Module 1

Framework for the support of the modules: CT & STEAM for future teacher education

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General overview and aim

In this module future (pre-service) teachers are introduced to the theoretical background of Computational Thinking (CT) and STEAM (Science, Technology, Engineering, Arts, Mathematics) education using different approaches. Teacher educators are free to choose any of the module units, which they think are relevant to the target groups of students (future teachers), they are educating and training. Teacher educators are also free to use any practical activities that suit the policy, philosophy and context of teacher education in their country.

Background

This module is designed for the study of computational thinking (CT) education within the field of STEAM education. It is one of the ten modules developed in the TeaEdu4CT project (2019-2022), to be piloted in ten partner institutions of the project.

The module consists of six units and can be applied to different teacher education situations and backgrounds. The flexibility of the module makes it possible to adapt and integrate this module into future teacher education and training, taking into consideration their different needs, interests, cultural backgrounds and learning experiences. It is expected that they will perform better in CT and STEAM when the key concepts, theories, models and frameworks introduced in this module, are discussed in their daily life contexts, which are easily recognised by them.

Aim

As it is an introductory and a methodologically multipurpose module (M01), it is aimed at:
- Introducing the theoretical background of CT & STEAM to future teacher education;
- Presenting of main theoretical approaches and frameworks used in CT & STEAM education: cognitivism, a TPACK framework (**T**echnological, **P**edagogical **A**nd **C**ontent **K**nowledge), a digital competence framework, inquiry based learning (IBL) and project based learning (PBL).
- Providing examples of how theories, frameworks and models can be applied in educational practice: practical activities of problem solving and knowledge building.

The module structure

The module consists of 5 units.
Each unit is oriented to approximately 3–5 hours of contact time, including assessment and 3-7 hours of independent student self-study work.

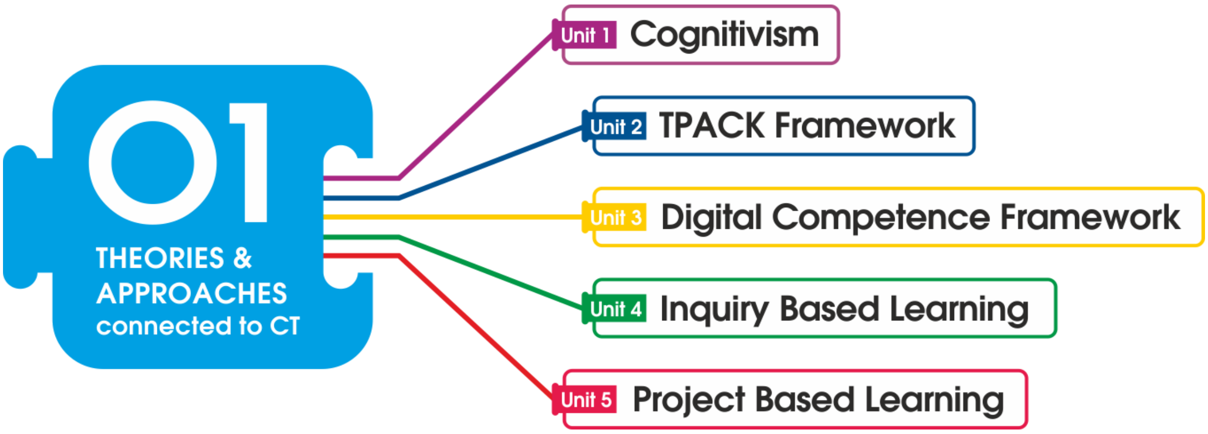


Fig. 1. The module structure: theories, frameworks and approaches to CT

Target groups and prerequisites

This module (or some units of it) may be delivered to students (i.e. future teachers) studying in different profile teacher education study programmes. They are the main target group.
Additionally, the module can be used for the continuous professional development of in-service teachers, interested in computational thinking education and working in STEAM education field. Thirdly, this module may be of interest to teacher educators involved in curriculum development and improvement.
The module is flexible and can be easily adapted for different forms of study programme delivery (e.g. face-to-face, on-line, distant and blended or hybrid learning).

Regarding **the prerequisites**, this module is recommended to students, who have already studied General Pedagogy and have the understanding of the main theories and approaches of general education. On the one hand, this module (or some chosen units of it) can be integrated into the existing General Pedagogy university curricula (modules/ course units), this way enriching them with theories and approaches to Development of Computational Thinking skills, then there is no prerequisites. On the other hand, if students decide to go deeper into the study of computational thinking education and choose more specific modules (namely, modules 3-10 of TeaEdu4CT project) this module should be considered as a compulsory prerequisite. For one needs to understand the theories and frameworks, which are used in CT & STEAM education.

Learning Outcomes and Assessment Methods

There are two options offered to future teachers for studying this module: 1) to study the whole module (all 5 units); 2) to study some units of the module, so accordingly, for this purpose there are learning outcomes of a module level and a unit level formulated.

A successful learner, who has completed the whole module, will:

- Gain the knowledge and understanding of theories (cognitivism) and frameworks (TPACK, Digital Competence in Education (DigCompEdu) used in CT and STEAM education;

- Understand and be able to apply inquiry-based and project-based learning strategies and practically implement them in STEAM and CT education;
- Be able to identify advantages and disadvantages while working in groups, analysing and comparing different educational approaches and learning strategies, suitable for school CT and STEAM education;
- Be able to use computers and other digital tools in real life problem solving, while practicing the use of different approaches and educational strategies.

When not a whole module, but separate units of this module are chosen, the formulated learning outcomes of a unit level to be achieved upon the completion of the unit(s) and assessment methods used, should provide evidence that learning outcomes have been achieved (see the examples in Contribution to the learning outcomes below).

Contribution to the learning outcomes

Learning Outcomes	Assessment Methods
1. Understands the importance of teaching CT& STEAM in schools	Participation in discussions
2. Knows and is able to apply technological, pedagogical, and content knowledge framework in his/her educational practice	Answering questions
3. Evaluates his/her digital competencies, i.e. makes DigCompEdu test SELFIE*	Testing (SELFIE)
4. Applies various approaches: cognitivism, TPACK, IBL, PBL	Developing posters, writing plans of school lessons

* SELFIE (*Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies*)

Assessment Requirements and Assessment Strategy

Assessment Requirements. All self-study tasks (oral and written presentations, lesson plans, projects, posters, analytical tasks) are **compulsory**, they have to **meet the agreed-on criteria** and have to be handed in to the lecturer **in time.**

Assessment Strategy. The summative assessment can be of a cumulative type and include the assessment tasks from all the units, providing evidence about the achieved learning outcomes. It is important that a lecturer decides, what assessment tasks are included as parts of summative assessment and what are the weights of them **(**e.g., Task A (a poster presentation) -30 per cent.; task B a lesson plan -20 per cent; task C (a project) -50 per cent), and what mark is written to the student upon the completion of the module. There should be such assessment methods chosen, which provide evidence about the achievement of the learning outcomes.

In case not the whole module, but one or a few units are chosen, the lecturer has to decide what structure of the summative assessment strategy will be, which assessment tasks are included into the assessment strategy and what are their weights, as well as what the assessment methods are chosen.

Module plan and didactical approaches

A module consists of five units. Each of them consisting of 3–5 hours of face-to-face or virtual interaction. All units are structured into several activities, in which there can be different didactical approaches and learning methods used. Activities may begin with introductory warming-up and brain-storming. They can include reading and analysis of pieces of articles, watching video, pair and group work discussions, modelling of problem solving, followed by self-study tasks, reflection and assessment.

Besides, when using this module as background for other modules (M 03-10) developed in TeaEdu4CT project, the teachers, developers of the modules, should creatively use such didactical approaches and learning methods, which would be: a) relevant to STEAM education disciplines; b) suitable for development of computational thinking skills including: decomposition, abstraction, algorithms and automation, modelling and simulation, data collection, data representation, data analysis and parallelization.

