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

Project Report

04 - DEVELOPMENT OF FIELD RELATED CONTENT FOR ARCHITECTURE STUDENTS

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

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1. INTRODUCTION

In this report, Integration of STEAM approach to an existing or a new subject is illustrated in three different courses given in METU, UNIBO and Aalborg, Digital Design Studios, METU, Lab-based Course on Building and Architecture (Integrated Course), UNIBO, Urban Technologies Course, AAU.

These three courses addressed in the project are chosen as being different than each other in terms of their subject matters, the way they are conducted and how they are integrated in the curriculum of each university. These differences are served to exemplify how STEAM and related skills can be conveyed and to show how any teaching experience can be structured and designed accordingly.

As it can be seen in the coming sections, the way courses are designed and explained are closely related with the curriculum of the each university, their educational approach and scenarios and yet it is possible to implement STEAM and structure any module or course accordingly. These example courses prove that STEAM approaches can be implemented and be used in any teaching level from a simple module to whole curriculum.

The STEAM Skills defined in O3 Report of the ArchiSTEAM Project are merged and summarized in the table below. These skills are also used for establishing a common ground for three proposed courses in three universities; namely, METU, UNIBO and AAU.

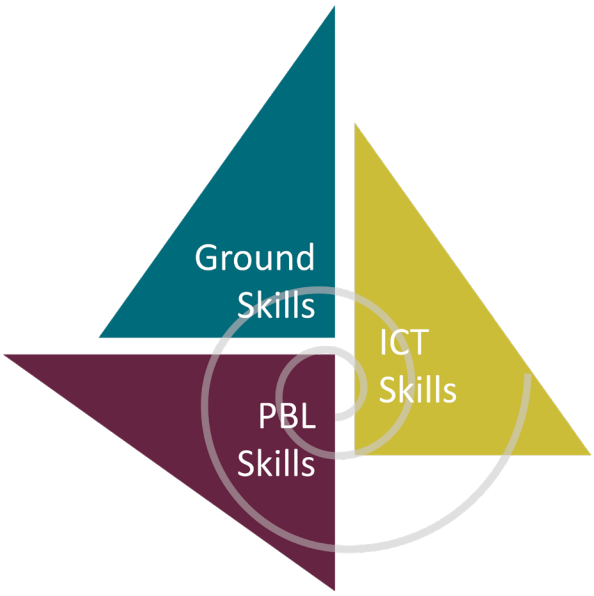


Figure 1: ArchiSTEAM Skills for Architectural Education

Table 1: Ground Skills and respective Learning Outcomes, Content, Teaching Materials, Teaching/Learning Activities and Assessment Methods

<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">GROUND SKILLS</td></tr>
<tr><td colspan="5">G-A Design Process</td></tr>
<tr><td>G-A1</td><td>Being able to design the architectural structure in relation to the character of the places and the size of contemporary cities</td><td rowspan="6">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</td><td rowspan="6">Hands-on practice via studio education
Guided practice
Demonstrating how to criticize existing architectures
Descriptive information with best practices from the field</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-A2</td><td>Being able to design at different scales, from urban dimension to technological detail</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-A3</td><td>Being able to conceive, plan, design and manage systems and processes in the construction sector</td><td>Graphical Rating Scale</td></tr>
<tr><td>G-A4</td><td>Being able to design and manage the construction process phases</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-A5</td><td>Being able to verify the possibilities of transformation and configuration of urban spaces</td><td>Graphical Rating Scale</td></tr>
<tr><td>G-A6</td><td>Being able to historically recognize and critically evaluate architectures</td><td>Numerical Rating Scale</td></tr>
<tr><td colspan="5">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</td></tr>
<tr><td>G-B1</td><td>Being able to critically detect an artifact</td><td rowspan="2">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</td><td>Descriptive information about the building physics
Demonstrating conservation and restoration examples
Case study demonstrations</td><td>Numerical Rating Scale</td></tr>
<tr><td>G-B2</td><td>Being able to verify the relations between buildings, the theoretical resolution of the constructive system and choice of technological procedures</td><td>Numerical Rating Scale</td></tr>
</table>

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
G-B3	Being able to control and manage building processes, considering the relationship between buildings, environment and available resources	**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		Numerical Rating Scale
G-B4	Being able to define and manage building maintenance plans			Numerical Rating Scale
G-B5	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			Numerical Rating Scale
G-B6	Being able to analyze the conservation status of an architectural artifact			Numerical Rating Scale
G-B7	Being able to design conservation and restoration interventions			Graphical Rating Scale
G-B8	Being able to evaluate the problems related to plant adaptation and consolidation			Numerical Rating Scale
G-B9	Being able to evaluate the compatibility of new uses in an existing building			Numerical Rating Scale
GC Ground Skills				
G-C1	Being able to understand the application of the mathematical and physical principles underlying the architecture and engineering sector	**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	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	Numerical Rating Scale
G-C2	Being able to work independently and in a team			Numerical Rating Scale
G-C3	Being able to communicate in written and spoken English			Numerical Rating Scale
G-C4	Being able to identify, formulate and solve complex problems that require an interdisciplinary approach			Graphical Rating Scale
G-C5	Being able to communicate the results of your work graphically, through presentations and technical reports			Graphical Rating Scale

Table 2: 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	Numerical Rating Scale
PBLA2	Be able to select the proper sources for the search		Deductive investigation and inquiry	Graphical Rating Scale
PBLA3	Being able to summarize and conclude the search		Memorization	Numerical Rating Scale
PBLA4	Being able to understand the purpose of taking notes		Synectics	Graphical Rating Scale
PBLA5	Being able to use note-taking techniques		Design and problem solving	Numerical Rating Scale
PBLA6	Being able to sort and use notes for writing		Projects and reports	Numerical Rating Scale
PBLA7	Having a general understanding of the purpose and use of different technologies		Direct Instruction	Graphical Rating Scale
PBLA8	Having specific knowledge of concrete technologies		Anxiety reduction programmed instruction	Numerical Rating Scale
PBLA9	Being able to use specific technologies to relevant tasks		Simulations	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

Table 3: 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

Skill Indicator	Learning Outcomes	Content & Teaching Materials	Teaching Learning Activities	Assessment
ICT-C Collaboration				
ICT-C1	Being able to cope with digital collaboration tools	**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	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	Numerical Rating Scale
ICT-C2	Being able to utilize cloud based technologies	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	Guided practice on utilization of cloud based technologies	Numerical Rating Scale
ICT-D Self Sustainability				
ICT-D1	Being able to use learning management systems	**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?	Demonstrating learning management systems of partnering institutions (METU: metuclass) Introducing and demonstrating self-regulation tools such as Mendeley.	Graphical Rating Scale
ICT-D2	Being able to use self-regulation tools	**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	Demonstrating the keywords regarding the emergent technologies Giving examples of questions triggering the new technological development	Graphical Rating Scale
ICT-D3	Being able to keep him/herself up to date with new emergent technologies	**Skill:** Using learning management systems Using self-regulation tools Keeping him/herself up to date with new emergent technologies		Graphical Rating Scale

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

Among the commonly used rating scales, graphical and numerical rating scales are selected for the exemplary assessment methods of the STEAM. While numerical rating scale is suitable for assessment with discrete values such as existing/ non-existing or not observed/partially observed/ observed, the graphical rating scale is used for conducting the assessment within a continuous domain. Design skills and skills for which the assessment with discrete values are not possible are adequate to be assessed with a graphical rating scale. In addition, the number of discrete values are not given within the scope of the report and should be determined by the instructor with respect to the extent of the skills required for the specific course.

2. IMPLEMENTING PROPOSED MODULE TO EXISTING COURSES

STEAM is implemented in two existing courses in METU, focused on computational design, namely, Digital Design Studio and Advanced Digital Design Studio. These two design studios exist in the curriculum of METU Department of Architecture more than 15 years aiming to not only computational thinking, algorithm development, and related mindsets but also state of art computational technologies including scripting, modeling, representation and fabrication.

Computational design problems, in essence, necessitate multi-disciplinary design approach and from ill-defined design problem to design process, it is important for the designer/learner to design their own eco-system which means to choose proper technologies and being able to recognize related disciplines. In this regard, computational design problems are actually prone to be good examples of how STEAM approach can be employed.

mathematical principles behind such technologies. Inherently, the courses have been modified each and every year not only in terms of course content with respect to the changing technologies but also as a ground for utilizing new educational techniques. Inherently, ARCH 470 and ARCH 475 courses are valid candidates for implementation of STEAM skills which are defined in Table 1 both as having the STEAM mindset since from the beginning of the course and being open to changes.

Although both courses are modified with respect to the proposed STEAM Skills, due to the timing of the project, ARCH 475 course is documented and shared in the scope of this report.

The first part describes the course objectives, content, and outcomes of both courses, while the second part depicts ICT skills that are integrated and distribution of STEAM content across sub-topics of the Arch 475 course in 2017-2018 Spring semester.

