



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



Project Report

O2 - DELIVERY OF GENERIC STEAM MODULES:

DESIGN AND DEVELOPMENT OF A TEACHING MODULE AND ITS IMPLEMENTATION



Erasmus+

PROJECT INFORMATION

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Project coordinator organisation:	Middle East Technical University (METU)
Project coordinator:	Prof. Dr. Arzu Gönenç Sorguç
Project coordinator telephone number:	+90 3122102202
Project coordinator email address:	archisteam.metu@gmail.com
Project Partner Organizations:	University of Bologna (UNIBO) Aalborg University (AAU)

Project Team:

METU	UNIBO	AAU
Arzu Gönenç Sorguç	Ernesto Antonini	Nicolai Steinø
Soner Yıldırım	Luigi Bartolomei	Camilla Brunsgaard
Çağlar Fırat Özgenel	Lia Marchi	Nis Ovesen
Müge Kruşa Yemişcioğlu	Tommaso Rovinelli	Julie Pallesen
Serkan Ülgen		Tamara Al-Yousefy
Fatih Küçüksubaşı		Malene Munkholt Kristensen
Ramin Rasulzade		
Mert Ozan Katipoğlu		

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I. INTRODUCTION

Educational institutions are expected to prepare individuals who are proactive members of the 21st century and the new industrial era called Industry 4.0. Such expectations also requires the workforce of the future to have necessary skills to be able live and survive in the next mode of production. In June 2017, European Commission just published a document prepared by Education & Training 2020 Working Group on Digital Skills and Competences

1. *Conscious and active participation of students in the learning process is important. This starts with planning, setting goals, selecting learning strategies, defining success criteria, implementation, and evaluation. Digital technologies, when used appropriately can support such strategies.*
2. *Personalization of education should not be confused with students working on their own. Learners are eager to take control of their own learning and want to learn from and with peers.*
3. *Digital devices should support collaborative learning, peer learning, and peer feedback, and can help to strengthen both in-person and online social skills.*

A set of skills that are required for success in 21st century's societies and professional life is called as 21st-century skills. These skills differ from traditional schools' outcomes in terms of not only being content-based knowledgeable. Critical thinking, creativity, communication, and collaboration have been proposed as the Four Cs of 21st century's learning by the United States Based Partnership for 21st-century skills which is a non-profit organization founded in 2002².

I.1. Critical vs. Creative Thinking Skills:

The new educational paradigm forces educational institutions to furnish individuals with critical and creative thinking skills. On the other hand, there is a never ending discussion on what are the communities and differences between the two.

Critical Thinking is more logical, structured and stepwise approach to solve problems. On the other hand Creative Thinking is more context situated and requires a fresh and new perspective to approach and solve a problem. Some attributes linked to creative vs critical thinking are listed in the following table.

Table 1: Comparison of Critical and Creative Thinking based on <http://thepeakperformancecenter.com/educational-learning/thinking/critical-thinking/critical-thinking-vs-creative-thinking/>

Critical Thinking	Creative Thinking
Analytical	Generative
Convergent	Divergent
Left brain	Right brain
Logical	Intuitive
Sequential	Imaginative
Objective	Subjective
Reasoning	Speculating
Reality Based	Fantasy Based
Vertical	Lateral
Probability	Possibility
Judgemental	Non-judgemental
Verbal	Visual
Hypothesis testing	Hypothesis forming
Close-ended	Open-ended
Pattern Users	Pattern Seekers

I.2. Brain & Human Learning

In recent years, especially for the last couple decades, educators are more enthusiastic about transferring the findings of neurosciences into educational practices. In their book entitled "Making Connections: Teaching & Human Brain" Caine & Caine (1991) provided very early principles about a brain-based learning environments which are still valid and in use for constructivist learning approach. Caine & Caine describes those 12 principles as follows³:

1 https://ec.europa.eu/education/sites/education/files/201708-mobile-learning_en.pdf) provided the following issues which describes the learning environment of the new era. (page 3)

2 p21.org, 2016

3 Bada, S. O. (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning. IOSR Journal of Research



1. *The brain is a parallel processor. It simultaneously processes many different types of information, including thoughts, emotions, and cultural knowledge. Effective teaching employs a variety of learning strategies.*

2. *Learning engages the entire physiology. Teachers can't address just the intellect.*

3. *The search for meaning is innate. Effective teaching recognizes that meaning is personal and unique, and that students' understandings are based on their own unique experiences.*

