O1

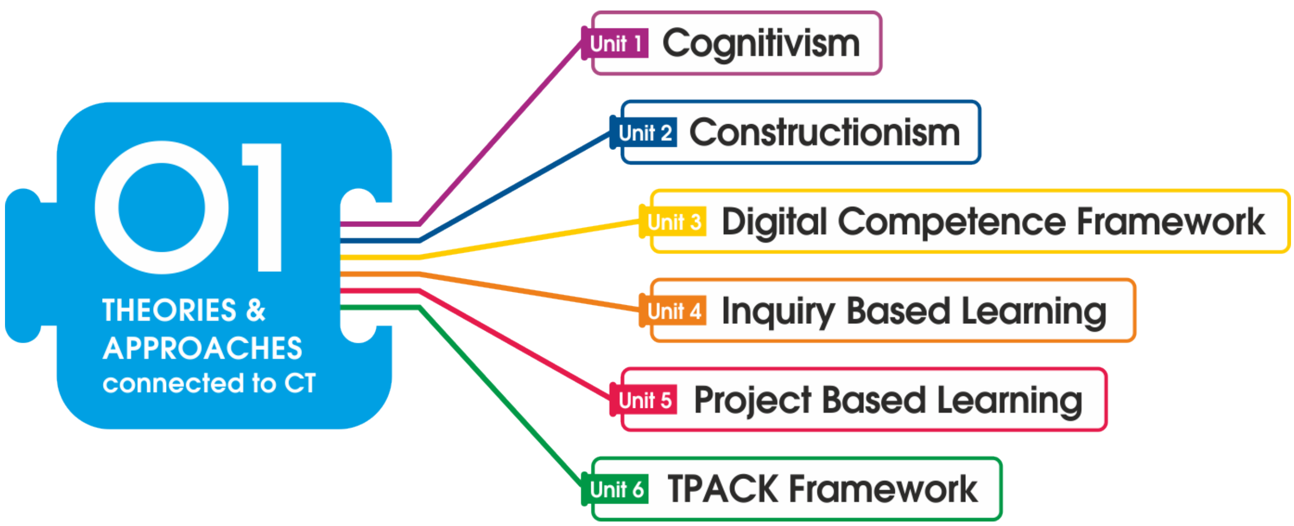
Framework for the development of the modules: CT&STEM for future teacher education

The module O1 provides theoretical background for future teacher training in CT & STEM.

CT is composed of several aspects like decomposition, abstraction, algorithms and automation, modelling and simulation, data collection, data representation, data analysis, parallelization. This skill set provides capabilities for designing content and context specific models and simulations with (or without) computers.

The evolution of school STEM pedagogy: 1) Traditional discipline specific STEM; 2) Integrated STEM; 3) STE(A)M – includes arts and humanities subjects. STEAM integration process is based on the development of models and/or simulations with an emphasis on informatics (computer science) and CT.

While students perform the STEM program, they can learn to use these three thinking skills if the STEM program is well developed, planned, and implemented in class. Hence, the framework should consider major learning theories (constructionism and cognitivism) and approaches (digital competency, TPACK, project based and inquiry based learning). The module consists of several units, for example:



Cognitivism

The study of cognitive theory is the study of the information processing of the mind. All processes of thought fall within the realm of cognition. These processes operate by manipulating information that comes into the mind. When the mind receives new information, it does two things: codes it as 'new' information or retrieves it from memory as 'not new' information. For this reason, cognition also means knowing. There are three basic steps to the cognition or thinking process: perception, selective attention, and memory.

CT also involves cognition skills like abstraction and decomposition for algorithmic problem solving and requires intelligence where mind should be able to arrange information and do logical reasoning, demonstrating “computational ability”. Hence, a cognitive approach is required to explain computational thinking since it consists of three abilities from the CattellHorn-Carroll (CHC) model of intelligence as: fluid reasoning, visual processing and use of memory. Each step in problem solving, namely understanding the problem, gathering data, computing, decision making, formulating and solving the problem are cognitive processes of mind. That is why, the current project will use this learning theory to explain certain learning scenarios and learning outcomes.

Constructionism

Constructionism is built on the main idea that knowledge is not passively received either through the senses or by way of communication – it is actively built up by the learner during the learning process. This learning theory, developed by Seymour Papert, highlights that though learning happens when children are engaged in personally meaningful activity outside of their mind. Four aspects are essential to the design of constructionist learning environments: learning through designing, personalising, sharing, and reflecting. Constructionism is grounded on the belief that the most effective learning experiences grow out of active construction of all types of artefacts. Researchers argued that constructionism is learning by designing, or frameworks for action methodology. Constructionism has appeared in many other frameworks of activities, for example, the integration of smart devices.