2.1. Digital Design Studio, METU, Turkey

This section examines two elective courses named ARCH470 Digital Design Studio and ARCH475 Advanced Digital Design Studio given by the Department of Architecture at Middle East Technical University. Both ARCH470 and ARCH475 are studio courses which are offered since 2003 as being one of the pioneering studio in computational design in architecture not only in Turkey but also globally. The course is conducted with an interdisciplinary nature by instructors from various disciplines ie engineering, natural sciences, and architecture. Arch 475 is the continuation of the course Arch 470. While being conducted with the similar weekly schedule and learning/teaching activities, course objectives, learning outcomes, and content are advanced in Arch 475 course. Both of these courses are 8 ECTS courses which are mainly based on project work.

By nature, two elective studio courses explore contemporary technology and its applications in architecture in the realm of computational design with the aim of grasping the scientific and

2.1.1. CURRENT COURSE STRUCTURES

The three components of the course structure as objectives, content and learning outcomes are listed as follows for two courses:

ARCH 470 Digital Design Studio

Course Goals and Objectives

At the end of this course, it is first expected that student will

- develop basic knowledge in understanding computational design,
- understand new architectural geometries,
- develop parametric design models,
- question digital media as a design medium rather than a medium for representation, and
- be familiar with fabrication technologies.

Course Content

ARCH 470 Digital Design Studio is a design research studio which Architectural representation medium will be questioned as an architectural thinking environment. The course aims to enable

designing thematic and conceptual environments to reveal the enriching relation between the digital and tectonic worlds. The course is a facilitator for the use of high-end software together with their potentials and limitations and covers the relation between model making and digital thinking, physical and digital/virtual realms. The course starts with a wicked problem which is to be elaborated by the students by means of research and problem redefinition. The course is concluded with the digital or physical fabrication of their designs which are to be realized through the computational design process. The concepts covered in the scope of the course include but not limited to algorithmic thinking, parametric design, computational design, the mapping between various disciplines, digital fabrication and virtuality.

Learning Outcomes

By the end of the course the successful students are expected to:

- Be able to follow up state of art computational technologies
- Be able to use at least one parametric design software
- Be able to design the design process in an algorithmic way
- Be able to use at least one fabrication technology in a competent way

Arch 475 Advanced Digital Design Studio

Course Objectives

This course provides knowledge on:

- advanced themes and topics of digital environment
- different computational design approaches
- complex parametric design models
- complex representation techniques like animations

Course Content

Arch 475 Advanced Digital Design Studio is an advanced design research studio which is the continuation of Arch 470 course. Similar to Arch 470, the course starts with a wicked problem which is to be elaborated by the students by means of research and problem redefinition. It is aimed to develop an innovative consciousness for advanced themes and topics of digital environment. Themes and topics will differ in each semester. Architectural thinking and space in relation to digital environment will be further elaborated and discussed through a design project.

Course Learning Outcomes

By the end of the course the successful students are expected to be able to :

- follow up state of advanced computational technologies
- learn any parametric design software
- propose complex design models
- integrate several soft-tools into their design process
- analyze the performance of their design
- explore fabrication technologies

2.1.2. STEAM SKILLS TO BE EMBEDDED INTO THE COURSE ARCH 475 COURSE IN METU

Both Arch 470 and Arch 475 courses are modified with respect to the STEAM skills which are described in Table 4 . Yet, due to the timing of the project report, documentation of the course is conducted on Arch 475 course which is offered in 2017-2018 spring semester. The primary learning activity is hands-on studio work which is fostered with scaffolding. Hence, although the skills mentioned below are expected to be gained by the students, the level of scaffolding is dependent on the level of student and there is no standardized set of actions for the course. On the other hand, the process and expected outcomes are well documented and shared with the students to enable them their progress and end goal even though the STEAM skills listed below are not explicitly shared but is required to reach the ultimate goal.

In this respect, Table 5 shows the distribution of the covered ICT skills throughout the weekly schedule in the modified version of the course and Table 3 describes distribution of STEAM content across sub-topics of the course. In this regard, the ICT skill codes that can are listed in Table 5 in the scope of ARCH 475 course can be traced from Table 4.

Table 4: Weekly distribution of STEAM skills in Arch 475 Course in METU

Week #	Teaching Learning Activities	Ground Skills	PBL Skills	ICT Skills
Week 1	Introduction of the course Warm up with short video Brainstorming about the semester theme	C- 3, 5	A- 4, 5, 11, 13, B- 1, 5, 6, 21 C- 22, 24	-
Week 2	Research on possible keyword of theme Introduction of semester theme	C- 2, 3, 4, 5	A- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 16, B- 1, 2, 3, 5, 6, 7, 8, 9, 12, 14, C 17, 20, 21, 22, 24	A- 1, 2, 3, 4 D 1, 2
Week 3	Research on inspiration for design with respect to theme Workshop on parametric design software Analysis and definition of design constraints and parameters	B- 1, 5, C- 1, 2, 3, 4, 5	A- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, C- 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	A- 1, 2, 3, 4 B- 1, 2 D- 1, 2
Week 4	Workshop on parametric design software Design	A- 1, 2, 5, B- 1, 5, C- 1, 2, 3, 4, 5	A- 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, C- 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	B- 1, 2, 3 C- 2 D- 1, 2, 3 E-1
Week 5	Workshop on parametric design software Design	A- 1, 2, 5, B- 1, 5, C- 1, 2, 3, 4, 5	A- 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, C- 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	B- 1, 2, 3 C- 2 D- 1, 2, 3 E-1
Week 6	First jury			-
Week 7	Design	A- 1, 2, 5, B 1, 5, C- 1, 2, 3, 4, 5	A- 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B- 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, C- 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	B- 1, 2, 3 C- 2 D- 1, 2, 3 E-1
Week 8	Finalization of design phase	A- 1, 2, 5, B- 1, 5, C- 1, 2, 3, 4, 5	A- 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B- 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, C- 1, 2, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20	B- 1, 2, 3 C- 2 D- 1, 2, 3 E-1
Week 9	Fabrication (Soft Models and/or Scale Models)	C- 2, 3, 5	A- 7, 8, 9, 10, 11, 12 13, 14, B- 1, 2, 3, 5, 7, 9, 10, 11, 12, 14, 15, 16, 17, C- 7, 8, 9, 11, 12, 13, 14, 15, 16, 20	B- 1, 2, 3 C- 1, 2 D- 1, 2, 3 E-1
Week 10	Final Jury	C- 2, 3, 5	-	-

Table 5: Distribution of STEAM content across sub-topics of the course: Arch475 Advanced Digital Design Studio

	Research	Redefinition of the Problem	Design & Modeling	Fabrication
Science	●●●	●	●●	●●
Technology	●●●	●	●●●	●●●
Engineering	●●●	●	●	●●●
Arts	●●●	●●	●●●	●
Mathematics	●●●	●●	●●●	●●

ARCH 475 2017-2018 Spring Semester Outcomes

The theme of the project is given as "Hole in the Wall" with one major constraint of learning from an animate biological being . 9 students who took Arch 470 course in the fall semester are grouped into three groups. The project groups worked together for the whole semester.

At the first part of the course, the students are expected to conduct research on firstly to select a biological being to learn from by acknowledging the wicked problem of "Hole in the Wall". After conducting the initial research on biological beings, three groups selected Mycellium, Sea Urchin and Armadillo to learn for their designs. After selecting their biological beings, the students are asked to deepen their research by finding the corresponding examples or products which also learnt from the selected biological beings. In that sense, it is aimed to broaden the students' horizon in terms of analyzing the possible implementations and different methods of learning from different disciplines (Figure 2-3-4).

After the problem redefinition phase, the students iterated their designs and finally fabricated in both physical and virtual mediums. In the course of fabrication, several technologies such as rapid prototyping, cnc routing and laser cutting are utilized. In that sense, students are encouraged to use more than one technology to confront the challenge of solving the detailing between different fabrication technologies.