4. *The search for meaning occurs through 'patterning'. Effective teaching connects isolated ideas and information with global concepts and themes.*

5. *Emotions are critical to patterning. Learning is influenced by emotions, feelings, and attitudes.*

6. *The brain processes parts and wholes simultaneously. People have difficulty learning when either parts or wholes are overlooked.*

7. *Learning involves both focused attention and peripheral perception. Learning is influenced by the environment, culture, and climate.*

8. *Learning always involves conscious and unconscious processes. Students need time to process 'how' as well as 'what' they've learned.*

9. *We have at least two different types of memory: a spatial memory system, and a set of systems for rote learning. Teaching that heavily emphasizes rote learning does not promote spatial, experienced learning and can inhibit understanding.*

10. *We understand and remember best when facts and skills are embedded in natural, spatial memory. Experiential learning is most effective.*

11. *Learning is enhanced by challenge and inhibited by threat. The classroom climate should be challenging but not threatening to students.*

12. *Each brain is unique. Teaching must be multifaceted to allow students to express preferences.*

In the same study, Caine & Caine (1991), made a comparison of traditional learning environments

and Brain based learning environments. This comparison is summarized in Table 2.

1.3. Constructivism as a Paradigm for Teaching and Learning

Basically, constructivism is a paradigm that aims to explain how individuals learn. One of the basic assumption of constructivism is that people construct their own knowledge and the meaning of knowledge based on their own learning experience and observations.

Even though constructivism is not a specific teaching pedagogy, constructivist teaching and learning environments have similar attributes.

Tam (2000) lists the following four basic characteristics of constructivist learning environments, which must be considered when implementing constructivist instructional strategies: (1) Knowledge will be shared between teachers and students. (2) Teachers and students will share authority. (3) The teacher's role is one of a facilitator or guide. (4) Learning groups will consist of small numbers of heterogeneous students.

Similarly, Jonassen described fundamental characteristics of a constructivist learning environment as follows⁴:

Eight characteristics of constructivist learning environments:

1. *Constructivist learning environments provide multiple representations of reality.*

2. *Multiple representations avoid oversimplification and represent the complexity of the real world.*

3. *Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.*

4. *Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context.*

5. *Constructivist learning environments provide learning environments such as real world settings or case-based learning instead of predetermined sequences of instruction.*

& Method in Education 5(6). Pp. 66-70. Available at <http://www.iosrjournals.org/iosr-jrme/papers/Vol-5%20Issue-6/Version-1/105616670.pdf>

4 (Jonassen, 1994) From: <http://www.unm.edu/~devalenz/handouts/construct.pdf>



6. *Constructivist learning environments encourage thoughtful reflection on experience.*

7. *Constructivist learning environments “enable context and content- dependent knowledge construction.”*

8. *Constructivist learning environments support “collaborative construction of knowledge through social negotiation, not competition among learners for recognition.*

1.3.1. PEDAGOGICAL GOALS OF CONSTRUCTIVIST LEARNING ENVIRONMENTS:

As cited in Bada (2015) Honebein (1996) summarizes what he describes as the seven pedagogical goals of constructivist learning environments as:

1. *To provide experience with the knowledge construction process (students determine how they will learn).*

2. *To provide experience in and appreciation for multiple perspectives (evaluation of alternative solutions).*

3. *To embed learning in realistic contexts (authentic tasks).*

4. *To encourage ownership and a voice in the learning process (student centered learning).*

5. *To embed learning in social experience (collaboration).*

6. *To encourage the use of multiple modes of representation, (video, audio text, etc.)*

7. *To encourage awareness of the knowledge construction process (reflection, metacognition).*

1.4. STEAM as a Constructivist Learning Approach

Educators and academics tried to improve their students’ 21st-century skills by using different learning approaches. Science, Technology, Engineering, Math, Art (STEAM) education is one praxis of efforts. STEAM education contains skills, knowledge, and beliefs that are collaboratively constructed at the intersection of more than one STEAM subject area (Çorlu, Capraro, & Capraro, 2014). Several studies related to different thinking skills such as critical thinking, computational thinking, analytical thinking has been conducted under higher-order thinking skills (HOTs) label to improve learning outcomes and prepare students

for era that we live in.

The driving idea behindof HOTs is that some types of learning (Analyze, Evaluate, and Create) require more cognitive processing than others, but also have more generalized benefits. In Bloom’s taxonomy, for example, skills involving analysis, evaluation and synthesis (creation of new knowledge) are thought to be of a higher order, requiring different learning and teaching methods than the learning of facts and concepts.