Units and activities

Unit 1: Cognitivism

Activity 1.1 Cognitivism as a learning theory: information processing, communication and computational models of cognition

- Warm-up discussion: 15 min
- Cognitivism as a learning theory. Information processing. Communication and computational models of cognition: 30 min
- Discussion on cognitivism and information processing: 15 min
- Reading – Self-study: 60 min

Activity 1.2 Encoding processes and concept maps

- Application of the encoding processes: 60 min
- Collaborative Development of a Concept Map: 60 min
- Creating a concept map: 60 min

Activity 1.3 Reflection: Poster making

- Reflection: Poster making: 60 min
- Self-study: 60 min
- Assessment: Presenting the report: 30 min

Total: 4.5 + 3 hours

Unit 2: TPACK framework

Activity 2.1 Analyzing the TRACK framework

- Warm-up discussion: 15 min
- TPACK presentation: 30 min
- Video reflection: 15 min
- Reading – Self-study: 60 min

Activity 2.2 Playing TPACK game

- Play TPACK game: 30 min
- Collaborative application of the TPACK model: 60 min

Activity 2.3 Reflection

- Self-evaluation in TPACK: 60 min
- Write a plan: 30 min
- Group discussion on self-evaluation: 30 min
- Self-study: 60 min
- Assessment: 30 min

Total: 4 + 3 hours

Unit 3: Digital competence framework

Activity 3.1 Introducing to digital competencies

- Warm-up discussion: 15 min
- Presentation of *DigCompEdu*: 60 min
- Discussion: 15 min
- Reading: Self-study: 60 min

Activity 3.2 Analysing the DigCompEdu areas

- Pair discussion: 15 min
- Group work: 45 min
- Reading: Self-study: 60 min

Activity 3.3 Reflection and Self-evaluation of digital competencies

- Self-evaluation of digital competencies: 30 min
- Discussion on self-assessment: 30 min
- Self-study: 60 min
- Assessment: 30 min

Total: 4 + 3 hours

Unit 4: Inquiry Based Learning

Activity 4.1 Introducing methodology of the IBL

- Warm-up discussion: 15 min
- Presentation on IBL: 30 min
- Discussion: 15 min
- Reading: Self-study: 60 min

Activity 4.2 Questioning in IBL

- Work in pairs: 15 min

- Role play: 45 min
- Work in pairs: 30 min
- Group work: 30 min

Activity 4.3 Reflection

- Practical work: 60 min
- Reading: Self-study: 60 min
- Assessment: 30 min

Appendix 1: Example of IBL task for school teachers to be used in class

Total: 4,5 + 2 hours

Unit 5: Project Based Learning

Activity 5.1 Introducing to methodology of the PBL

- Warm-up discussion: 15 min
- Theoretical background to PBL: 30 min
- Video introduction: 15 min
- Group work: 30 min
- Reading: Self-study: 60 min

Activity 5.2 Implementing PBL

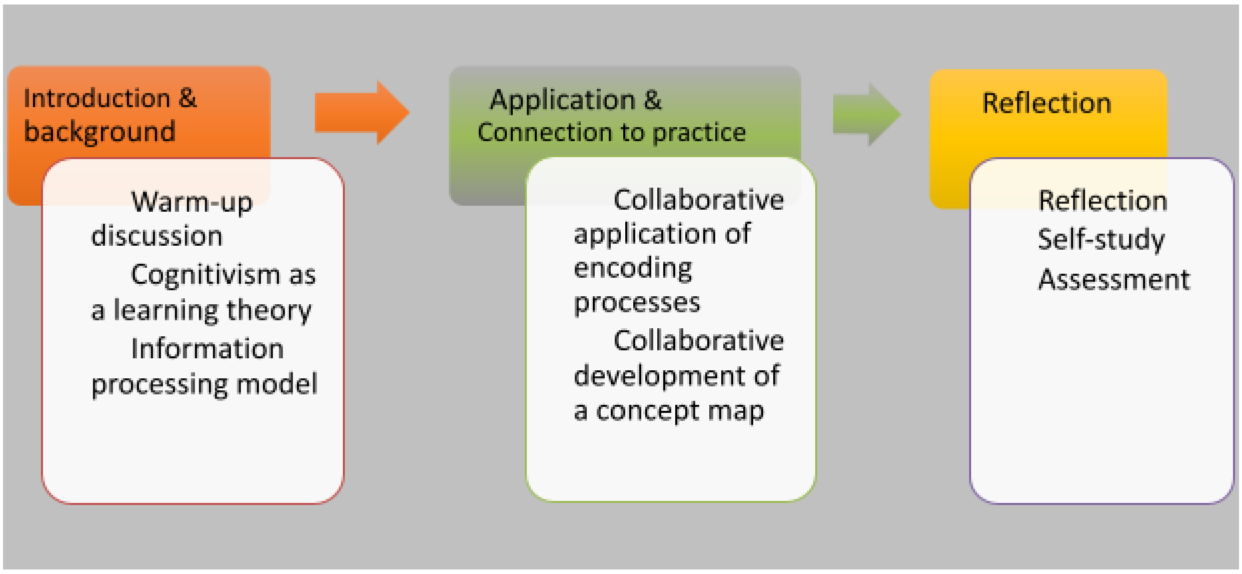
- Introducing to Problem Based Learning: 30 min
- Discussion: Problem Based Learning vs. Project Based Learning: 30 min
- Reading: Self-study: 60 min

Activity 5.3 Reflection

- Practical work: 60 min
- Reading: Self-study: 60 min
- Assessment: 30 min

Total: 4 + 3 hours

UNIT 1: Cognitivism



Keywords
Concept map, encoding, long term memory, memory, short term memory, pattern recognition

Contribution to the learning outcomes

Learning outcomes	Assessment methods
1. Understands the cognitivism, provide definition, presents advantages and disadvantages.	Proper definition, at least 3 educational practices/examples, at least 3 advantages, at least 3 disadvantages, schematic representation.
2. Understands the information processing model.	Questionnaire for assessing the knowledge about cognitivism (multiple-choice, drag-and-drop style).
3. Understands and can apply encoding processes.	Discussions, providing examples.
4. Develops collaboratively a conceptual map when learning topics.	Creating example of a conceptual map.

Activity 1.1 Cognitivism as a learning theory: Information processing, communication and computational models of cognition

Aim of the activity: to understand the basic concepts (memory, short term memory, long term memory, pattern recognition) and ideas of the cognitive theory.

Warm-up discussion

Learners are asked to think about

- What is cognition?
- What cognitive activities occur during learning process?

Then learners discuss their ideas in the class.

Theoretical background: "Cognitivism Learning Theory" and "Information Processing Model"

Lecturer's presentation of the "Cognitivism Theory" and "Information Processing Model" are supported by video and other resources of their own choice.

Activity 1.1. Cognitivism as a learning theory: information processing, communication and computational models of cognition

Learning as an internal cognitive process

Cognitivists view the learning as an internal process, where memory, thinking and information storage have significant roles. They define learning as a change in the mental structure of an individual, which leads to behavioural change or attainment of new behaviours.

Information Processing Model

Cognitive learning theory explains learning through information processing model, and considers the importance of cognitive schemas. Information processing models are mainly based on Atkinson and Shiffrin (1968), who offered a multistage theory of memory, in which information was applied as a set of transformations prior to its permanent storage in the human memory. The flow of information is demonstrated in the following figure, which covers three components of memory (i.e., sensory memory, short-term memory, and long-term memory) together with the processes that transfer information from one level to the next.