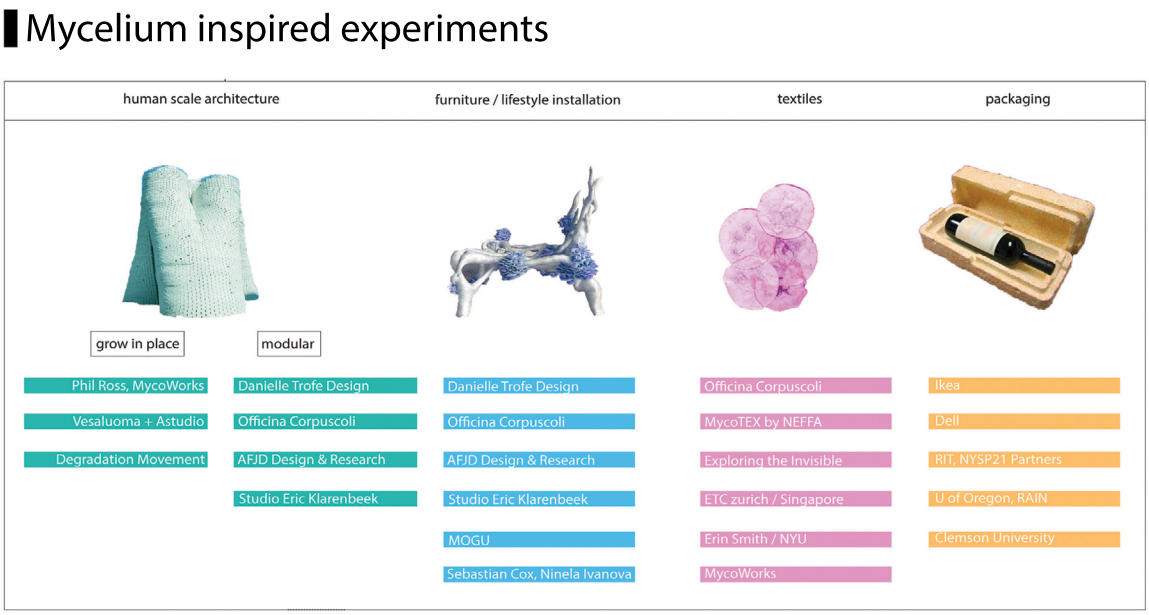


Figure 2: Research of Mycelium group on applications using mycelium as a material and inspiration

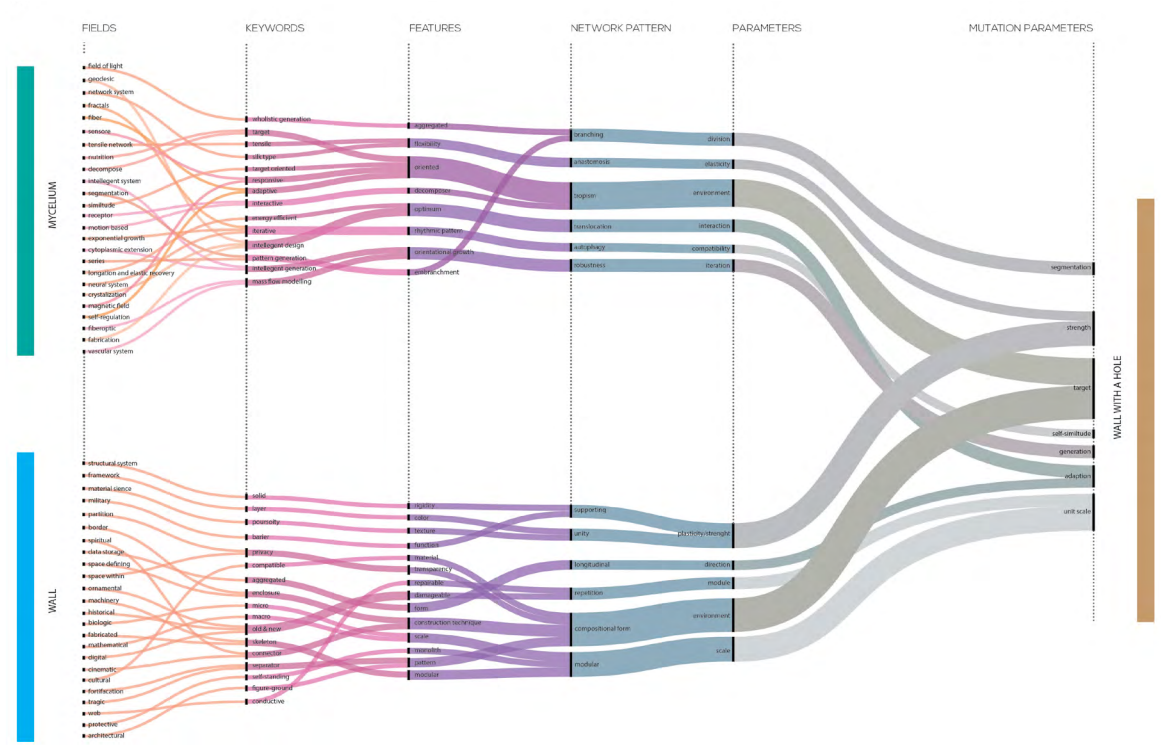


Figure 3: Exercise on retrieving keywords, features, patterns from different fields and generating design parameters accordingly by Mycelium Group.

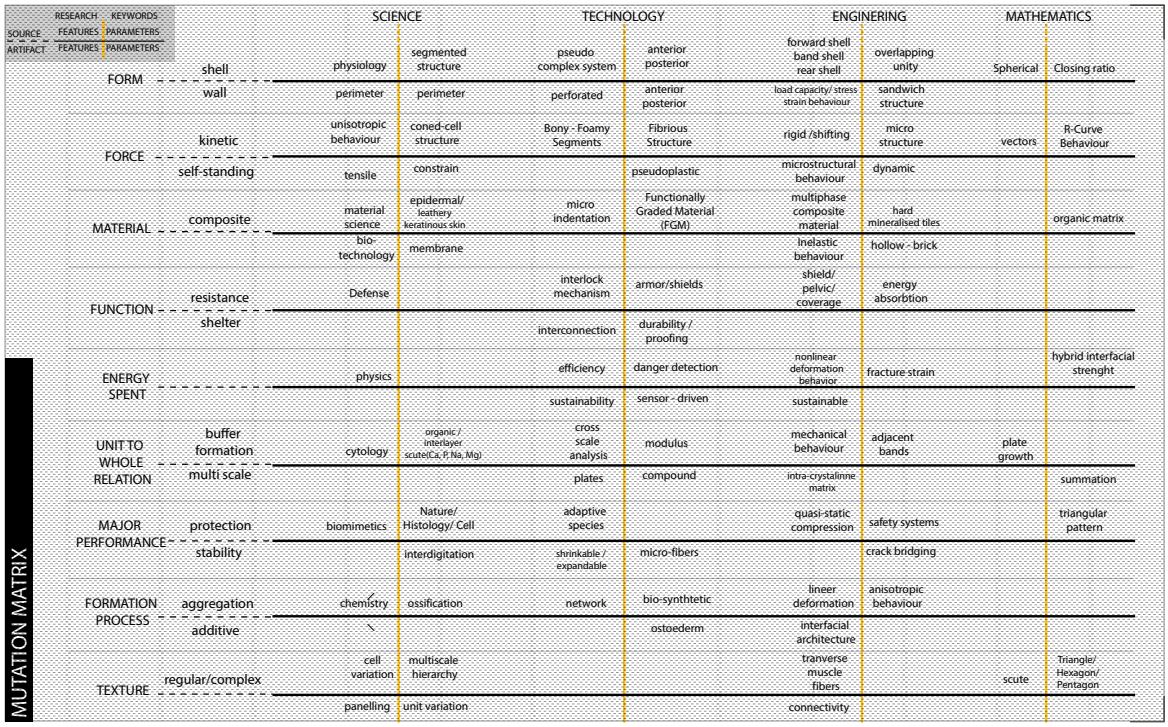


Figure 4: Exercise on retrieving keywords from different fields and generating parameters accordingly by Armadillo Group.

Throughout the semester, not the aesthetics of the design but the consistency of both biology, architecture and the mapping between them is inspected. Meanwhile, students are continuously forced to utilize STEAM skills listed in Table 2 . It is observed that sticking to the STEAM Skills (regardless of the STEAM category), forcing students out of their comfort zone and broadening the horizon of the students by confronting with multiple disciplines positively influence both the design process and the final product. Motivated and influenced by the implementations in other disciplines, students are observed to encourage themselves to come up with innovative ideas and push their limits and knowledge even in the areas which they were already in advanced level prior to the course. These areas include but not limited to fabrication technologies, generative design through custom coded simulations, developing kinetic systems and implementations in virtual and augmented reality.

2.2. Lab-based Course on Building and Architecture (Integrated Course), UNIBO, Italy

Both the integrated courses we mentioned in Output 3 present a certain degree of opacity with respect to their training objectives, contents, activities they propose and methods for evaluating the results. According to a well rooted tradition in our academic environment, the character of a course, the contents it offers and the modalities of its delivery are often left to the oral communication among different generations of students (a kind of tacit knowledge). This derives from a tradition of cultural elitism that amplified the teaching freedom of the professor and entrusted the prestige of the course rather to the fame of its teacher than to its organization. It is well known that such attitudes are difficult to eradicate both in the teaching and in the student body.

The description of a course, and therefore of each of its modules, is an approximation of the contents it actually offers and of the methods of its delivery. Now, the gap or, as we said, the opacity in the description of the educational offer is not a merely descriptive fact. A better description of the training offer allows a better forecast of its phases, of the methods of its supply, of management of the operating procedures and of absorption of unexpected events.

The STEAM reconfiguration of a module among the ones we described in Output 3, is therefore not just a verbal restructuring, or a simply rephrasal. The reformulation of the course implies a critique of the teaching proposal as it has been formulated today and a new configuration of the educational offer.

For our STEAM implementation we considered the first course we mentioned in the upper part: Lab-based Course on Building and Architecture (Integrated Course).