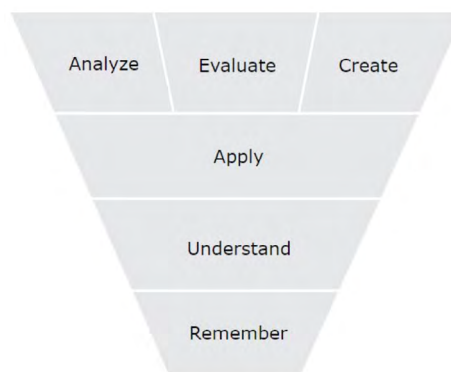


Figure 1: Learning Pyramid

Higher-order thinking involves the learning of complex judgmental skills such as Critical Thinking and problem solving. Higher-order thinking is more difficult to learn or teach but also more valuable because such skills are more likely to transfer into new learning contexts.

STEAM approach in teaching aims to prepare individuals with high creative and innovative skills who can achieve in the high-tech industry. As a constructivist approach, in STEAM learners are active and responsible of constructing their own meaning. Knowledge is not seen as fixed and existing independently outside the learner. Rather, learning is a process of accommodation or adaptation based on new experiences or ideas (Jenlick & Kinnucan-Welsch, 1999, p. 4) Furnishing students with STEAM skills are considered as the key for sustainable development in the 21st century. Moreover, STEAM provides a learning frame for instructors of different fields to create an innovative and highly creative learning environment for students. It is a catalyst for students to combine their science and art skills to provide innovative solutions to challenging problems of the real world.



2. REVISITING THE GENERIC SKILLS IN THE AGE OF INDUSTRY X

Every discipline is continuously in the process of defining the skills and competencies for their domains and try to tune educational system with the practice. In this pursuit, understanding the real meaning of “technology” is important. Fernandez³⁹ defines technology as “a measure of human ability to configure tools and develop processes” which can be accepted as the baseline for generic skills and competencies since technology itself is very broad and changing.

In this regard, focusing on the ground skills and competencies rather than the content of curriculum is more viable.

Objectives of education to fulfil such new skills and competencies should not only incorporate the ones already defined but also the new ones regarding the features of coming ages. One of the important references is the document prepared by Partnership P21 “Framework for 21st Century Learning”¹.

What is important in this document is the articulation of the aim of these new skills and knowledge as “the skills and knowledge students need to succeed in work, life and citizenship” which they are already changing praxis with new technologies and rapidly developing digital ethos.

In this study, key subjects and themes which are also themes of today and tomorrow are grouped under four major categories as:

“global awareness (collaboration open to dialogue, understanding different cultures, being able to dress global issues), Financial, Economic, Business and Entrepreneurial Literacy (entrepreneurial skills, conscious in economy and business), civic literacy (being an active citizen, aware of rights and obligations, assessing the results of civic decisions), health literacy (understanding health information and services, preventive health care), environmental literacy (understanding ecosystem and balance, environmental problems, conscious and contributing to the environmental solutions,

individual or collective initiative for solving environmental problems)”

In the very same study, skills are also grouped as “learning and innovation skills, information, media and technology skills, life and career skills” which are described under several sub categories.

“Creativity, critical thinking and problem solving, communication and collaboration, information, ICT and media literacy” are some of the skills addressed in the study. P21 organisation defines skills related with life and career by the following features “flexibility initiative, self-direction, and adaptability, social and cross cultural skills, productivity and accountability as well as responsibility and leadership”.

The themes and skills framed in the study are generic and any discipline which would like to be an actively engaged part of the future should shape the education accordingly. How the disciplines achieve those skills is also related with customisation of them in the context of related curriculum as well to develop a rubric for the assessment as aimed in this project.

There are different taxonomic approaches in defining the skill sets related with the domain of interest. For example one of the widely used definition sets is The European Qualifications Framework (EQF). EQF defines skill sets regarding to levels from 1 to 8 including descriptors related with learning outcomes², but in this project, it is addressed to green or survival skills of the coming ages as a whole. In this project it is believed that such skills should be fostered from the very first year first year and should be advanced each and every level of the education. Expected skills and related competencies of the 21st century and beyond are not only domain specific but rather it requires new mind sets and formation of backgrounds to be able to survive in the new digital-technological eco system. EQF system has been applied to several domains and each year new subject fields are added and skill sets are defined. There are many other researches and frames outlining skills and descriptors in the