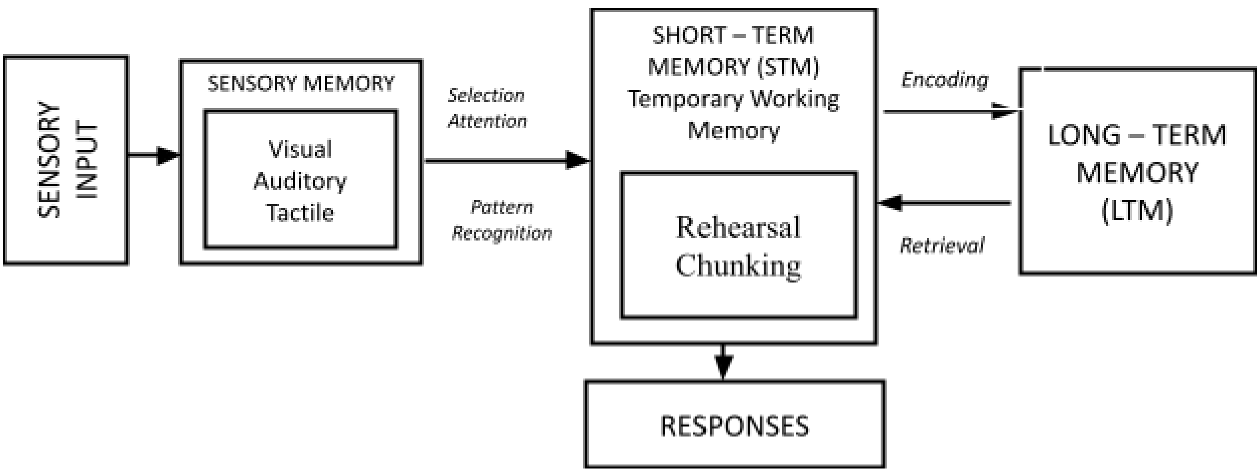


Fig 1.1. Information Processing Model of Human Learning
(Adapted from https://www.cs.ucy.ac.cy/~nicolast/courses/cs654/lectures/LearningTheories.pdf)

Each component of the model can be explained as follows:

Sensory Memory is the reaction to a sensual input received at the initial stage of information processing. It is related to the senses (visual, auditory, tactile), this information is held in memory temporarily but it can be further transferred and processed.

Selective Attention, given to the received input, shows that certain information is chosen by a learner for further processing, while the remaining information is ignored.

Pattern Recognition process complements the selective attention in further processing of information, which needs to be analysed and known patterns should be detected in order to present a base for further process.

Short-Term Memory (STM) works as a temporary working memory, in which processing is performed in order to allow information to be ready for a long term storage or provide a response. In this stage, concepts located in long-term memory can be activated in order to clarify the incoming information. When we think about ideas in an active way and are conscious of them, they are located in a working memory. STM holds a certain amount of information for a limited amount of time. When we actively think about ideas and are conscious of them, they are said to be in working memory.

Encoding considers the process of associating incoming information to existing concepts and ideas in the long term memory, so that the new information can be more memorable.

Rehearsal & Chunking are offered as two processes that allow individuals encode information into a long-term memory. Rehearsal refers to the repetition, while chunking refers to the grouping of phrases, letters etc. into bits of information for facilitating the encoding process.

Long-term memory (LTM) refers to the permanent storage of information in unlimited amount and in various types. If something is remembered for a long time, it should be passed from STM to LTM. Schemas, mental models and structures proposed for the store of information in LTM.

Retrieval is the process of bringing back to the mind the prior learned information. The purpose of retrieval can be understood as a new input or providing a response.

Video Analysis

Videos below can be used as part of introduction or as tasks for independent analysis.

Cognitivism: https://www.youtube.com/watch?v=uSk9idufNSM

Information Processing Theory: https://www.youtube.com/watch?v=aURqy9BEJO4

Discussion on cognitivism and information processing

Discuss in pairs the ideas presented in videos

Reading – Self-study

Cognitivism:
https://opentextbc.ca/teachinginadigitalage/chapter/3-3-cognitivism/
Teaching in a Digital Age by Anthony William (Tony) Bates is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Communication models (learning as communication process. Communication Process: Encoding and Decoding. The transmission, interaction and transaction models of communication). See: Computational models of cognition (video lectures by Josh Tenenbaum (MIT), part 1, 2, 3 in YouTube (2018)

Activity 1.2 Encoding processes and concept maps

Aim of the activity: to investigate encoding processes and develop a concept map

Application of the encoding processes

Learners can be divided into six different groups. Each group can analyse and discuss one chosen encoding process (see information About encoding given below) considering explanation and examples, then present the results in the class or in the wiki/blog page.

About encoding

Encoding is the process of integrating new information processed in the working memory with what is already known to facilitate storage in the long-term memory. Encoding is influenced by organization, elaboration, and schema (Schunk, 2012). For cognitivist researchers, encoding is where the magic happens. This is where all of the cognitive processes and executive control functions work together to "learn" new information and store it for future use.

"Elaboration is the process of expanding upon new information by adding to it or linking it to what one knows" (Schunk, 2012). Mnemonic devices can assist with elaboration by giving meaning to something easily remembered, such as using the first letter of the order of operations in math: Please Excuse My Dear Aunt Sally (Parentheses, Exponents, Multiplication, Division, Addition, and Subtraction). I used elaboration in memorizing the license plate number on my old car, 6AT1830. There are six children in my family, so I linked that information to the six. AT formed the word "at," and 1830 could be the military time for 6:30. I asked myself the question, "How many for dinner?" The answer is 6 at 6:30 (or 1830). It may seem a convoluted process to memorize, but it has stuck, so much so that after I bought a new car and switched license plates, I still try to give the old plate number. The process of elaborating new information with meaningful knowledge increases the likelihood that it will be remembered.

Schemas or schemata are personalized organizational structures. They encompass our general knowledge of specific situations that are used to plan our actions and interactions. They often prescribe a routine of actions based on our past experience (Schunk, 2012). For example, a schema could be the process of ordering fast food. For one person, the schema may include using the drive through, carefully considering different options on the menu, ordering their meal, pulling forward, paying, and then eating on the road. The schema for another customer might include going inside the restaurant, ordering the same items as always, chatting with the employees, and sitting down to eat. Any schema about ordering fast food allows a person to go into the situation with some prior knowledge and expectations of the process.

Schemas can also assist in processing new information using a pre-existing or familiar structure. For example, a schema for a Hollywood romantic comedy would contain consistent elements. When watching the newly released summer blockbuster, a moviegoer would likely recognize familiar types of characters, themes, and plot points: the heroine, the love interest, the misunderstanding or obstacle to the relationship, and the eventual happy ending. Schemas can help learners encode by integrating new information with familiar knowledge and structure.

60 **Collaborative development of a concept map**

Learners are divided into groups and are expected to draw a concept map, which would display concepts related to cognitive learning. Some concepts from the map can be deleted to be filled by the students also.

60 **Creating a concept map**

Draw a concept map for displaying concepts and relations for cognitive learning. Some concepts from the map can be deleted to be filled by the student also.
An example of a cognitive map are presented in Figure 1.2 and can be found here:
http://etec.ctlt.ubc.ca/510wiki/images/f/f9/Cognitivism2.jpg