The main weakness of this educational offer already transpires from its description: it regards the integration between modules which seem to intervene more by succession or juxtaposition than by fusion. Within the strategies advanced by this European project, the proposal of the working group at the University of Bologna has been to substantially integrate all the disciplinary contributions which converge in the lab, in such a way that the process of integration between the disciplines could adhere to the more general production and gradual refinement of the architectural project itself. This general process is graphically described in Figure 5 (Bartolomei, 2011).

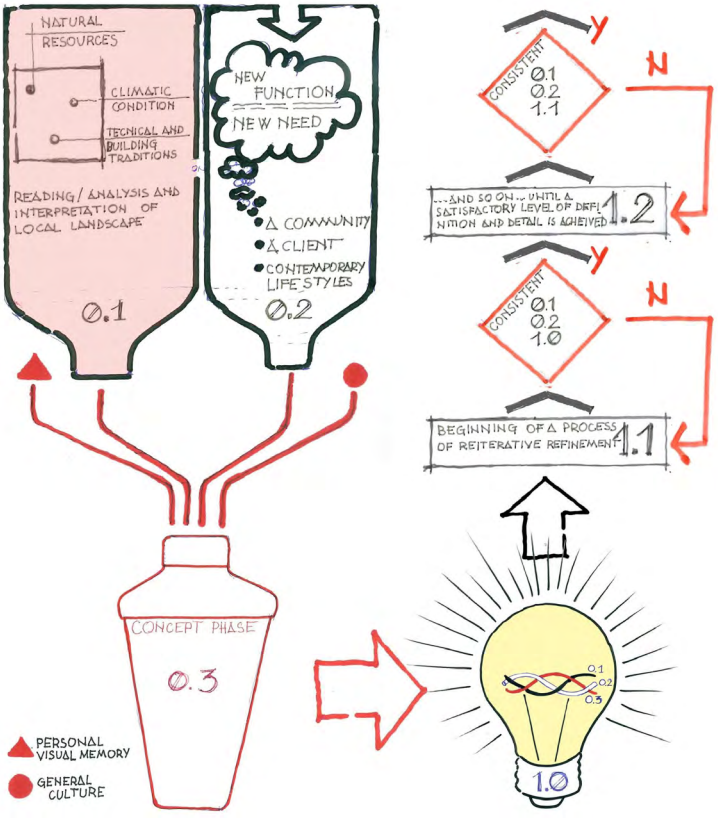


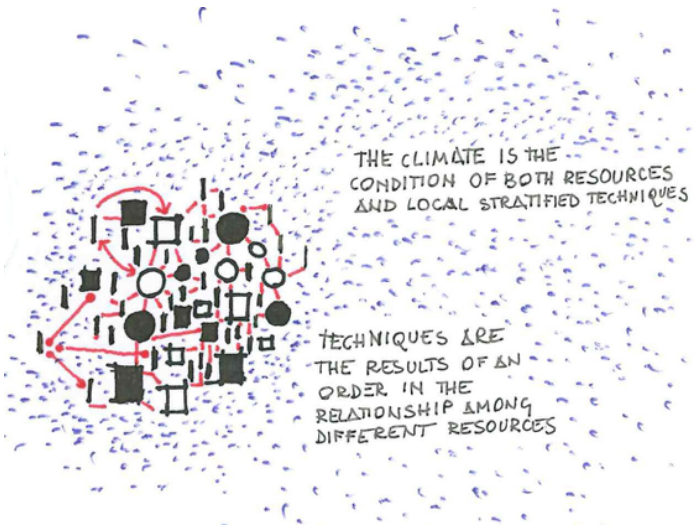
Figure 5: General design process illustration

The resulting course therefore rejects the former separation in two distinct modules, but it proposes to integrate different disciplines within both the modules by which it is constituted.

Table 6: Curriculum of the Proposed Course in UNIBO

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

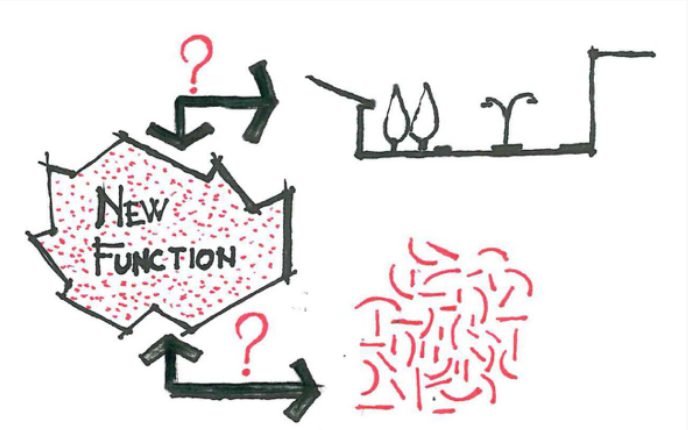
(Laboratorio di Costruzione dell'Architettura, Corso Integrato)

PHASE 1, MODULE A (8CFU)	**From Real to Imaginary.** **Reading the context to prepare its transformation**
Instructional Goals /Objectives	At the end of the module, students must be able to: • choose among different methods for reading the landscape and local context, both in its material components (natural and anthropogenic) and intangible ones (such as traditional building techniques) • examine new function required by a hypothetical client and its impact in the context. • configure a possible solution to the expressed needs, taking into account the analysis of the context, the proposed functions, the contemporary lifestyles,working with a specific attention to the energetic balance of the building in its entire life-cycle. • to express the above mentioned contents through two vertical plates 70x100, the first one dedicated to the analysis of the context, the second to the illustration of an initial concept (1.0) already integrated in aesthetic and formal, technological and energetic aspects.
Content	**0.1_site visit; site analysis** 0.1_1 how to see and interpret a Landscape (concept of Landscape, its fundamental descriptors, punctual and widespread symbolic and identity elements) — A 0.1_2 reading the relationship between resources-techniques and climate in the specific landscape (analysis of the evolution of resources and local techniques) — E/T 

PHASE 1, MODULE A (8CFU)	**From Real to Imaginary.** **Reading the context to prepare its transformation**
Content	**0.2_analysis of the client and of new functions requested.**

0.2_1 The relation with the client: criteria and methods to know its expressed and unexpressed needs . (formal-informal dialogue techniques and meetings; prefiguration of the client's role in the design process)	A
0.2_2 Gain a broader understanding of customer needs. (by means of an analysis of a collection of similar contemporary case studies)	E/T/A

0.3_elaboration of a concept / meta-project

0.3_1 techniques of decision-making on the design of the new building and on the contextualization of the new artifact, both with respect to its physical environmental surroundings, and with respect to its cultural one, that is traditional construction techniques and building typologies.  	A/T

1.0_notions of visual communication to prepare the synthetical meta-project presentation

<table>
<tr><td>PHASE 1, MODULE A (8CFU)</td><td colspan="3">From Real to Imaginary.

Reading the context to prepare its transformation</td></tr>
<tr><td>Teaching / Learning Activities</td><td colspan="3">Above mentioned contents will be achieved by:</td></tr>
<tr><td>0.1</td><td>0.1_1</td><td>• formal communication / frontal lecture
• site visit
• group debate on site visit
• sketches exchange</td></tr>
<tr><td></td><td>0.1_2</td><td>• collecting narratives from the locals;
• personal observation and drawings;
• group debate;
• frontal communication;
• sketches exchange;
• personal bibliographical research.</td></tr>
<tr><td>0.2</td><td>0.2_1</td><td>• role-play</td></tr>
<tr><td></td><td>0.2_2</td><td>• bibliographical - media search;
• group debate;
• comparative analysis.</td></tr>
<tr><td>0.3</td><td>0.3</td><td>• frontal communication;
• group debate by sketch and drowning;
• personal elaboration and research by design.</td></tr>
<tr><td>1.0</td><td>1.0</td><td>• frontal communication;
• bibliographical media search;
• group debate;
• personal drawing.
• finalization.</td></tr>
<tr><td>Assessment</td><td>Personal anonymous Self-Assessment</td><td colspan="2">The personal self-assessment of the present training proposal will take place in two different moments, the first-one at the beginning of the module, the latter at its end.

Pre-survey will include:
• self evaluation on ground skills required by this module (visual communication and social-interaction skills);
• expectations on course contents;
• expectations regarding the increase in personal skills and knowledge.

Post-survey will include:
• verification of expectations in relation to the contents of the course;
• self-evaluation of the personal and professional growth in relation to skills and knowledge typical of the course;
• evaluation of the teaching techniques and methods with eventual suggestions.</td></tr>
</table>

PHASE 1, MODULE A (8CFU)	**From Real to Imaginary.** **Reading the context to prepare its transformation**	
Assessment	Group Self-Assessment	Each member of each group will be asked to fill in an anonymous questionnaire to assess the quality of his/her group work. This survey will evaluate by means of numerical answers by dots: • The methods of debate within the group, • their results; • difficulties and their reasons; • time to reach a shared result.
	Formal/Final Assessment	the formal assessment to the module will be determined by a commission made up of all the professors who intervened during the course after that each group will have briefly introduced its final works. The commission could consult the results of group self evaluation to obtain clarification on the progress of each group work.

