill:** Basic design skills, such as sketching, drawing, and creative techniques.	Inductive investigation and inquiry Deductive investigation and inquiry Memorization Synectics Design and problem solving Projects and reports Indirect teaching Awareness training and values clarification Role modeling Self-reflection	Numerical Rating Scale
PBL-C2	Knowing basic drawing techniques			Numerical Rating Scale
PBL-C3	Being able to apply drawing tools and techniques to freehand drawing			Numerical Rating Scale
PBL-C4	Being able to understand the purpose of sketching as an iterative design development skill			Numerical Rating Scale
PBL-C5	Being able to apply drawing/ modeling skills in the process of sketching			Graphical Rating Scale
PBL-C6	Being able to evaluate sketches as a basis for new sketches			Graphical Rating Scale
PBL-C7	Having a sense of three-dimensional space			Numerical Rating Scale
PBL-C8	Being able to analyze spatial situations			Numerical Rating Scale
PBL-C9	Being able to conceive spatial situations			Numerical Rating Scale
PBL-C10	Being able to understand the way things work in practice			Numerical Rating Scale
PBL-C11	Being able to analyze proper needs			Numerical Rating Scale
PBL-C12	Being able to turn concepts and models into real-world solutions			Numerical Rating Scale
PBL-C13	Being able to feel the value of striving for better solutions			Numerical Rating Scale
PBL-C14	Having the perseverance to perform repeated cycles of trial and error			Numerical Rating Scale
PBL-C15	Being able to apply unconventional concepts, methods and techniques to problem solving			Graphical Rating Scale
PBL-C16	Being able to build worst-case scenarios			Numerical Rating Scale
PBL-C17	Being able to dare to venture into the unknown			Numerical Rating Scale
PBL-C18	Being unfearful of social stigmatisation			Numerical Rating Scale
PBL-C19	Being broad in insight and outlook			Graphical Rating Scale
PBL-C20	Being able to transfer knowledge, concepts and ideas between areas in life			Numerical Rating Scale
PBL-C21	Being able to dare to fabulate			Numerical Rating Scale
PBL-C22	Being able to let thoughts wander			Numerical Rating Scale
PBL-C23	Being able to enter a state of flow			Numerical Rating Scale
PBL-C24	Being able to let fantasy form ideas			Numerical Rating Scale

3.3. ICT Baseline Skills for Architectural Education

Information and Communication Technology (ICT) skills are becoming more predominant in all aspects of our lives. It's not only because of the advancement in IT hardware but ICT redesigned the way we interact, learn, communicate and run a business. Thus, educational institutions are well aware that ICT skills enhance students' abilities to access and use information in a productive and effective manner in their future professions. By the same token, the following ICT skills are proposed for architecture students to better perform at the university and in their professional practice.

ICT Skills are realized under 5 groups which contains several respective skills. These groups can be defined as:

- Skills related to conducting information search by means of ICT
- Skills related to the use of appropriate software
- Skills related to digital collaboration and cloud technologies
- Skills related to self-regulated learning by means of ICT
- Skills related to troubleshooting

Even though several skills reside under the mentioned groups and can be operated with same content, teaching materials and teaching-learning activities, and yet they may require a different assessment method. Skill groups are explained in conjunction with their respective content and activities.

Skills related to conduct information research by means of ICT

This group refers to the skills required to survive and reach relevant information among the vast amounts of data present in world wide web. Being able to conduct effective searches by means of relevant syntax, being able to differentiate relevant information and being able to enrich one's own repository of data sources constitutes the core of this group. Content of search syntax, keyword combinations, information on how to distinguish reliable data, how to effectively reach information is delivered by means of giving descriptive information and case study demonstrations.

Skills related to use of appropriate software

This group refers to the required skills for effective use of software to produce and manage data. Being able to acknowledge the conformability of task and software by acknowledging potentials and limitations of the respective software, being able to effectively use the right software for the task and being able to switch between softwares as the requirement changes form the core of this skill group. As it is neither possible nor feasible to cover architecture-related software, content is based on knowledge on how to differentiate and internalize the working principles of software, limitations and potentials of algorithms which the software are built upon. In addition, the possibilities of data transfer among different software are covered within the scope of this group. Learning activities are based on descriptive information, demonstrations of best practices and case studies.

Skills related to digital collaboration and cloud technologies

Being able to use digital collaboration tools and being able to utilize cloud-based technologies (e.g. rendering, simulation) forms this group. The content is based on the potentials and best practices of utilization of these tools and activities target demonstrations and guided practices.

Skills related to self-learning by means of ICT

This group refers to self-learning in general. These skills include but not limited to being able to learning management systems, self-regulation tools and being able to keep him/herself up to date with emergent technologies. The content is composed of principles of learning management systems, self-regulated tools, strategies to find the most appropriate tools for the individual is delivered by means of demonstrations.