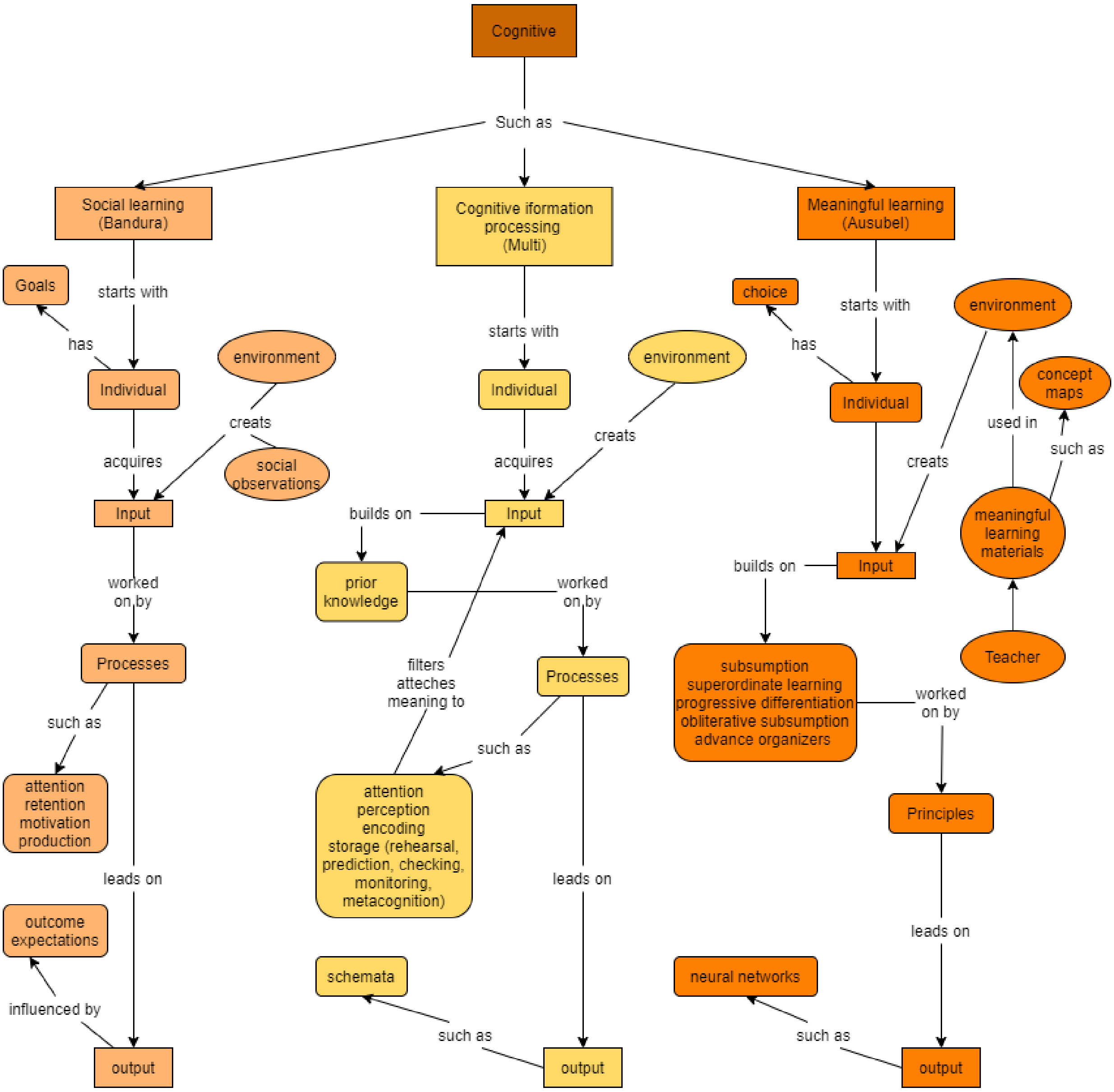


Fig. 1.2. Concept map of cognition

Activity 1.3 Reflection: Poster making

Aim of the activity: to reflect on cognitivism and the cognitive approach.
Make a poster about the cognitive approach to learning including strengths and weaknesses (an example in Fig. 1.3). The poster can be electronic and include visuals, videos and podcasts also.

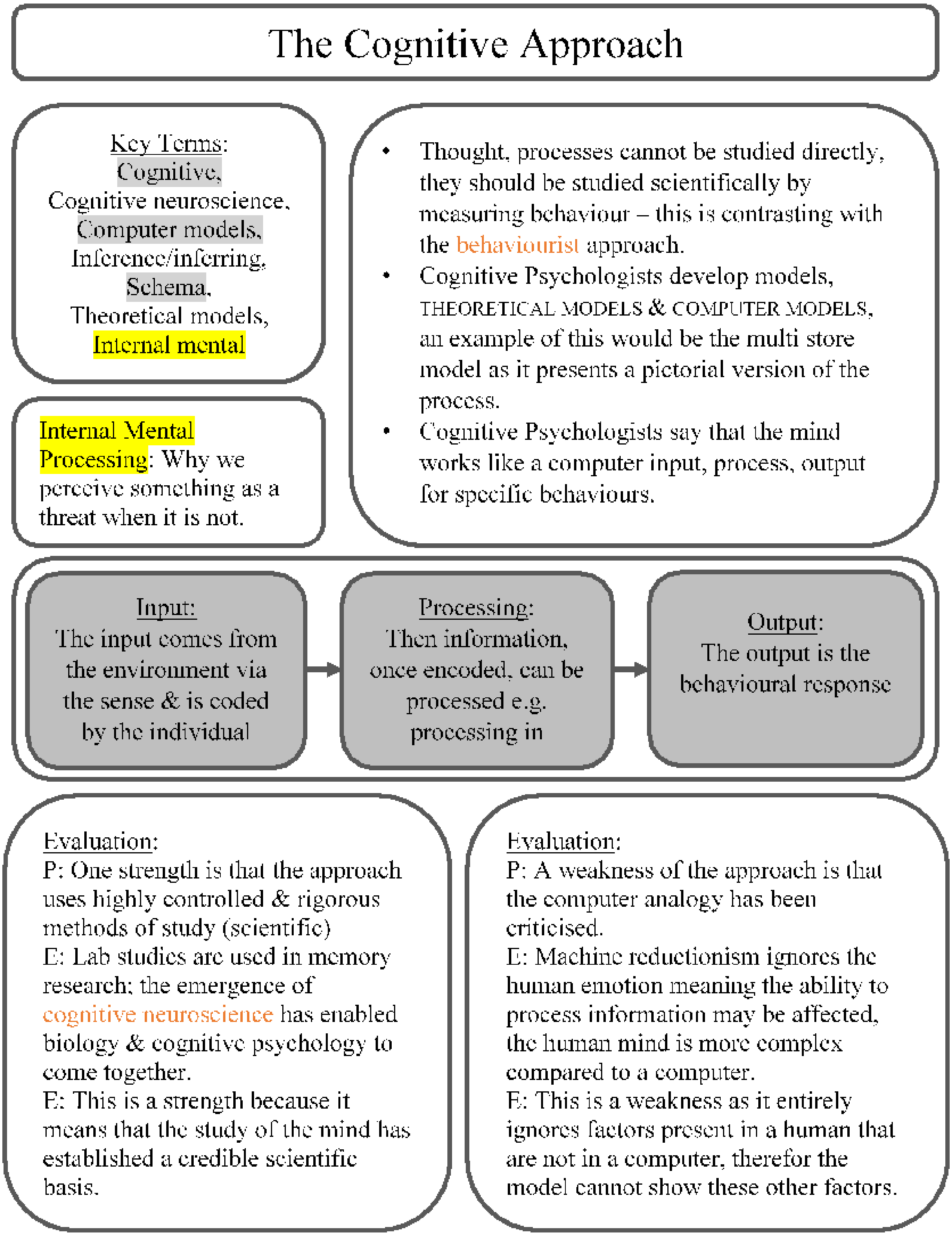


Fig. 1.3. The Cognitive Approach (adapted from alevels4life.wordpress.com)

Students discuss what is the cognitive approach, and what criteria needs to be applied.

Self-study

Students work on a home assignment:
Learners should analyse the occurrence of forgetting, describe this issue in each memory type, and submit the results as a report.

Assessment: Presenting the report

Students should present orally their home assignments as poster presentations (online or face-to-face, depending on the mode of study program delivery).

Learning resources

Learning and Teaching: Theories, Approaches and Models
Cognitive Learning Theories
http://www.ijonte.org/FileUpload/ks63207/File/chapter_3.pdf

Presentation (pptx). Cognitivism Theory and Information Processing Model.
Information Processing Model :
http://www.expertlearners.com/cip_theory.php

Video

Cognitivism: https://www.youtube.com/watch?v=uSk9idufNSM
Information Processing Theory: https://www.youtube.com/watch?v=aURqy9BEJO4

References

Atkinson, R. C. and Shiffrin, R. M. (1978) Human Memory: A Proposed System and its Control Processes / in The Psychology of Learning and Motivation, Elsevier, v. 2, Academy Press.