Digital Competence Framework

Computational thinking lies behind all the digital solutions as algorithms, hardware and software that we use today. Thus, in order to understand the digital world, make use of data, and learn in a meaningful way, everyone have to get some idea about CT and become a computational thinker. CT is not only a means of effectively using technology but also solving problems and implementing ideas digitally. To understand this digital world, everyone also needs to be digitally competent in order to cope with computers to be used effectively in the process of problem solving. As a digital citizen, everyone has to deal with digital information and data literacy, communicate and collaborate in digital environments, create digital content, be aware of how to behave to maintain information safety besides the problem solving related issues mentioned previously. Thus, digital competence framework and computational thinking skills present a nested pattern and should be considered as a combination.

Inquiry based learning

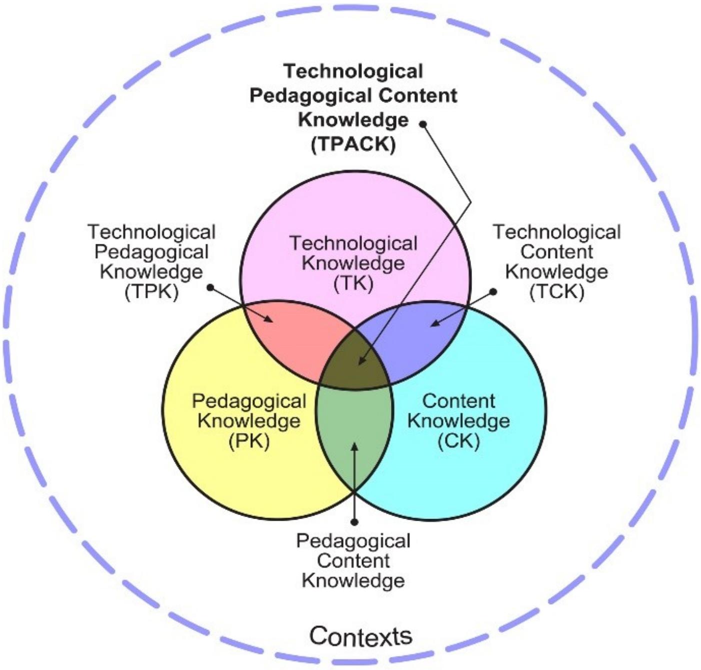
Inquiry-Based learning, where students across all disciplines learn through inquiry at all levels by observing and reflecting. This learning process starts by posing questions, problems or scenarios, and continues with identifying and researching to develop knowledge or reach solutions. The inquiry-based learning is mainly related to the development and practice of thinking and problem solving skills. Moreover, it includes problem-based learning, which is the intersection point with CT, since CT relies on problem solving process through digital means. Thus, CT can be used to enhance inquiry-based learning and vice versa. There exists an essential skill set with respect to any computation and thinking skill, all focused around questioning different concepts and processes which can be achieved through guided inquiry. Hence, overlapping skills set makes CT and inquiry-based learning interdependent to each other.

Project based learning

Project based learning (PBL) is a constructionist method, allowing students to learn about a subject by exposing them to multiple problems and asking them to construct understanding of the subject through these problems.
Defining characteristics of PBL as related to STEM includes 8 components: 1) learning is driven by challenging, open-ended problems or tasks; 2) problems are context specific; 3) brainstorm possible solutions; 4) generate ideas; 5)explore possibilities; 6) select an approach; 7) build a model or prototype (computer model and/or simulation); 8) refine the design.
For future teacher education we must provide the instruments to creatively solve the problems that children face in their daily lives. In the PBL cycle, students should be motivated to design the investigation to find the best appropriate solution from issues raised from the community. We should highlight the main principles: the situated problem solving, creative design, emotional grounding, as well as an integrative approach and focus on competences –scientific thinking, computational thinking, and contextual thinking. Teachers adopt the role as facilitators of learning, guiding the learning process and promoting an environment of inquiry.

TPACK framework

TPACK framework focuses on technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK).
According to the TPACK framework, specific technological tools (hardware, software, applications, associated information literacy practices, etc.) are best used to instruct and guide students toward a better, more robust understanding of the subject matter. The three types of knowledge – TK, PK, and CK – are thus combined and recombined in various ways within the TPACK framework. Technological pedagogical knowledge (TPK) describes relationships and interactions between technological tools and specific pedagogical practices, while pedagogical content knowledge (PCK) describes the same between pedagogical practices and specific learning objectives; finally, technological content knowledge (TCK) describes relationships and intersections among technologies and learning objectives. These triangulated areas then constitute TPACK, which considers the relationships among all three areas and acknowledges that educators are acting within this complex space.



Seven components of TPACK (image ©2012 by tpack.org)

TPACK model: (C) knowledge of the content includes knowledge of CT and aspects related to STEAM and contextual modelling; (P) pedagogical knowledge includes knowledge related to pedagogy of CT as a whole and STEAM pedagogy, including interdisciplinary, integrative and contextual aspects as well as PBL pedagogy; (T) technological knowledge provides support to PBL and related modelling; (CX) contextual knowledge, among others, includes knowledge of modern school reform and European educational policy.