¹ http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf

² <https://ec.europa.eu/ploteus/en/content/descriptors-page>



literature either generic or domain-specific. For example Alice Liao suggest that 21st century architects should be familiar with automation, coding, data mining, and to be people and business savvy T(he 21st-Century Skill Set for Architects, by Alice Liao (2015) in JAIA) — Another important proposal is made by P21 Partnership for 21st Century learning³ This document states that *“the skills, knowledge and expertise students must master to succeed in work and life; it is a blend of content knowledge, specific skills, expertise and literacies”*. This framework has a three-fold structure containing; key subjects, skills and support systems. Global awareness, Financial, Economic, Business and Entrepreneurial Literacy ,civic, health, environmental literacies constitute the key subjects that should anyone be familiar with. Another must feature of individuals of coming age defined in P21 is to be creative and thus be innovative. The importance of critical thinking and problem solving are also highlighted together with communication and collaboration skills. Sustainability of the careers is a prominent problem of the coming ages hence flexibility, adaptability, self-directivity, having social and cross-cultural skills become very important for individual learners. Leadership, being able to have initiatives are also key for the success in the 21st century as defined in P21. It is very clear that the role of media literacy and ICT is crucial and education should foster all those skills and competencies in general.

3 http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf



3. GUIDELINE FOR DESIGNING A MODULE

3.1. Aim

In addition to ‘professional skills’, today, one of the most important aims to reach sustainable development may be achieved by pursuing green economy strategies. The term “green economy” was first declared by UK in 1989 and defined by UNEP as “as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive”¹. An important aspect of green economy is “regeneration of individuals, communities and ecosystems”.

Green economy necessitates educated individuals together with innovation. They are implied as “prime movers of sustainable growth in green economies, where innovation, green skills and the capacity to cope with change will be significant drivers of each economic sector”. It might be anticipated that societies comprised of well educated and adaptable professionals in order them to cope with rapidly transforming technologies in any industry.

3.2. How to develop a teaching module?

Teaching modules are usually conceptualized as self-contained “units” of content that with other such segments constitutes an educational course or training program. A unit can cover just one class or more. Modules can also teach techniques. A course may contain variety of modules whereas a module teaches a complete skill or a meaningful content.

Instructional Design Approaches are commonly use in developing teaching modules. ADDIE Model is a framework that lists generic processes that instructional designers and training developers use. It represents a descriptive guideline for building effective training and performance support tools in five phases. Analysis-Design-Development-Implementation-Evaluation. ADDIE model is one of the most commonly used models because

of its clear guidelines for developing an effective instruction.

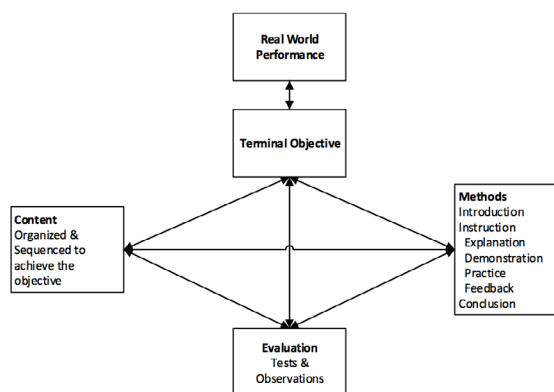


Figure 2: The secret of instructional design: All instructional elements are integrated and consistent (Retrieved from Yelon, S. L. (1996)

Teaching Models have 4 component components including instructional goals and/or learning outcomes, Content, Instructional Activities and Assessment. In his book entitled “Powerful principles of instruction” Prof. Stephen Yelon² from Michigan State University, depict the instructional design process with 4 main components.

Instructional Goals: 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 provides directions for assessment. Thus, based on the instructional goals, the instructor can determine the function and the type of assessment.

Content: In his instructional design model, Yelon (1996) links Content directly with the instructional goals, method 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

1 <http://www.unep.org/greeneconomy/AboutGEI/WhatisGEI/tabid/29784/Default.aspx>

2 Yelon, S. L. (1996). Powerful principles of instruction. Longman Publishers USA. Page234



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.

Methods: Throughout the history, human kind developed and used several teaching methods to transfer their knowledge and experience to the next generation. In their work 2013 Joyce & Weil & Calhoun 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*
 - * *Memorization*
 - * *Synecotics (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.

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. Additionally 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 are listed in the literature. One of the best classification is provided by Miller & Linn & Gronlund (2013) in their book entitled "Measurement & Assessment in Teaching" published by Pearson. The following table is extracted from their book. (page 43).