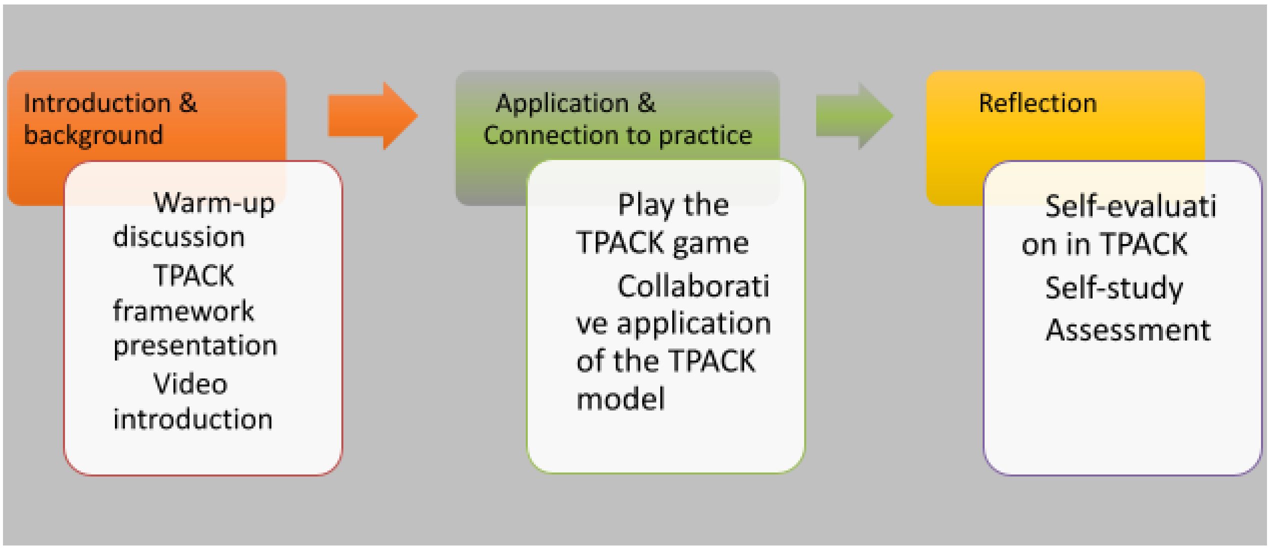
Michela, E. (2018). Cognitivism. In R. Kimmons *(Ed.),* The Students' Guide to Learning Design and Research. EdTech Books. Retrieved from https://edtechbooks.org/studentguide/cognitivism

Schunk, D. H. (2012). Learning Theories An Educational Perspective (6th ed.). Boston, MA: Pearson.

Sweller, J. (2011). Cognitive load theory. Psychology of Learning and Motivation, 55. Elsevier.

Woolfolk, A. (2015). Educational psychology (13th ed.). Boston, MA: Pearson.

UNIT 2: TPACK Framework



Keywords
Content (C), Pedagogy (P), plan, self-evaluation, SELFIE, Technology (T), TPACK

Contribution to the learning outcomes

Learning outcomes	Assessment methods
Describes TPACK framework and its components	Contributing to discussion
Applies TPACK framework for solving of the chosen problem	The solution of a chosen problem using TPACK framework
Develops an integrated STEAM lesson using all components of the TPACK model. As a Content area selects at least two STEAM subjects' topics and Computational thinking, addressing particular grade students.	Presentation of at least 15 slides (using *PowerPoint*, *Prezi* or other digital tool). Proper use of terms. Logical selection and combination of technological tools, selected content topic, and pedagogical approaches.
Developing structural writing skills, prepares a written presentation of a lesson and presents its plan orally to the audience	Properly structured written and oral presentation of a lesson (or lecture) plan
Understands and conducts self-evaluation using TPACK criteria.	Development of Self-evaluation scheme using TPACK criteria.

Activity 2.1 Analyzing the TPACK framework

Aim of the activity: to analyse TPACK framework

Warm-up discussion

Ask students to discuss in groups of 3–4 about educational technology tools (2–3 tools) they know (apply or would like to apply) for the lessons of the main subject. For example: for teaching math we can use *MathPlayground*, *Geometry Pad*, *Dragon Box*.

What pedagogical theories you already know fit best to work with these tools during the lessons?

Theoretical background: Definitions of important concepts. Explanation and illustration of how it can be used in STEAM. Integrational approach to STEAM education

Lecturer's presentation of the TPACK framework is combined with a 5 min video resource and its discussion.

TPACK presentation

TPACK framework (official website: http://www.tpack.org/) 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.

TPACK framework includes:

- Technological knowledge (TK) – knowledge about certain ways of thinking about, and working with technology, tools and resources. Working with technology can apply to all technology tools and resources. This includes understanding information technology broadly enough to apply it productively at work and in everyday life, being able to recognize when information technology can assist or impede the achievement of a goal, and being able continually adapt to changes in information technology (Koehler & Mishra, 2009). TK provides support to PBL and related modelling.
- Pedagogical knowledge (PK) – teachers' deep knowledge about the processes and practices or methods of teaching and learning. They encompass, among other things, overall educational

purposes, values, and aims. This generic form of knowledge applies to understanding how students learn, general classroom management skills, lesson planning, and student assessment." (Koehler & Mishra, 2009). PK includes knowledge related to pedagogy of CT as a whole and STEAM pedagogy, including interdisciplinary, integrative and contextual aspects as well as PBL pedagogy.

- Content Knowledge (CK) is teachers' knowledge about the subject matter to be learned or taught. The content to be covered in middle school science or history subject is different from the content to be covered in an undergraduate course on art appreciation or a graduate seminar on astrophysics. This knowledge would include knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge" (Koehler & Mishra, 2009). CK includes knowledge of CT and aspects related to STEAM and contextual modelling.
- Contextual knowledge (CX), among others, includes knowledge of modern school reform and European educational policy.

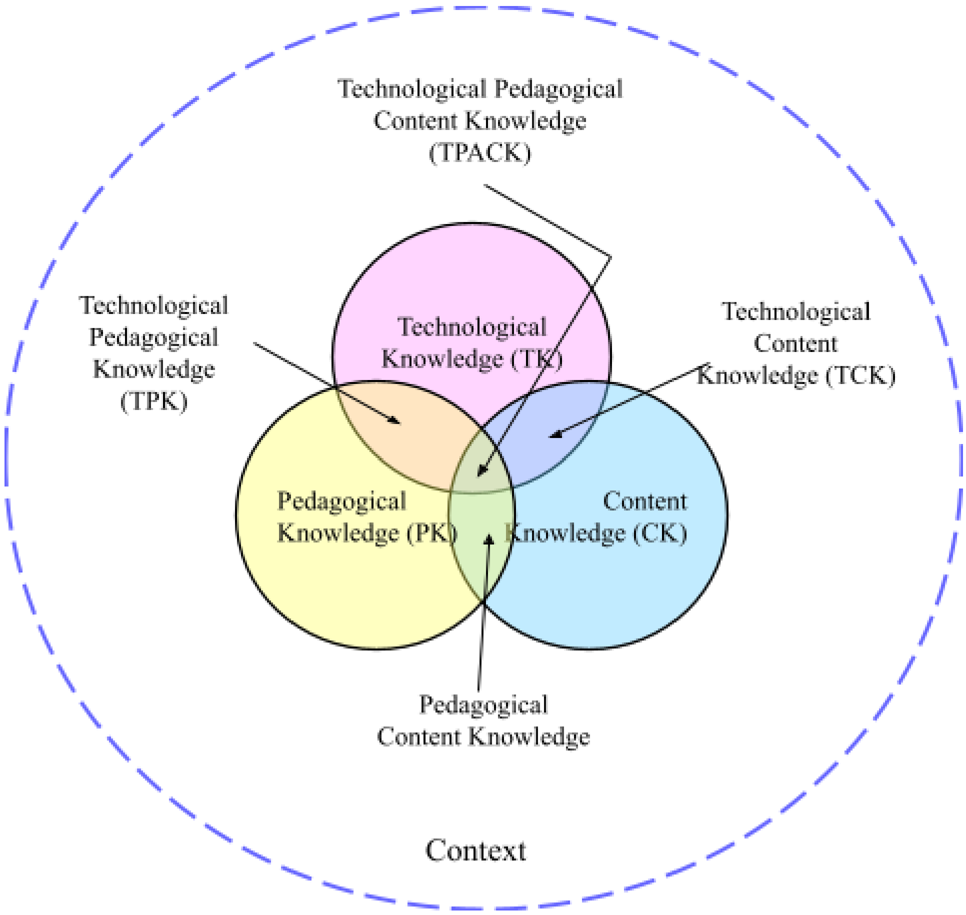
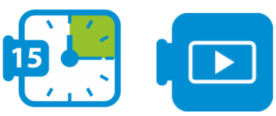


Fig. 2.1. Components of TPACK (image ©2012 by tpack.org)



Video reflection

Ask students to watch and discuss an introductional video (1) "Introduction to the TPACK Model",
https://www.commonsense.org/education/videos/introduction-to-the-tpack-model

Reading: self-study

Students should read a paper below (or a similar one of their choice) and prepare for discussion:

M. J. Koehler, P. Mishra, K. Kereluik, T. S. Shin, C. Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J.M. Specter, M.D. Merrill, J. Elen, & M.J. Bishop (Eds.), Handbook of research on educational communications and technology, pp. 101-111, Springer New York, 2014.