Skills related to troubleshooting

This group targets troubleshooting strategies which are crucial in the digital age referring to both hardware and software. Being able to detect and resolve the problem forms the core of this group and content of possible medium for finding solutions to problems encountered and strategies to approach these problems are delivered by means of guided practices with use cases.

All the skills and their indicators are summarized and exemplified in Table 8.

Table 8: ICT Skills and respective Learning Outcomes, Content, Teaching Materials, Teaching/Learning Activities and Assessment Methods

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
INFORMATION COMMUNICATION TECHONOLOGIES RELATED SKILLS				
ICT-A Information Retrieval				
ICT-A1	Being able to conduct in depth research in relation with the problem	**Fact:** What is smart keyword, syntax such as “”, or, and, -, etc. **Concept:** Enable to distinguish architecture related content by giving architectural and non-architectural examples. Being able to distinguish valuable sources from others **Principle:** How to check the validity of the information **Skill:** Conducting an extensive research in relation with the problem Collecting relevant information Using different search tools and medium Conducting smart search by using a number of combination of keywords	Descriptive information with infographics e.g. Google Infographics Demonstrating what is the correct way of searching and what is not. e.g. “How to spot fake news” Case study demonstration	Graphical Rating Scale
ICT-A2	Being able to collect relevant information			Graphical Rating Scale
ICT-A3	Being able to use different search tools and medium			Numerical Rating Scale
ICT-A4	Being able to conduct smart search by using a number of combination of keywords			Numerical Rating Scale
ICT-B Data Usage				
ICT-B1	Being able to acknowledge the limitations and potentials of software and choose appropriate tools for given task	**Fact:** What is the limitations of a particular software? What is the potentials of a particular software? **Concept:** Showing the appropriate software to be used for the task and explaining in the limitations of the other software types Enable to operate in different media **Principle:** How to transfer data from one medium to another **Skill:** Acknowledging the limitations and potentials of software and choose appropriate tools for given task Producing & transferring data in different media Transferring data to different media	Descriptive information on limitations and potentials of different software Demonstrating how to produce data in different media Descriptive information on similarities and differences of working principles of different software Demonstrating how to transfer data to different media Case study demonstrating on best and worst case scenarios regarding data transfer	Graphical Rating Scale
ICT-B2	Being able to produce data in different media			Numerical Rating Scale
ICT-B3	Being able to transfer data to different media			Numerical Rating Scale

<table>
<tr><th>Skill Indicator</th><th>Learning Outcomes</th><th>Content & Teaching Materials</th><th>Teaching Learning Activities</th><th>Assessment</th></tr>
<tr><td colspan="5">ICT-C Collaboration</td></tr>
<tr><td>ICT-C1</td><td>Being able to cope with digital collaboration tools</td><td rowspan="2">Fact:
What is digital collaboration?
What are the cloud based technologies?
What are the limitations, potentials and constraints of digital collaboration tools?
What are the limitations, potentials and constraints of cloud based technologies?
Concept:
Enable to choose the most appropriate digital collaboration tools
Being able to conduct cloud based operations when available and needed
Principle:
How to use digital collaboration tools
How to use cloud based technologies
Skill:
Coping with digital collaboration tools
Utilizing cloud based technologies</td><td rowspan="2">Demonstrating the use of digital collaboration tools such as Trello, Google Drive, Dropbox, Autodesk 360, etc.

Presentation of current cloud based technologies with their potentials and limitations

Guided practice on utilization of cloud based technologies</td><td>Numerical Rating Scale</td></tr>
<tr><td>ICT-C2</td><td>Being able to utilize cloud based technologies</td><td>Numerical Rating Scale</td></tr>
<tr><td colspan="5">ICT-D Self Sustainability</td></tr>
<tr><td>ICT-D1</td><td>Being able to use learning management systems</td><td rowspan="3">Fact:
What are the learning management systems in the field of architecture?
What is self-regulated learning, and its environment and tools?
What are the limitations, potentials and constraints of learning management systems, self-regulated tools?
What are the media for following emergent technologies?
Concept:
Enable choosing appropriate self-regulated tools
Enable to choose the most appropriate learning management systems
Principle:
How to use self-regulated tools
How to use learning management systems
How to find appropriate tools for individual
Skill:
Using learning management systems
Using self-regulation tools
Keeping him/herself up to date with new emergent technologies</td><td rowspan="3">Demonstrating learning management systems of partnering institutions (METU: metuclass)

Introducing and demonstrating self-regulation tools such as Mendeley.