Table 2: Describing Classroom Assessment Procedures

BASIS FOR CLASSIFICATION	TYPE OF ASSESSMENT	FUNCTION OF THE ASSESSMENT	ILLUSTRATIVE INSTRUMENTS
Nature of assessment	Maximum performance	Determines what individuals can do when performing at their best	Aptitude tests, achievement tests
	Typical performance	Determines what individuals will do under natural conditions	Attitude, interest, and personality inventories; observational techniques; peer appraisal
	Fixed-choice test	Efficient measurement of knowledge and skills, indirect indicator	Standardized multiple-choice test
Form of assessment	Complex-performance assessment	Measurement of performance in contexts and on problems valued in their own right	Hands-on laboratory experiment, projects, essays, oral presentations
Use in classroom instruction	Placement	Determines prerequisite skills, degree of mastery of course goals, and/or best mode of learning	Readiness tests, aptitude tests, pretests on course objectives, self-report inventories, observational techniques
	Formative	Determines learning progress, provides feedback to reinforce learning, and corrects learning errors	Teacher-made tests, custom-made tests from textbook publishers, observational techniques
	Diagnostic	Determines causes (intellectual, physical, emotional, environmental) or persistent learning difficulties	Published diagnostic tests, teacher-made diagnostic tests, observational techniques
	Summative	Determines end-of-course achievement for assigning grades or certifying mastery of objectives	Teacher-made survey tests, performance rating scales, product scales
	Criterion referenced	Describes student performance according to specified domain of clearly defined learning tasks (e.g., adds single-digit whole numbers)	Teacher-made tests, custom-made tests from test publishers, observational techniques
Method of interpreting results	Norm referenced	Describes student performance according to relative position in some known group (e.g., ranks 10th in a classroom group of 30)	Standardized aptitude and achievement tests, teacher-made survey tests, interest inventories, adjustment inventories



4. GENERIC STEAM SKILL MODULES

In this section it is aimed to discuss how a STEAM module can be constructed based on the four pillars of module design presented in the previous sections. It is evident that subject matter to be intended to teach students determines the content and related instructional activities in any teaching module. When STEAM approach is considered specifically, the whole module should be designed in such a way that critical and creative thinking is encouraged in a carefully set PBL environment.

In this regard how the content is structured becomes a critical issue. Although each content requires different frameworks, presentation of the problem/subject, introduction of the learning environment, introduction of research methods, introduction of methods for analysis/synthesis of data, collecting relevant information, assignments to promote learning are the major constituents of framework.

In reaching the goals of teaching, it is important to actively engage students in the learning process in constructivist learning environment. Hence in designing the module, the way problems are presented or assigned plays a crucial role. It is consented that ill-defined problems, problems forcing learners to leave their comfort zones with proper scaffolding enhance learning, and thus instructional activities should be determined accordingly together with appropriately designed instructional goals and their assessments.

In the following section, generic frameworks for three modules, ground skills, PBL related skills and ICT skills are presented in Table 3,4 and 5 respectively as an illustrative guide to develop a teaching module. It is important to emphasize that the general structure, i.e. expected skills/instructional goals, instructional activities and assessment methods of generic steam skill modules is the same for any subject matter but the content should be adopted accordingly.



Table 3: Generic Framework of Ground Skills

INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to work in groups	Debate Argue Discuss	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? 	Likert Expert Opinion
Being able to self-assessing his/her own capabilities/ deficiencies	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert Expert Opinion
Being able to transform/ reflect knowledge and information of different domains into his/her own profession	Create Construct Compare	<ul style="list-style-type: none"> • What differences exist between...? • Do you know another instance where...? • Can you apply the method used to some experience of your own...? • How was this similar to ...? 	Likert T/F
Being able to self-critic and whenever he/she feels that some of the skills are expiring s(he) should replace them with new ones so self learning and self-motivated	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert
Being able to operationalize data-driven insights by relating them to real physical/ concrete implications and conditions.	Plan Devise Analyze Predict	<ul style="list-style-type: none"> • How effective are...? • If you had access to all resources how would you deal with...? • Why don't you devise your own way to deal with...? 	Likert Expert Opinion
Being able to revisit and revise steps in a process according to systematic feedback loops.	Decide Restate Propose Devise	<ul style="list-style-type: none"> • Do you think ... is a good or a bad thing? • Is there a better solution to... • What changes to ... would you recommend? • Can you create new and unusual uses for...? 	Likert Expert Opinion
Being able to demonstrate pragmatism, cultural and political awareness.	Explain	<ul style="list-style-type: none"> • Can you explain what must have happened when...? 	Likert
Being able to work in groups	Debate Argue Discuss	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? 	Likert Expert Opinion
Being able to self-assessing his/her own capabilities/ deficiencies	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert Expert Opinion



INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to transform/ reflect knowledge and information of different domains into his/her own profession	Create Construct Compare	<ul style="list-style-type: none"> • What differences exist between...? • Do you know another instance where...? • Can you apply the method used to some experience of your own...? • How was this similar to ...? 	Likert T/F
Being able to self-critic and whenever he/she feels that some of the skills are expiring s(he) should replace them with new ones so self learning and self-motivated	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert
Being able to operationalize data-driven insights by relating them to real physical/ concrete implications and conditions.	Plan Devise Analyze Predict	<ul style="list-style-type: none"> • How effective are...? • If you had access to all resources how would you deal with...? • Why don't you devise your own way to deal with...? 	Likert Expert Opinion
Being able to revisit and revise steps in a process according to systematic feedback loops.	Decide Restate Propose Devise	<ul style="list-style-type: none"> • Do you think ... is a good or a bad thing? • Is there a better solution to... • What changes to ... would you recommend? • Can you create new and unusual uses for...? 	Likert Expert Opinion
Being able to demonstrate pragmatism, cultural and political awareness.	Explain	<ul style="list-style-type: none"> • Can you explain what must have happened when...? 	Likert
Being able to look for the truth, even if it sheds unwanted light; demonstrate integrity (adheres to moral and ethical standards; admits flaws in thinking).	Investigate Examine	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? • What was the underlying theme of...? • What was the problem with...? 	Likert
Being able to seek help as needed; suspend or revise judgment as indicated by new or incomplete data	Examine Analyze Restate	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? • Can you provide an example of what you mean...? 	Likert
Being able to work in groups	Debate Argue Discuss	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? 	Likert Expert Opinion
Being able to self-assessing his/her own capabilities/ deficiencies	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert Expert Opinion



INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to transform/reflect knowledge and information of different domains into his/her own profession	Create Construct Compare	<ul style="list-style-type: none"> • What differences exist between...? • Do you know another instance where...? • Can you apply the method used to some experience of your own...? • How was this similar to ...? 	Likert T/F
Being able to self-critic and whenever he/she feels that some of the skills are expiring s(he) should replace them with new ones so self learning and self-motivated	Assess Judge Identify	<ul style="list-style-type: none"> • Judge the value of... • What changes to ... would you recommend? • How effective are...? • What do you think about...? 	Likert
Being able to operationalize data-driven insights by relating them to real physical/concrete implications and conditions.	Plan Devise Analyze Predict	<ul style="list-style-type: none"> • How effective are...? • If you had access to all resources how would you deal with...? • Why don't you devise your own way to deal with...? 	Likert Expert Opinion
Being able to revisit and revise steps in a process according to systematic feedback loops.	Decide Restate Propose Devise	<ul style="list-style-type: none"> • Do you think ... is a good or a bad thing? • Is there a better solution to... • What changes to ... would you recommend? • Can you create new and unusual uses for...? 	Likert Expert Opinion
Being able to demonstrate pragmatism, cultural and political awareness.	Explain	<ul style="list-style-type: none"> • Can you explain what must have happened when...? 	Likert
Being able to look for the truth, even if it sheds unwanted light; demonstrate integrity (adheres to moral and ethical standards; admits flaws in thinking).	Investigate Examine	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? • What was the underlying theme of...? • What was the problem with...? 	Likert
Being able to seek help as needed; suspend or revise judgment as indicated by new or incomplete data	Examine Analyze Restate	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? • Can you provide an example of what you mean...? 	Likert
Being able to anticipate consequences, to plan ahead, acts on opportunities.	Examine Identify Interpret Plan	<ul style="list-style-type: none"> • If you had access to all resources how would you deal with...? • What would happen if...? • Can you see a possible solution to...? 	Likert
Being able to stand up for beliefs, to advocate for others	Debate Argue	<ul style="list-style-type: none"> • If you had access to all resources how would you deal with...? • What would happen if...? • Can you see a possible solution to...? 	Likert



INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to listen well (shows deep understanding of others' thoughts, feelings and circumstances); to speak and write with clarity (gets key points across to others)	Debate Argue Discuss	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? 	Likert Expert Opinion
Being able to ask questions; look for reasons, explanations, and meaning; to seek new information to broaden understanding.	Investigate Examine Analyze	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? 	Likert
Being able to show tolerance for different viewpoints; to question how own viewpoints are influencing thinking.	Judge Discuss Debate	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? • Judge the value of... • How would you feel if...? 	Likert
Being able to anticipate consequences, to plan ahead, acts on opportunities.	Examine Identify Interpret Plan	<ul style="list-style-type: none"> • If you had access to all resources how would you deal with...? • What would happen if...? • Can you see a possible solution to...? 	Likert
Being able to stand up for beliefs, to advocate for others	Debate Argue	<ul style="list-style-type: none"> • If you had access to all resources how would you deal with...? • What would happen if...? • Can you see a possible solution to...? 	Likert
Being able to listen well (shows deep understanding of others' thoughts, feelings and circumstances); to speak and write with clarity (gets key points across to others)	Debate Argue Discuss	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? 	Likert Expert Opinion
Being able to ask questions; look for reasons, explanations, and meaning; to seek new information to broaden understanding.	Investigate Examine Analyze	<ul style="list-style-type: none"> • What were some of the motives behind...? • What was the problem with...? 	Likert
Being able to show tolerance for different viewpoints; to question how own viewpoints are influencing thinking.	Judge Discuss Debate	<ul style="list-style-type: none"> • Can you defend your position about...? • What changes to ... would you recommend? • What do you think about...? • Judge the value of... • How would you feel if...? 	Likert



Table 4: Generic Framework of PBL related skills

INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to identify own learning, personality, and communication style preferences; clarify biases, strengths, and limitations; acknowledge when thinking may be influenced by emotions or self-interest.	Define Describe Identify Predict	<ul style="list-style-type: none"> • Can you provide a definition for...? • Can you tell why...? • What do you think could of happened next...? • Who do you think...? • What would happen if...? 	Likert
Being able to show true self; demonstrate behaviors that indicate stated values.	Explain Compare Contrast Discuss Relate	<ul style="list-style-type: none"> • Can you write in your own words...? • Can you write a brief outline...? • Can you distinguish between...? • What differences exist between...? • Can you provide an example of what you mean...? • With what do you associate this issue, concept, idea, principle? 	Likert
Being able to look for changes in circumstances that warrant a need to modify approaches; investigate thoroughly when situations warrant precise, in depth thinking.	Identify Explain Analyze Predict	<ul style="list-style-type: none"> • Can you explain what must have happened when...? • What do you see as other possible outcomes? • What are some of the problems of...? 	Likert Expert Opinion
Being able to consider the meaning of data and interpersonal interactions, ask for feedback; correct own thinking, alert to potential errors by self and others, find ways to avoid future mistakes.	Reflect Analyze	<ul style="list-style-type: none"> • What was the underlying theme of...? • What were some of the motives behind...? • What was the turning point in the game? • What was the problem with...? 	Likert
Being able to identify relationships; express deep understanding.	Generalize List Analyze Classify Do algorithm Hypothesise Identify Explain Relate	<ul style="list-style-type: none"> • Do you know another instance where...? • Can you group by characteristics such as...? • From the information given, can you develop a set of instructions about...? • Would this information be useful if you had a ...? • What differences exist between...? • Can you distinguish between...? • What would happen if...? • Can you explain what must have happened when...? • What are some of the problems of...? • Can you distinguish between...? • What differences exist between...? 	Likert Expert Opinion



INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to draw reasonable conclusions (if this is so, then it follows that because...); uses intuition as a guide; acts on intuition only with knowledge of risks involved.	Procedure Do algorithm Formulate Explain Sequence Analyze Relate Hypothesise	<ul style="list-style-type: none"> • Can you apply the method used to some experience of your own...? • From the information given, can you develop a set of instructions about...? • Can you see a possible solution to...? • If you had access to all resources how would you deal with...? • Why don't you devise your own way to deal with...? • What would happen if...? • How many ways can you...? 	Expert opinion
Being able to offer alternative solutions and approaches; come up with useful ideas.	Imagine Create Predict Hypothesise Reflect Combine Formulate Analogy	<ul style="list-style-type: none"> • Can you design a ... to ...? • Can you see a possible solution to...? • If you had access to all resources how would you deal with...? • Why don't you devise your own way to deal with...? • What would happen if...? • Can you create new and unusual uses for...? 	T/F Expert Opinion
Being able to admit when things aren't feasible; looks for useful solutions.	Identify Compare Contrast Reflect Do simple Procedure Sequence Apply	<ul style="list-style-type: none"> • Can you explain what must have happened when ... ? • Can you compare your ... with that presented in ... ? • Can you distinguish between ...? • What do you see as other possible outcomes? • What was the underlying theme of ... ? • What are some of the problems of ... ? • Why is this important? • Can you apply the method used to some experience of your own...? • From the information given, can you develop a set of instructions about...? • Can you group by characteristics such as...? • What was the problem with...? 	T/F
Being able to reflect on Learning Goals, Strategies, and Results (Metacognition)	Predict Imagine Analogy Evaluate	<ul style="list-style-type: none"> • If you had access to all resources how would you deal with ... ? • Can you create new and unusual uses for ... ? • Is there a better solution to ... • Judge the value of. .. • How was this similar to ... ? 	Expert Opinion