Activity 2.2 Play the TPACK game

Aim of the activity: to apply TPACK framework to practice

Play the TPACK game

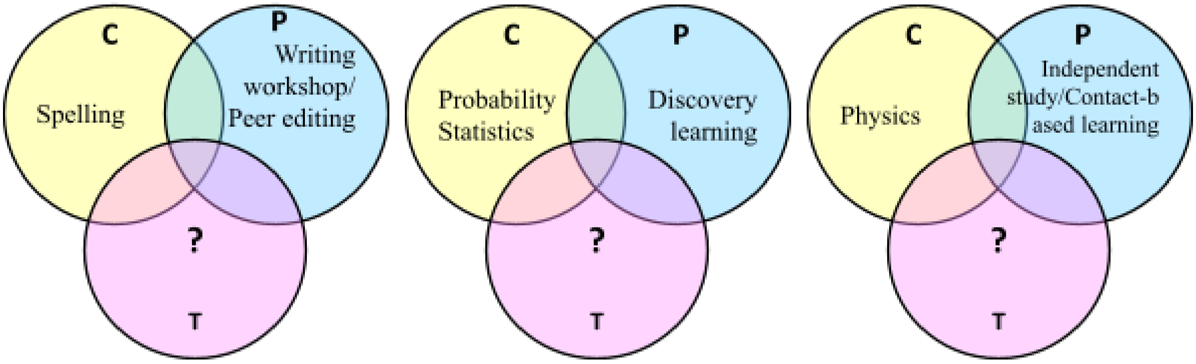
Students work in pairs.
Using a below presented Worksheet or a game page (the TPACK game, see Resources section) students are asked to fill in the missing component of the TPACK model.

In this activity students consider how Technology (T), Pedagogy (P), and Content (C) work together by randomly choosing two of the three (C, P, and T), and thinking deeply to find the third that makes them all work together in a pedagogically sound way to teach the content.

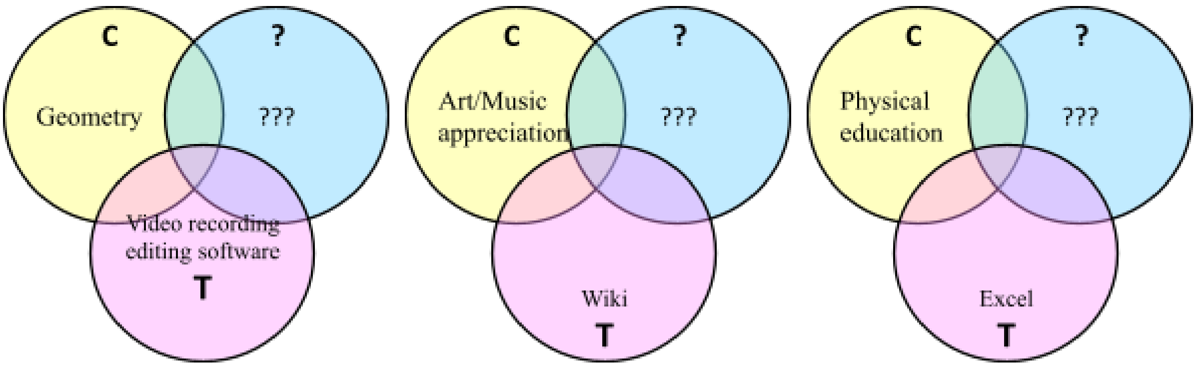
Discuss in pairs more than one alternative for the missing component. You may address Video 2, listed in video resource section. Use internet search to find out suitable Technology or Pedagogy or check the meaning of the given component.

The TPACK game Worksheet

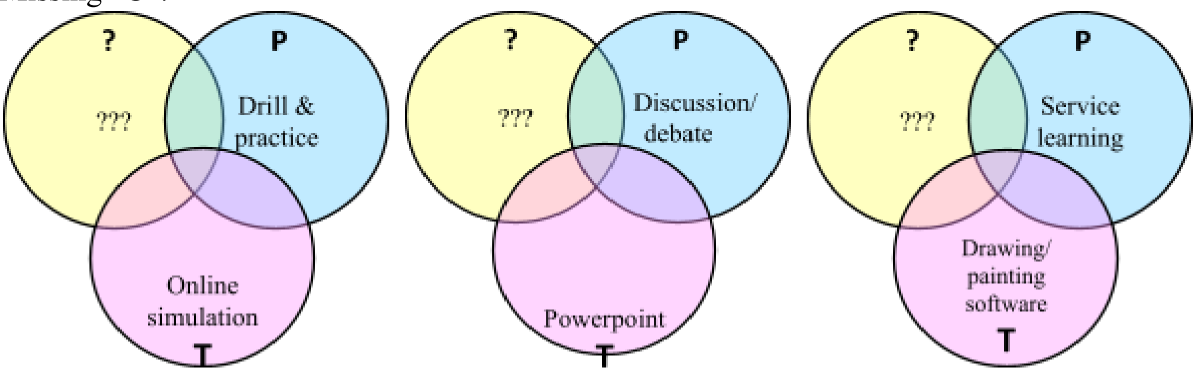
Missing "T":



Missing "P":



Missing "C":



Collaborative application of the TPACK model

Students work in groups of 3 persons.

Content topics are selected (according to the main subject of the students, a list of topics may be suggested for the students, or they can choose their own topic). Students get 3 cards each marked with T, P, C). Each student draws one of these cards (T, P, or C).

For the selected subject topic, students prepare their part for the topic (as selected: T, P, and C). Students discuss the preliminary results, and are suggested to define intersection knowledge: TP, TC, PC, and, finally, to form the TPC area.
For documenting and sharing results, a collaborative writing platform is used (e.g. Moodle, Wiki activity, Google docs).

Activity 2.3 Reflection

Aim of the activity: to reflect on TPACK framework

Self-evaluation in TPACK

For TPACK evaluation we suggest to use the instrument: "Survey of Preservice Teachers' Knowledge of Teaching and Technology" developed by D. A. Schmidt, E. Baran, A. D. Matthew, J. Koehler (http://matt-koehler.com/tpack2/wp-content/uploads/tpack_survey_v1point1.pdf) (Worksheet 2).

- Analyse structure of the instrument.
- Using statements 1 to 57, self-evaluate your skills.
- Identify areas where you need more competence development.

How do we use the survey? The items were presented in order from 1 through 57. The questions you want are most likely questions 1-46 starting under the header "TK (Technology Knowledge)". The other items are more particular to individual study and teacher education context to better understand results found on questions 1-46. You are free to use them, or modify them. However, they are not the core items used to measure the components of TPACK.

Usage Terms: Researchers are free to use the TPACK survey, provided they contact Dr. Denise Schmidt (dschmidt@iastate.edu) with a description of their intended usage (research questions, population, etc.), and the site locations for their research. The goal is to maintain a database of how the survey is being used, and keep track of any translations of the survey that exist.

Write a plan

Write a plan how you are going to develop parts that you gave lower evaluation points. This activity is a personal student's reflection to himself.

Group discussion on self-evaluation

What do you think are the most important items?
Which areas have you identified where you need more competence development?

Self-study

Students work on a home assignment:

Develop an example of an integrated STEAM lesson using all components of the TPACK model. As a Content area select at least two STEAM subjects' topics and Computational thinking, address students of particular grade. Prepare a written presentation of your lesson and prepare to present it orally to your peers and tutor audience.

Assessment

Students are asked to present orally their home assignments (online / face-to-face, depending on study program).