PHASE 2, MODULE B (8CFU)	**From Imaginary to Reality.** **Rough-hewing the idea to get it to reality.**
Instructional Goals /Objectives	At the end of the module, each student must: • be aware that architecture is the result of a refinement process; • demonstrate the ability to dialogue with the professionals involved in the building process demonstrating technical language and abilities in basic calculation of building's structures and energy plants; • demonstrate problem solving attitude and ability to analyze and choose among different technical solutions, showing consistency with initial choices (1.0); • be able to draw up an executive project, including the resolution of all the key-nodes of the building both from a linguistic point of view, and from a structural and technological one with particular reference to the design and technologies choices related to energy efficiency and plant-system, with aim to obtain comfort condition in indoor spaces.

PHASE 2, MODULE B (8CFU)	**From Imaginary to Reality.** **Rough-hewing the idea to get it to reality.**
Content	The module will provide to the students: • element of aesthetic and visual perception; • recall of Environmental Technical Physics, thermodynamics and thermokinetics. In particular: Thermohygrometric wellbeing;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. • Knowledge on different Technologies and Materials to control the energy performance of the building; • knowledge of different structural solutions and of their mechanical behaviors; General feature in structures calculation.
Teaching / Learning Activities	The module will be organized by mixing three teaching methods and learning activities. **Method A** Above mentioned contents will be offered to the students in frontal communications by invited teachers. **Method B** The rest of the course will be organized as a LAB as an open square on which several kiosks will provide information, services and advices on real cases to each group. Each kiosk is representative of a specific group of consultants. **Method C** The refining process of the executive project remains in the hands of the group of students who has to manage a consistent project-path of decision-making by means of group discussion, bibliographical research, sketches exchange up to describe the project proposal in all its technical details with sufficient number of panels (3 at least, 70x100).

PHASE 2, MODULE B (8CFU)	**From Imaginary to Reality.** **Rough-hewing the idea to get it to reality.**	
Assessment	Personal anonymous Self-Assessment	The personal self-assessment of the present training proposal will take place in two different moments, the first-one at the beginning of the module, the latter at its end. Pre-survey will include: • self evaluation on ground skills required by this module (visual communication and social-interaction skills); • expectations on course contents; • expectations regarding the increase in personal skills and knowledge. Post-survey will include: • verification of expectations in relation to the contents of the course; • self-evaluation of the personal and professional growth in relation to skills and knowledge typical of the course; • evaluation of the teaching techniques and methods with eventual suggestions.
	Group Self-Assessment	Each member of each group will be asked to fill in an anonymous questionnaire to assess the quality of his/her group work. This survey will evaluate by means of numerical answers by dots: • The methods of debate within the group, • their results; • difficulties and their reasons; • time to reach a shared result.
	Formal/Final Assessment	the formal assessment to the module will be determined by a commission made up of all the professors who intervened during the course after that each group will have briefly introduced its final works. The commission could consult the results of group self evaluation to obtain clarification on the progress of each group work.

Table 7: Weekly distribution of STEAM skills course offered by UNIBO

Week #	Teaching Learning Activities	Ground Skills	PBL Skills	ICT Skills
Phase 0.1_1	site visit; site analysis	A5,6; C4; B1	A12,16,18; C 8, 9, 10, 11	-
Phase 0.1_2	Reading the relationship between resources-techniques and climate in the specific landscape	A 1, 2, 3, 4, 5, 6; B1,2	C 20,21,22 A 12, 16, 18	-
Phase 0.2_1	analysis on client's expressed and unexpressed needs	C 2, 3, 4, 5	B 12,13, 14 A 10, 11, 12, 13	A 1, 2, 3, 4 B 1, 2
Phase 0.2_2	broader understanding of customer needs	C 2, 3, 4 A 3, 4, 5	A 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B 5,6,7, 8, 9, 10, 18, 19 C 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	A 1, 2, 3, 4 B 1, 2 D 1, 2
Phase 0.3_1	Elaboration of a concept /meta project	A 4, 5 B 9 C 2, 4, 5	A 1, 2, 3, 10, 11, 12, 13, 14, 15 B 5, 6, 9, 10, 12, 13 C 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	A 3
Phase 1.0	Preparation of the synthetical meta-project presentation	A 1, 2, 5, B 1, 5, C 1, 2, 3, 4, 5	A 7, 8, 9, 10, 11, 12 13, 14, 15, 16, B 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, C 1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24	B 1, 2, 3 C 2 D 1, 2, 3 E1
Phase 2	From Image to Reality. Rough-hewing the idea to get it to reality	A 1, 2, 3, 4, 5, 6, C 1, 2, 3	A 7, 8, 9, 10, 11, B 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, C 5,6,7,8,9,10,11,12,13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	A 1, 2, 3, 4, B 2, 3 C 1, 2

Table 8: Distribution of STEAM content across sub-topics of the course

	Research (Site- approach; Phase 0.1)	Need understanding	Design & Modeling (meta-project)	Design
Science	●●●	●	●●	●●
Technology	●●●	●	●●●	●●●
Engineering	●●	●	●●	●●●
Arts	●●●	●●●	●●●	●●●
Mathematics	●●	●●	●●	●●●

2.3. Urban Technologies Course, AAU, Denmark

For the Spring 2018 run of the Urban Technologies 1 module at Aalborg University, a re-design was carried out in order to improve its STEAM alignment. In order to facilitate this, it was decided to change the format of the module from a traditional lecture series into a flipped classroom module. Flipped classroom, in brief, turns the sequence of learning activities on its head, so that instead of students (possibly) reading texts which form the basis for a lecture, followed by assignments, they will watch (a series of) recorded online video lectures and perform a number of assignments which will subsequently be presented and discussed in class.

Course modules at the AAU Architecture and Design program are generally organized with four modules per semester with the following weights:

- 15 ECTS Project module
- 05 ECTS Lecture module
- 05 ECTS Lecture module
- 05 ECTS Lecture module

From a PBL perspective, the idea of this distribution is that project modules are more student and application driven, while lecture modules are more instructor and content driven. The ambition thus, is that students should apply theories and methodologies introduced in the lecture modules in the project module.

The module chosen for STEAM alignment at the AAU Architecture and Design program is the so-called Urban Technologies 1 module. This is a 5 ECTS lecture module offered in the 4th semester of the architecture and urban design concentration. the overall topic of this semester is introduction to urban and site design. The modules in this semester are:

- 15 ECTS Urban and Site Design
- 05 ECTS Urban Technologies 1
- 05 ECTS Mathematics and Parametric Structures
- 05 ECTS Architecture, Theory and Society

Lecture modules at the AAU Architecture and Design program are typically integrated modules, introducing a number of subjects in an interdisciplinary format. The same is true for the Urban Technologies 1 module which introduces topics from the fields of traffic planning, site planning, micro-climate and geographic information systems (GIS). This lends it well to the purpose of STEAM alignment.

In its original format, the Urban Technologies 1 module consisted of a series of 12 learning sessions (lectures/workshops) with the following titles:

- 01 Traffic and Roads 1: Traffic Data, Surveys and Projections
- 02 Traffic and Roads 2: Road Planning Principles
- 03 Traffic and Roads 3: Road Planning Principles
- 04 Space Syntax in Urban Design
- 05 Site Planning, Densities and Areas
- 06 Site Planning, Land Use and Areas
- 07 Analysis and Evaluation of Sun and Daylight in Urban Space 1
- 08 Analysis and Evaluation of Sun and Daylight in Urban Space 2
- 09 Analysis and Evaluation of Sun and Daylight in Urban Space 3
- 10 Introduction to Geographic Information Systems (GIS)
- 11 Vector and Raster Analysis in GIS
- 12 Data Visualization in GIS

A translated and slightly truncated version of the full module description as it is presented to the students is shown

The module was instructed by six different instructors representing the four subjects in the course. Most of the sessions were classical lectures (2 x 45 mins.), followed by assignments. During assignments, instructors would supervise the students at their desks. A session would typically be a full morning or afternoon session of 3.5 hours.

2.3.1. STEAM CONTENT OF THE URBAN TECHNOLOGIES 1 MODULE

All STEAM components were present in the original module, albeit in varying degrees. As a technologies module in an engineering program, technology and engineering were the dominant components in the module, followed by math and science. All of these components were present in all four parts of the module. As an architectural discipline, the site planning part of the module had a small arts component which none of the other parts had. The site planning part, on the other hand, did not have a science component (Table 9).