Demonstrating the keywords regarding the emergent technologies

Giving examples of questions triggering the new technological development</td><td>Graphical Rating Scale</td></tr>
<tr><td>ICT-D2</td><td>Being able to use self-regulation tools</td><td>Graphical Rating Scale</td></tr>
<tr><td>ICT-D3</td><td>Being able to keep him/herself up to date with new emergent technologies</td><td>Graphical Rating Scale</td></tr>
</table>

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
ICT-E Troubleshoot				
ICT-E1	Being able to troubleshoot software and hardware problems	**Fact:** What is the importance of help file, forums, and proper web-based search for troubleshooting **Concept:** Enable to understand the problem related with software and hardware Being able to distinguish solutions targeting the problem **Skill:** troubleshooting software and hardware problems	Guided Practice on possible problem cases with their troubleshooting. Introducing alternative troubleshooting methods such as help file, forums, and proper web-based search	Numerical Rating Scale

4. SUMMARY

Constructivism is a frame of thought based on experiential learning, problem- and project-based learning. The role of the teacher is one of guiding students to construct knowledge. The learning process must be designed with meaningful stages and clear definition of objectives and expected outcomes.

STEAM enhances constructivist learning and meets the needs of 21st century learning, which is active, outcome based, student centered, and based on an integrated curriculum. This report defines skill sets, which respond to the 11 skill sets of the DIRECTIVE 85/384/EEC, and curriculum design. These skills can be described as ground skills, critical and creative skills, and ICT skills respectively.

Learning is typically formalised in modules – self-contained units of content – with learning goals and evaluation criteria. Module development is an application of the instructional design process.

The ADDIE model is a commonly used descriptive guideline for module design. It divides the process into five phases of analysis, design, development, implementation and evaluation.

Intended learning outcomes may be formulated as instructional goals according to the S.M.A.R.T. method focusing on Specific, Measurable, Action-oriented, Realistic and Time-based goals. Content must be linked directly to the instructional goals. Content may be categorised as facts, concepts, principles and skills, each of which require different mental processes and efforts to be learned.

Different teaching methods may be described as belonging to one of the four 'families' of social interaction, information processing, personal and behavioural modification. Assessment provides evidence about the realism and attainability of instructional goals by students, indicates the efficiency of teaching methods, and provides evidence for performance judgement.

While objective test items are easy to manage, they are difficult to apply in architecture and design education which covers complex skills and behaviours. Performance assessment allows to measure complex learning outcomes. Yet judgemental scoring represents a limitation to this method.

Three skill sets, ground skills, PBL skills, and ICT skills are presented. While ground skills are general university skills independent of the subject of study, and PBL skills relate to problem-solving, analytical thinking and decision making, ICT skills relate to the application of technology.

Skills relating specifically to architecture and design concern the design process, technical knowledge, management, maintenance, and restoration of buildings, and basic knowledge of the real estate market.

In a PBL university setting, skills in architecture and design comprise general university skills, PBL-related skills and architecture and design-related skills. General university skills comprise information searching, note-taking, technology savvy, aggregation, logical thinking, and curiosity. PBL-related skills comprise collaboration, problem formulation and solving, decision making, project management, understanding of process, social awareness and empathy. Architecture and design-related skills comprise freehand drawing, sketching, spatial thinking, sense of reality, explorative spirit, courage, imagination, fabulation, and creativity.

ICT skills categorised into five groups of skills related to the use of appropriate software, digital collaboration and cloud technologies, self-regulated learning by means of ICT, and troubleshooting respectively.

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APPENDIX I

Problem-Based Learning (PBL)

PBL is a pedagogical approach that gives the opportunities to students for engaging actively meaningful problems in a collaborative setting. In this approach, students learn while solving real life problems and create own mental representations for learning. It bases on the principle of constructivism by encouraging students as active knowledge seekers and guiding them to create personal mental models with the help of prior knowledge. It also reinforced by social theories of learning by providing social interaction environment in cognitive progress. PBL philosophy considers that learning is a constructive, self-directed, collaborative and contextual activity.

At the same time, Problem-Based Learning (PBL) is also a teaching method used in this approach called with the same name. This teaching method provides complex real-world problems as a tool to promote student learning of concepts and principles as well as provides the development of scientific and independent thinking skills, problem-solving abilities, and communication skills of students. The principles of scientific method are used in this teaching method and it can reinforce students for working in groups, finding and evaluating research materials, and provide students' life-long learning (Duch et al, 2001).

Project-Based Learning (PBL)

Project-based learning is a systematic teaching method that provide students with opportunities to construct knowledge and skills with complex, authentic questions and carefully designed products and tasks in real life based. (Markham, Larmer, & Ravitz, 2003) PBL has five definitive features which includes 1) a central project; 2) a constructivist focus on important knowledge and skills; 3) a driving activity in the form of a complex question, problem, or challenge; 4) a learner-driven investigation guided by the teacher; and 5) a real-world project that is authentic to the learner (Thomas, 2000).

Project-based learning is a model which differentiates from traditional teaching since the learners and their projects are focused. Learners have the opportunity to "construct own learning that is personally meaningful" and to "work more autonomously".

In recent years, a number of X-based learning approaches fitting into the general category of PBL like case-based learning, community-based learning, game-based learning, passion-based learning, service-based learning, team-based learning has emerged.