Learning resources

Main lecturer's presentation (pptx) on TPACK model

Worksheets

Include student activities for the module

1. The TPACK game Worksheet: http://www.matt-koehler.com/the-tpack-game
2. TPACK self-evaluation activity. Survey of Preservice Teachers' Knowledge of Teaching and Technology, http://matt-koehler.com/tpack2/wp-content/uploads/tpack_survey_v1point1.pdf

Using computers for internet research and collaborative work

1. TPACK official website. http://www.tpack.org/
2. The TPACK game, http://www.matt-koehler.com/the-tpack-game/

3. Teachers, Creativity & TPACK (The SITE 2008, Keynote presentation) A 45 minute interactive presentation by Matt and Punya, http://www.matt-koehler.com/publications/presentations/mishra_koehler_keynote_2008.mov

Video

1. **Introduction to the TPACK Model,** https://www.commonsense.org/education/videos/introduction-to-the-tpack-model
2. **Judi Harris – TPACK Introduction and Activity Types,** https://www.youtube.com/watch?v=HDwWg_g0JGE

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3. S.M. Uzzo, S.B. Graves, E. Shay, M. Harford, R. Thompson: Pedagogical Content Knowledge in STEM: Research to Practice. Springer, 2018.
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7. Brush, T., & Saye, J. W. (2009). Strategies for Preparing Preservice Social Studies Teachers to Integrate Technology Effectively: Models and Practices. Contemporary Issues in Technology and Teacher Education, 9(1), 46-59.
8. Glen Bull, Thomas Hammond & Bill Ferster (2008) Developing Web 2.0 Tools for Support of Historical Inquiry in Social Studies, Computers in the Schools, 25:3-4, 275-287, DOI: 10.1080/07380560802367761
9. Harris, J., Hofer, M. Society for Information Technology & Teacher Education International Conference, Mar 02, 2009 in Charleston, SC, USA ISBN 978-1-880094-67-9

Granularity

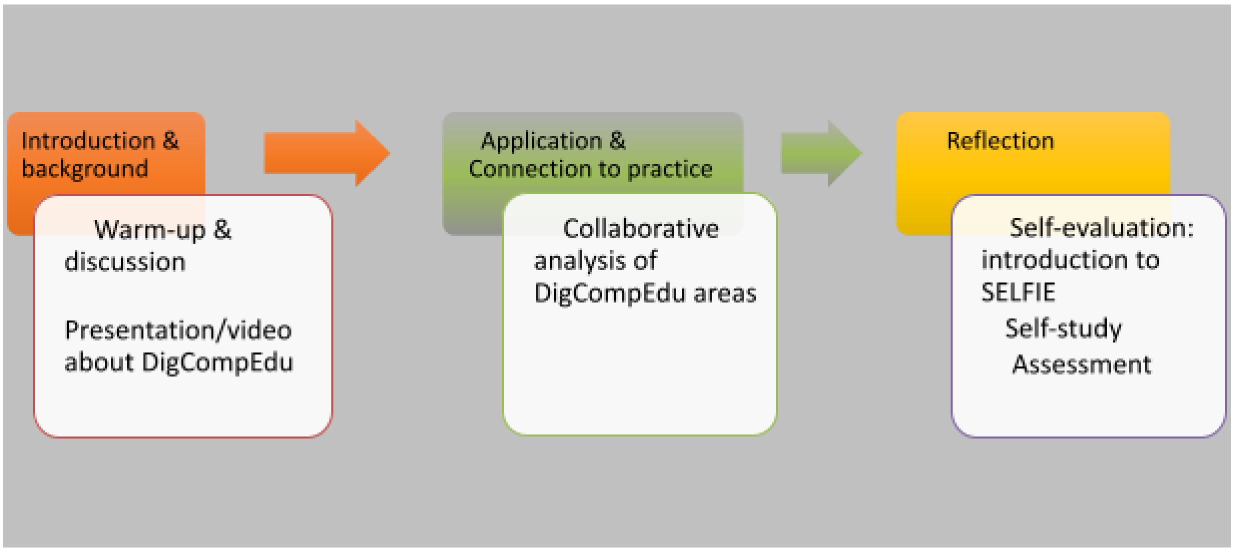
Learning resources presented on 3 levels:

- for teacher educators
- for future teachers with focus on STEM & CT
- for students in school(for example you can skip material for children)

Other suggestion can be presented also, for example:

- Skip readings of some papers
- Ask for searching more resources and do more readings

UNIT 3: Digital Competence Framework



Keywords
Communication and collaboration, digital competency, DigCompEdu, digital content, effective learning, security, self-reflection, SELFIE

Contribution to the learning outcomes

Learning outcomes	Assessment methods
Identifies digital competencies to be developed	Digital competencies weal (https://digital-competence.eu/)y,
Working in pairs and groups, discusses and analyses areas of digital competencies	Sharing of opinions and thoughts on areas of digital competencies
Working in a group, prepares a model of how teachers' digital competencies can be improved	Presentations of the models for improvement of teacher digital competencies
Develops a lesson plan aimed at development of chosen digital competencies	Presentation of properly structured lesson plan for development of 2-3 digital competences
Critically self-evaluates one's own digital competencies using SELFIE model	Self-reflections on Effective Learning by Fostering the use of Innovative Educational Technologies (SELFIE)

Activity 3.1 Introducing the Digital Competencies Framework

Aim of the activity: to introduce to digital competencies and the DigCompEdu framework.

Warm up discussion

Lecturer uses slides with video record, discussion question and overview of discussion.
Video introduction: 4th industrial revolution
https://www.youtube.com/watch?v=uvP4DnH1URg (CC?)

Ask students to discuss in groups of 3–4 about their understandings of digital competence: What are digital competences?

Students should provide concrete examples and discuss features.

Theoretical background: 4th industrial revolution and digital literacy. Definitions of important concepts in the European Digital Competence Framework for Educators (*DigCompEdu*). Areas of digital competencies. Ways of improving digital competencies. Assessment and self-assessment (using SELFIE - Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies)

Presentation of DigCompEdu framework

Lecturer's presentation of the *DigCompEdu* framework is combined with discussion.

Overview of presentation

Digital competence involves the confident and critical use of electronic media for work, leisure, and communication. These competencies are related:

- to logical and critical thinking,
- high-level information management skills, and
- Well-developed communication skills.

Fig. 3.1. Digital competencies

As the teaching professions face rapidly changing demands, educators require an increasingly broad and more sophisticated set of competencies than before. In particular the ubiquity of digital devices and the duty to help students become digitally competent requires educators to develop their own digital competence. On international and national level a number of frameworks, self-assessment tools and training programmes have been developed to describe the facets of digital competence for educators and to help them assess their competence, identify their training needs and offer targeted training.

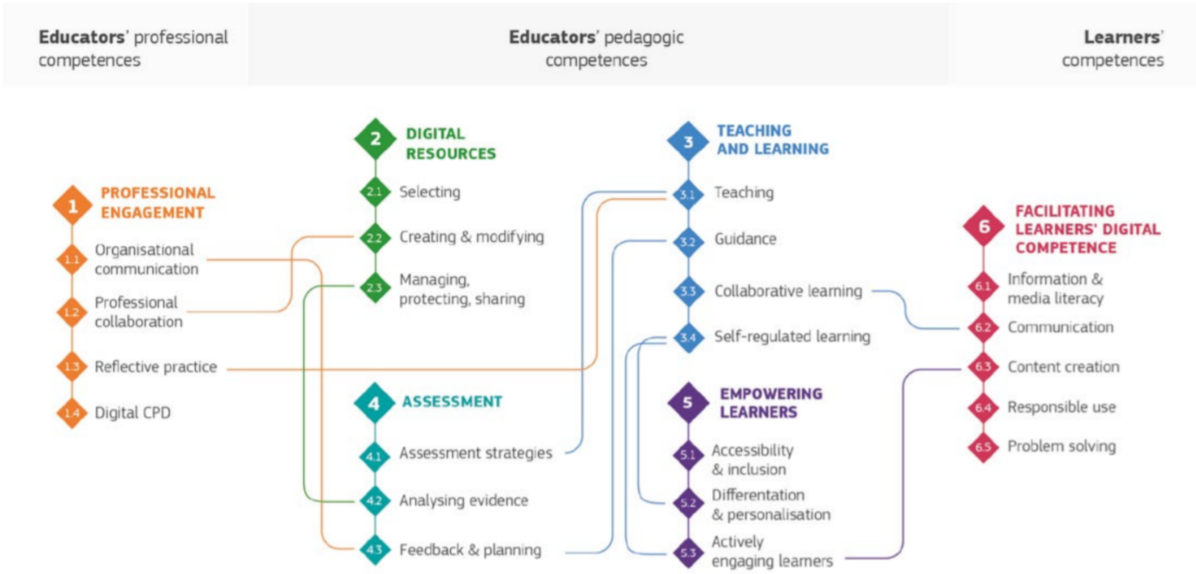
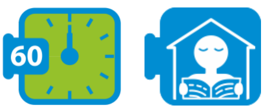