Table 5: Generic Framework of ICT Module

INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to plan an information search	Identify Use Outline Select	<ul style="list-style-type: none"> • Can you distinguish between...? • Can you identify the objective of ...? • From the information given, can you develop a set of instructions about...? • Can you write a brief outline...? • Is there a better tool for... 	Likert
Being able to conduct information search	Apply Compare Examine	<ul style="list-style-type: none"> • Can you apply the method used to some experience of your own...? • Can you compare your ... with that presented in...? • How was this similar to...? • Would this information be useful if you had a ...? 	Likert
Being able to evaluate the quality of information found	Analyze Assess Judge	<ul style="list-style-type: none"> • How effective are...? • What do you think about...? • Judge the value of... 	Likert
Being able to organize documents to be saved.	Use	<ul style="list-style-type: none"> • Could this have happened if...? • Can you apply the method used to some experience of your own...? 	t/f
Being able to identify pertinent elements of information	Identify Use Decide Choose	<ul style="list-style-type: none"> • What was the underlying theme of...? • What do you see as other possible outcomes? • Can you compare your ... with that presented in...? 	likert
Being able to analyze information.	Decide Analyze Judge Examine	<ul style="list-style-type: none"> • Which events could have happened...? • Judge the value of... • What do you think about...? 	likert
Being able to visually represent information	Compare Distinguish Categorize Identify Design Create Select Determine	<ul style="list-style-type: none"> • How effective are...? • Can you distinguish between...? • Can you design a ... to ...? • If you had access to all resources how would you deal with...? 	likert



INSTRUCTIONAL GOALS	VERBS	SAMPLE QUESTIONS	ASSESSMENT
Being able to plan information to be presented.	Select Determine Design Create Assess Predict Plan Analyze	<ul style="list-style-type: none"> • Can you see a possible solution to...? • Can you design a ... to ...? • If you had access to all resources how would you deal with...? • What are some of the problems of...? 	likert
Being able to carry out production	Apply Create Design Construct Compose Identify	<ul style="list-style-type: none"> • Can you design a ... to ...? • If you had access to all resources how would you deal with...? • Can you develop a proposal which would...? • From the information given, can you develop a set of instructions about...? 	t/f expert opinion
Being able to highlight production	Apply Design Select	<ul style="list-style-type: none"> • Can you design a ... to ...? • If you had access to all resources how would you deal with...? • Can you select appropriate method for ...? 	Likert expert opinion
Being able to share information	Identify Select Design Create	<ul style="list-style-type: none"> • Can you design a ... to ...? • If you had access to all resources how would you deal with...? • Can you explain what must have happened when...? 	t/f



5. CONCLUSION

Second intellectual output of the ArchiSTEAM project delivers the definition and explanation of educational module. Each module is composed of 4 components namely; skills/instructional goals, content, instructional activities and assessment methods. Furthermore, three STEAM skill sets are determined which are applicable to any discipline. Undoubtedly, content of the modules and instructional activities may show variances with respect to the subject matter. Yet, the expected skill sets remain unchanged. In that sense, the generic STEAM skills are actualized in a three fold setting as ground skills, PBL related skills and ICT skills.

In the scope of following reports of the projects, the generic skills and the complementary modules presented above will be revisited regarding the peculiarities and specific requirements of architecture education.

Although there is a great diversity in teaching approaches in architecture education as it is discussed previously, skill sets to be attained in the course of education can also be categorized under ICT, creative and critical thinking and ground skills. It is also important to understand that skill sets can be conveyed by deliberately designed teaching modules by following ADDIE model.