Table 9: Distribution of STEAM content across sub-topics of the original Urban Technologies 1 Module

	Traffic Planning	Site Planning	Micro-climate	GIS
Science	•		••	•
Technology	•	•	••	••
Engineering	•••	•	•	••
Arts		•		
Mathematics	•	••	•	•

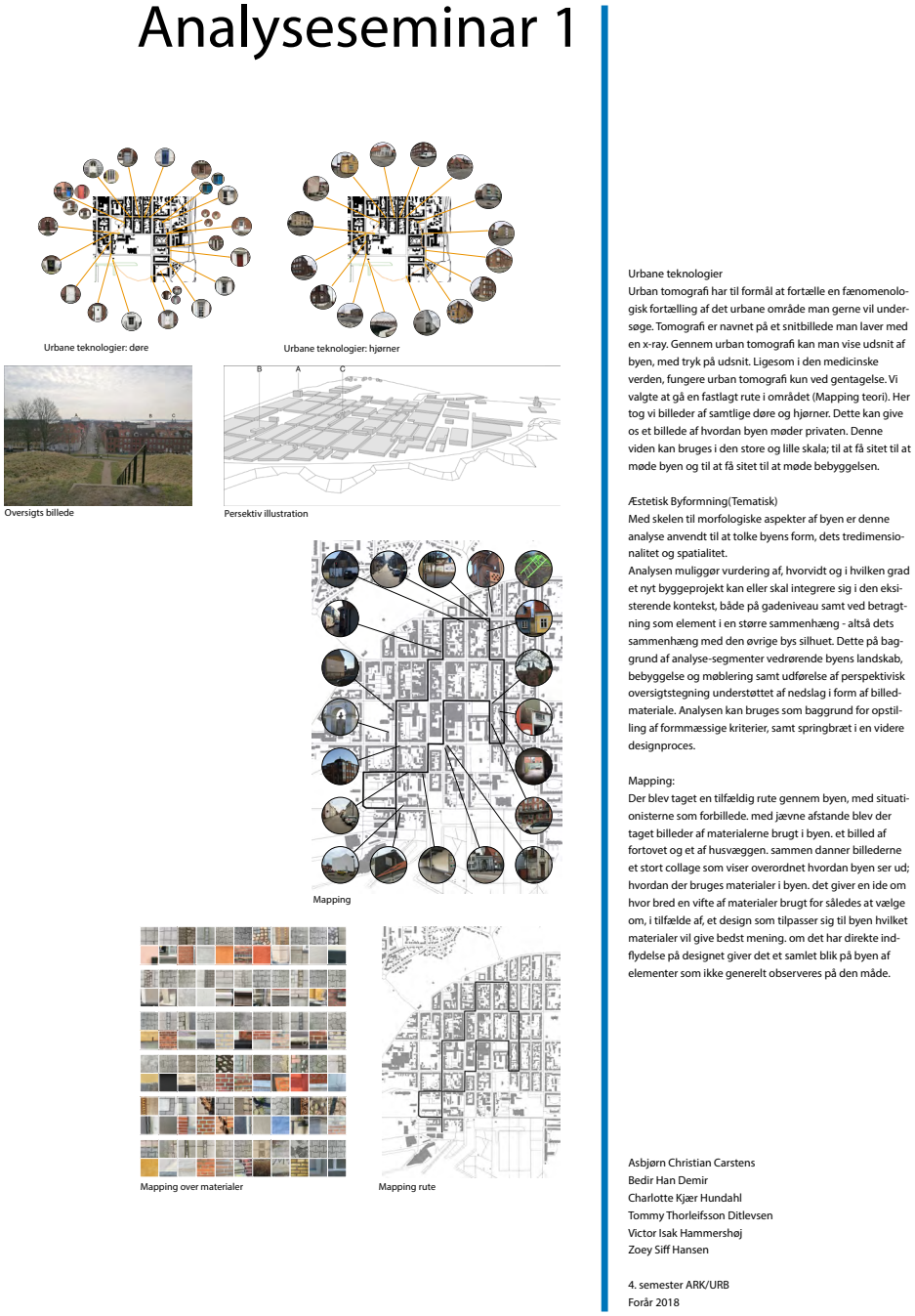
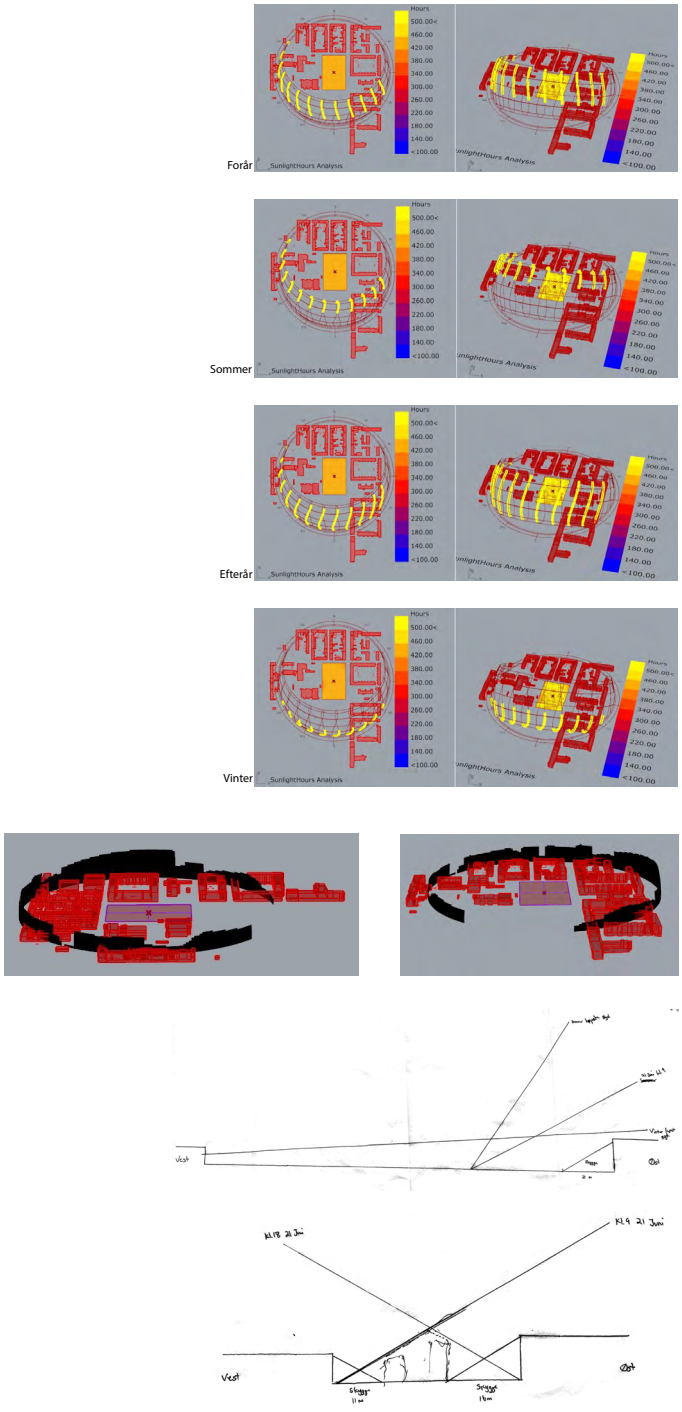


Figure 6: Student poster from Analysis seminar 1 from the Urban Technologies 1 course at AAU

LYS ANALYSER



Sollys
Ved hjælp af Rhino, Grasshopper og Ladybug er det muligt at lave lys analyser af lokationen. Et kort over området laves i QGIS og indsættes i Rhino, hvorefter konteksten kan tegnes op. Ved hjælp af QGIS kan bygningshøjderne findes. Herefter indsættes forskellige komponenter i Grasshopper, hvorved en lys analyse kan foretages.

Her er der fokuseret på sollys på lokationen i hhv. forårs-, sommer-, efterårs- og vintermånederne, alle dage i et tidsrum fra kl. 8-22. Udover at få et tal på hvor mange timer der er sol på pladsen i løbet af 3 måneder, er det også muligt at se solens placering på himlen, og at se hvilke steder på grunden der vil være problemområder.

Det ses at der på to punkter af grunden vil være mindre sollys end den resterende del af grunden i vintermånederne. Ellers lader det ikke til at der vil være problemer med sollys på grunden, sådan som konteksten ser ud nu. Da der i fremtiden vil laves bebyggelse syd for grunden, vil disse resultater ændre sig i en fremtidig kontekst.

Himmellys
Derudover er det også muligt at undersøge hvor meget af himlen der kan ses, fra et givent punkt. Dette har betydning for himmellyset, hvilket vil sørge for at der stadig vil være lyst, selv hvis man står i skygge fra solen. Krydset i midten af den markerede grund er det punkt der ses fra, og de sorte felter rundt om, er altså det af himlen der er blokeret af bygninger, når der ses fra netop det punkt.

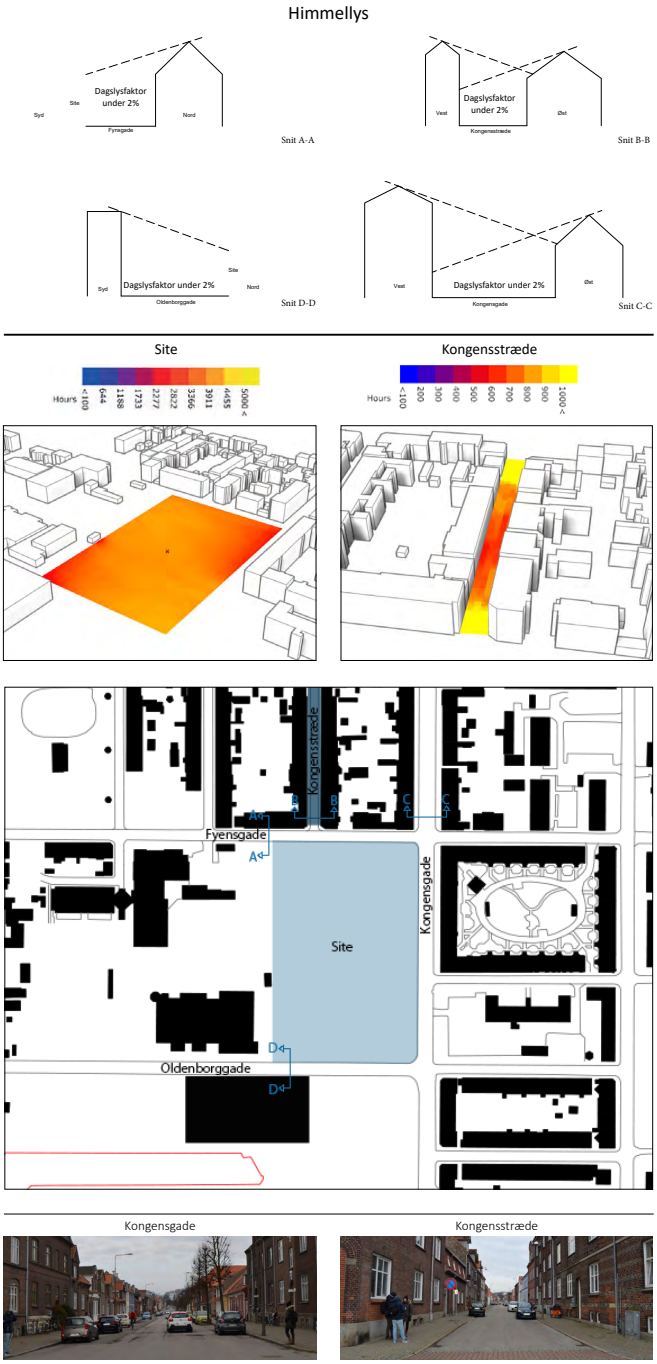
Lyssnit
At skitsere lysets retning ind på et snit, er en hurtig metode, men den kan give en god ide om hvorvidt der forekommer skygge i byrummet. Der er i skitsen snittet, så øst og vest er synlig, derved kan dette snit give ide om det direkte sollys om morgenen og om aftenen. Der er i snittet taget udgangspunkt i d. 21 juni, da det er solsommerhverv.

Andi Kiriakos Youssef
Anushanth Selladurai
Christina Nelleberg Krogh
Christine Marie Elnegaard
Dylan Chau Huynh
Rasmus Nyborg Andersen

4. semester ARK/URB
Forår 2018

Figure 7: Student poster on light analysis from the Urban Technologies 1 course at AAU

DAGSLYS



Fredericia

I perioden 20/2-22/2 2018 blev der foretaget en række registreringer omhandlende lys og skyggeforhold i Fredericia, hvilket er præsenteret igennem illustrationer.

Himmellys

Der er foretaget målinger på udvalgte veje og bygninger omkring projektområdet for at få en forståelse for problematiske skyggeforhold i og omkring bygningerne i det givne område. Ud fra registreringerne blev der bl.a. observeret, at de laveste etager i gaderummene på Fynsgade, Oldenborggade, Kongensstræde og Kongensgade ikke opnår en solfaktor på 2 %. Dette betyder at etagerne tæt på jorden ikke er egnet til kontorbrug, da lysmængden først er optimal fra seks meter over jordoverfladen.

Antal soltimer

Der er lavet en måling af antal soltimer på et år af henholdsvis projektområdet og Kongensstræde. Ud fra disse solanalyser, samt viden om at solen på et år skinner ca. 4500 timer kan det konkluderes, at kun små dele af konteksten afskærmer sitet fra at få sol i knap 500 timer på et år. Derudover blev det klart, at Kongensstræde ikke rammes af megen direkte sollys i løbet af et år, hvilket skyldes bygningernes højde. Dimensionering af veje og bygninger og disses indflydelse på mængden af sollys vil derfor undersøges videre i designprocessen.

Caroline Elkjær
Jannik Højer
Lasse Friis
Louisa Borup
Morten Hviid
Niamatullah Ahmadi

4. Semester ARK/URB
Forår 2018

Figure 8: Student poster showing a daylight analysis from the Urban Technologies 1 course at AAU

2.3.2. EVALUATION OF THE ORIGINAL MODULE

In its original format as a series of lectures, followed by assignments, there was very little relation or interaction between the different sub-topics. In this format each lecturer is responsible only for his/her own lectures and assignments, and has no inclination to consider what the other lecturers do in their sessions. This characteristic was emphasized by the fact that the six instructors came from two different university departments in addition to two external lecturers, and had little, if any contact with one another, neither in the context of the course module nor in any research or other context. As such, the module could more appropriately be considered to be four modules in one.

For this reason, it was unclear to the students (and to the instructors as well) why the different sub-topics were presented in the context of the same course module. Therefore, it was also difficult for the students to relate the different sub-topics to one another, as the module was polydisciplinary rather than interdisciplinary. As the overall ambition of the Architecture and Design program is to train the students to achieve design synthesis through the integration of technical, social, functional and artistic parameters, this was not an ideal situation.

2.3.3. RE-DESIGN OF THE URBAN TECHNOLOGIES 1 MODULE

The motivations for the previously mentioned change of format in the Urban Technologies 1 course were manifold. Due to the AAU resource allocation model, the teaching load (i.e. the number of sessions carried out by each instructor in a given teaching module) had to be kept the same. The traditional lecture format, however, did not allow for multidisciplinary activities, nor for an improved interdisciplinary understanding on behalf of the students. It also would not allow for instructors to engage with each others' teaching across the presented disciplines in the module.

The flipped classroom format frees up lecture time, as lectures are not given live but will be watched online. Therefore, this format would allow for learning sessions of a more interactive nature, with more instructors present at each session, without increasing the teaching load of each instructor. In addition, the flipped classroom format allows for a much appreciated opportunity on behalf of the students to engage interactively with the instructors about their own findings an the questions which they give rise to.

Hence, the module was restructured with 8 new learning sessions in the following format:

- 4 introductory lectures introducing each of the four sub-topics of the module
- 2 workshops in each of which 2 instructors supervise the students and discuss their presented first thoughts and work on their assignments.
- 2 seminars in each of which students present their work in progress to each other and to 2 instructors.

While the students would now turn up for four learning sessions less than in the original format, the instructors would still take part in each 3 learning sessions. In the written course material as well as during the introductory lectures, the flipped classroom format and its implications for the students were meticulously explained, so that the students would be aware of their new and more involved role in their own learning, including the obligation to both prepare and present in connection with workshops and seminars[1].

The fact that instructors would now work together during both workshops and seminars, forced them to engage mutually with each others' professional fields and to reflect on their potential inter-relatedness. In order to stimulate this process as much as possible, instructors were combined in such a way that they would engage with different fields in workshops and seminars respectively (Table 10).

1 While the Urban Technologies 1 module was restructured only in format, not in content, the module description of the re-designed module differs only marginally from that of the original course. For this reason, it has not been considered meaningful to also present the module description of the re-designed module in the context of this report.

Table 10: Distribution of session formats and content fields of the re-designed Urban Technologies 1 module

Session	Field
Lecture 1	Introduction to traffic planning
Lecture 2	Introduction to site planning
Lecture 3	Introduction to micro-climate
Lecture 4	Introduction to GIS
Workshop 1	Traffic planning and site planning
Workshop 2	Micro-climate and GIS
Seminar 1	Traffic planning and GIS
Seminar 2	Site planning and micro-climate

Table 11: Weekly distribution of STEAM skills of the re-designed Urban Technologies 1 module

Teaching event #	Teaching Learning Activities	Ground Skills	PBL Skills	ICT Skills
Lecture 1	Introduction to traffic planning	-	A2,A4,A5	D1
Lecture 2	Introduction to site planning	-	A2,A4,A5	D1
Lecture 3	Introduction to micro-climate	-	A2,A3,A4,A5	D1
Lecture 4	Introduction to GIS	-	A2,A3,A4,A5	D1
Workshop 1	Traffic planning and site planning	A6,A7,A8 B1 C1,C2,C3,C5,C6	A1,A5,A6 B1,B3,B4,B5 C1,C3,C4,C5	A2,A3,A4 C1,C2,D1
Workshop 2	Micro-climate and GIS	B7 C1,C2,C3,C5,C6	A3,A5 B1,B3,B4,B5	B1,B2,B3 C1,C2,D1
Seminar 1	Traffic planning and GIS	C3,C5,C6	A4 B1,B2,B4	B2 C2 D1
Seminar 2	Site planning and micro-climate	C3,C5,C6	A4 B1,B2,B4	B2 C2 D1

2.3.4. EVALUATION OF THE RE-DESIGNED MODULE

While a formal evaluation of the re-designed module has not yet been carried out at the time of writing, some preliminary observations and feedback can already be reported. These regard student involvement and appreciation of the mode of learning, as well as instructor observations of the quality of learning and level of interdisciplinarity in comparison to the old format of the module.

Although the re-design of the module was introduced to the involved instructors as described in the previous section, practical and time-related issues meant that flipped classroom material could only be produced for three out of the four sub-topics of the module. Hence, one sub-topic was given in the traditional live lecture format, with three full lectures instead of one introductory lecture with additional recorded online video lectures. Nonetheless, the involved instructor still participated in both the subsequent workshop and seminar.

Despite the fact that the students had only limited, if any, prior experiences of flipped classroom learning, the reception was generally good. As the setting for carrying out many of the assignments was a 3-day excursion to the town of Fredericia, Denmark, where they performed a number of site analyses and studied phenomena relating to traffic planning and daylight conditions as survey activities for their parallel site design studio module, the time-frame for their out-of-class work was partly set. Also the awareness that they had to present to each other and to their instructors during workshops and seminars motivated out-of-class work.

The general impression of the students' performance is good. During workshops and seminars, the width of topics was broad and the level of reflection was deep. Also, with one exception, students expressed high appreciation of the amount and the quality of feedback which they received on their work during these sessions. On behalf of the instructors, at least in part, the topically integrated seminars gave rise to a higher level of situatedness of each sub-topic in relation to the others (Appendix 1).

Thus, it may be presumed that, over time, a mutual understanding of the relations between the different fields and their foci will grow, allowing for a closer integration of the STEAM components of the fields involved. As a formal evaluation has not been carried out, it would be premature to estimate the distribution of STEAM content across sub-topics of the re-designed Urban Technologies 1 Module. However, there is reason to suggest that the more integrated format of the module in combination with the flipped classroom format has resulted in both a more situated and integrated understanding of STEAM and a higher level of understanding of the presented topics all together, compare to the old module format.

Figure 9: Students and instructor in dialogue over presented student work in progress at joint site analysis and micro-climate seminar. Video still image by Helene Geertsen.

3. SUMMARY

This report has presented the integration of STEAM approaches in three different courses given in METU, UNIBO and Aalborg respectively. The courses presented was:

- Digital Design Studios, METU
- Lab-based Course on Building and Architecture (Integrated Course), UNIBO
- Urban Technologies Course, AAU.

These three courses were different from each other in terms of their subject matters, the way they were conducted and how they were integrated in the curriculum of each university. However, despite these differences, a common understanding of the characteristics of STEAM is clearly identifiable. In the following are some of the common experiences and findings summarised.

Problem exploration and redefinition

In all three cases, learning activities were initially centered around open and ill-defined problems for the students to work around. This forces the students out of their comfort zone and broadening the horizon of the students by requiring them to confront multiple disciplines, which positively influences both the design process and the final product. A clear example of this is from the UNIBO course, where one of the explicit goals is to "demonstrate problem solving attitude and ability to analyze and choose among different technical solutions, showing consistency with initial choices".

Student self-motivation and self-evaluation

Another general observation is the effect of multidisciplinarity and problem-orientation. Students were motivated and influenced by the implementations in other disciplines. They were observed to encourage themselves to come up with innovative ideas and to push their own limits and knowledge even in the areas which they were already in an advanced level prior to the course. In the AAU course, the flipped approach were engaged, which resulted in students being more aware of their new and involved role in their own learning, including the obligation to both prepare and present in connection with workshops and seminars.

Cross-disciplinarity in teaching and supervision

Cross-disciplinarity among the teaching staff was clearly present in the courses. In both the METU course and the AAU course, instructions were given within several distinctive and professional fields, and the cross-disciplinary teams of supervisors were regarded as deliberate assets in the courses. In the AAU course, the supervision was structured in a way that allowed the students to get supervision from multiple disciplines simultaneously. The fact that instructors would work together during both workshops and seminars, forced them to engage mutually with each others' professional fields and to reflect on their potential inter-relatedness.

The experience of integrating STEAM into the three courses has shown that it is possible to establish high student motivation and enable a high learning outcome based on student self-motivated efforts and a cross-disciplinary approach to problem solving. This is beneficial for both students and teachers, and it likely represents a strong and powerful trajectory in course development in higher education.

4. APPENDICES

4.1. Module description for the Urban technologies 1 module

Table 12: Module description for the Urban technologies 1 module.[1]

Module title:	Urban technologies 1: Daylight, energy and traffic
Credits:	5 ECTS
Module language:	Danish
Activity code:	DAA440003L
Module coordinator:	[name, department]
Instructors:	[names, departments]
Evaluation format:	Evaluation format V – lecture module Passing the module requires continuous and active participation in all teaching activities and a final submission. The module has internal examiners.
Prerequisites:	Students must have knowledge, skills and competencies in the field of architecture and urban design engineering at a level corresponding to the completion of 1-3rd semester of the Architecture and Design program or similar.
Learning objective:	To introduce the complexity of the built environment. The module focuses on the technical systems of the city, and introduces knowledge and tools to work with traffic, daylight and urban density. These aspects are related to urban structure and form, and enables the students to understand the built environment and to read/analyse its systems, structures, form and density.

Students completing the module must:

Knowledge:	– have knowledge about the infrastructure systems of the city, including road technology – have knowledge and understanding of urban climate and comfort criterias, including sun, shade, daylight and energy impact – have knowledge about the analysis of the built environment – have knowledge about urban density and how to calculate it – have acquired a general theoretical knowledge about urban space and composition
Skills:	– understand the technical systems of the city – be able to implement road technology skills in urban design – be able to perform and apply analyses of the built environment – be able to understand and use the concept of density – be able to understand and apply knowledge about urban climate and comfort criteria

1 *Actual names, dates, times and readings have been substituted by type information in hard brackets. The same is true for session descriptions. An exception is made for session 1 in order to give an idea of the full scope of the module description. Module and session titles are emphasized.*

Competencies: – be able to evaluate how technical aspects may be included as the basis for the formulation of design criteria
– be able to assess how a site design may impact aspects of traffic and daylight
– be able to translate technical problems into spatial design concepts

Complete readings: Primary readings:
[list of 13 primary reading items]

Secondary readings:
[list of 7 secondary reading items]

Subject matter and motivation: The module content is divided into 4 sub-topics: 1) Traffic and roads, including road technology aspects pertaining to urban and site design. 2) Site planning, including density, land-use and space syntax. 3) Micro-climate, including sun and daylight in urban space and associated comfort criteria. And 4) Geographical information systems (GIS), introducing the potentials of GIS, including the analysis of vector and raster data and map design.

Scope and expectations:

Lectures, workshops, seminars	18 hours
Preparation	42 hours
Portfolio	90 hours
Total	150 hours

Module activities (lectures, etc.):

Session 01: Traffic and Roads 1: Traffic Data, Surveys and Projections
Lecture with assignments

Description:

Knowledge of the existing and future traffic is a prerequisite for dimensioning the infrastructure of cities and to safeguard the integration of new urban areas into the existing circulation network. Likewise, knowledge of the amount and composition of traffic is a prerequisite for describing the environmental impact of traffic. In part, this lecture introduces different methods for mapping existing traffic, and in part, it introduces techniques to assess how urban development and renewal projects may impact the future amount and distribution of traffic the existing as well as planned roads. Finally, the organisation and use of traffic models is introduced.

Session 02: Traffic and Roads 2: Road Planning Principles
Lecture with assignments

Session 03: Traffic and Roads 3: Road Planning Principles
Lecture with assignments

Session 04: Space Syntax in Urban Design
Workshop

Session 05: Site Planning, Densities and Areas
Lecture with assignments

Session 06: Site Planning, Land Use and Areas
Lecture with assignments

Session 07: Analysis and Evaluation of Sun and Daylight in Urban Space 1
Workshop

Session 08: Analysis and Evaluation of Sun and Daylight in Urban Space 2
Workshop

Session 09: Analysis and Evaluation of Sun and Daylight in Urban Space 3
Workshop

Session 10: Introduction to Geographic Information Systems (GIS)
Lecture with assignments

Session 11: Vector and Raster Analysis in GIS
Lecture with assignments

Session 12: Data Visualization in GIS
Lecture with assignments

Examination:	The students' performance is evaluated through continuous evaluation as well as on the basis of timely submitted written material. Examinations are performed according to the Examination Protocol.
Re-examination:	The re-examination substitute assignment will be accessible on [date and time]. The re-examination substitute assignment must be submitted online to the Digital Examination System no later than [date and time].