Fig. 3.2 Areas of digital competencies for educators

Each area with competencies, progression model, proficiency levels have to be described and presented in slides. The description can be taken from *DigCompEdu* document:
https://ec.europa.eu/jrc/en/search/site/digcompedu?page=2

Discussion

Question: In what ways could you improve your digital competencies?



Reading: Self-study

Students can assess their own digital competencies with Digital competencies weal
https://digital-competence.eu/ or other tool.

Digital Competence Framework for Educators (*DigCompEdu*).
https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/european-framework-digital-competence-educators-digcompedu

This report presents a common European Framework for the Digital Competence of Educators (*DigCompEdu*). *DigCompEdu* is a scientifically sound background framework which helps to guide policy and can be directly adapted to implement regional and national tools and training programmes.

Activity 3.2 Analyzing the *DigCompEdu* areas

Aim of the activity: students are studying digital competencies of *DigCompEdu* document. They have to recognize, what competencies are developed in everyday life and what need to be strengthened for teachers and how. The students collaborate in virtual environment (for example Google Drive, Office 365 One Drive, etc.).

Pair discussion

Learners should discuss the following areas of digital competence in pairs and try to think how digital competencies are/can be developed:

Competence Area 1: Information and Media Literacy.
- 1.1. Browsing, filtering data, searching, information and digital content.
- 1.2. Evaluation of data, digital content and information.
- 1.3. Data, information and digital content management.

Competence Area 2: Digital Communication and Collaboration.
- 2.1. Communication using digital technologies (interoperability).
- 2.2. Sharing with digital technology.
- 2.3. Engaging with citizenship through digital technology.
- 2.4. Collaboration using digital technologies.
- 2.5. Network etiquette.

Competence Area 3: Digital Content Creation.
- 3.1. Creating digital content.
- 3.2. Redesigning and integrating digital content.
- 3.3. Copyright and Licenses.
- 3.4. Programming.

Competence Area 4: Security.
- 4.1. Device protection.
- 4.2. Protection of personal data and privacy.
- 4.3. Protection of health and well-being.
- 4.4. Environmental safety.

Competence Area 5: Problem solving.

5.1. Solving technical problems.
5.2. Needs identification and technological solutions.
5.3. Creativity through digital technology.
5.4. Identification of digital competence gaps.

Students working in pairs (or groups) share their thoughts on the areas of digital competencies (see instruction below).

45

Group work

Each group gets worksheet with one area of digital competencies and have to think what competencies teacher improves directly in everyday life and which have to be strengthened. Students must think how these competencies can be developed. The presentation of group work have to be prepared and presented to all participants

60

Reading: self-study

Digital Competence Framework for Educators (DigCompEdu).
https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/european-framework-digital-competence-educators-digcompedu

This report presents a common European Framework for the Digital Competence of Educators (DigCompEdu). DigCompEdu is a scientifically sound background framework which helps to guide policy and can be directly adapted to implement regional and national tools and training programmes.

Oberländer M., Beinicke A., Bipp T. (2020). Digital competencies: A review of the literature and applications in the workplace. Computers & Education, Volume 146.

Falloon G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educational Technology Research and Development.
https://link.springer.com/article/10.1007/s11423-020-09767-4

Activity 3.3. Reflection

Aim of the activity: to help students to get acquainted with the Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies (SELFIE)

30

Self-evaluation of digital competencies

Presentation with video record

There is a wide variety of self-assessment tools and curricula, both internationally and nationally, to describe various aspects of educators' digital competence, as well as to help them assess their competences, identify training needs and offer targeted training. This publication presents the Common European Digital Literacy System for Educators (DigCompEdu), which is based on the analysis and clustering of these tools.

DigCompEdu is a science-based system that assists in policy making and can be directly applied to regional and national measures and training programs. It also offers a common language and approach to facilitate dialogue and exchange of good practice across borders.

Video about SELFIE rating system

https://www.youtube.com/watch?v=8_6hVoYXCAI

SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies) is a tool designed to help schools embed digital technologies into teaching, learning and student assessment. It can highlight what's working well, where improvement is needed and what the priorities should be. The tool is currently available in the 24 official languages of the European Union with more languages to be added over time.

SELFIE gathers – anonymously – the views of students, teachers and school leaders on how technology is used in their school. This is done using short statements and questions and a simple 1-5 agreement scale. The statements cover areas such as leadership, infrastructure, teacher training and students' digital competence.

The assessment takes around 30 minutes. Questions are tailored to each group. For example, students get questions relating to their learning experience, teachers reflect on training and teaching practices and school leaders address planning and overall strategy.

Based on this input, the tool generates a report – a snapshot ('SELFIE' :-)) of a school's strengths and weaknesses in their use of digital technologies for teaching and learning. The more people in the school taking part, the more accurate the SELFIE of their school will be.

The results and insights from the SELFIE exercise are for your school only and are not shared unless you choose to do so.

The findings can help you see where you are at and, from there, start a conversation on technology use and develop an action plan for your school. SELFIE can then be used at a later stage to gauge progress and adapt the action plan.

Benefits:

- ✔ SELFIE involves the whole school community – school leaders, teachers and students – in a 360-degree process covering many areas of school practice.
- ✔ Because every school is unique, the tool can be customised. Your school can select and add questions and statements to suit your needs.
- ✔ SELFIE allows all participants to answer questions that match their experience, as students, teachers or school leaders.

- ✔ SELFIE is free of charge. Answers are anonymised and data is secure.
- ✔ You can take the assessment from a computer, tablet or smartphone.
- ✔ On completing SELFIE, each school receives a tailor-made, interactive report which provides both in-depth data and quick insights into strengths and weaknesses.

Discussion on self-assessment

In the discussion, give your opinion on how meaningful the self-assessment tools for personal development of a teacher are? How much do they benefit the body? Specify the positive and negative aspects specifically. Suggest a way for the teacher to evaluate his / her digital competences in order to benefit and encourage them to develop.

Advisor to the lecturer: If possible, the learners are divided into groups of 4 and answers the discussion questions. Provides his insights in a general discussion. At the end, the lecturer summarizes the discussion, providing summaries of the learners. Learners could use any of the concept map technology mentioned above.

How SELFIE works.
https://ec.europa.eu/education/schools-go-digital/how-selfie-works_en
SELFIE https://ec.europa.eu/education/schools-go-digital_en

Self-study

Students work on a home assignment:

Develop an example of a lesson for a chosen class, which aims at development of some digital competencies. Select as a Content area the 1-2 areas of DigCompEdu and Computational thinking. Prepare a written presentation of your lesson and present it orally to your peers and tutor audience.
The lecturer can share worksheets with lesson description template.

Assessment

Students are asked to present orally their home assignments (online or face-to-face, depending on the mode of study program delivery).

Learning resources

Presentations for educators

Each presentation can be adopted according to the lecturer’s or students’ group needs.
Activity 3.1 Introduction presentation (pptx)
Activity 3.2 DigCompEdu model presentation (pptx)
Activity 3.3 SELFIE presentation (pptx)

Videos

Video introduction: 4th industrial revolution; https://www.youtube.com/watch?v=uvP4DnH1URg
Video about SELFIE rating system: https://www.youtube.com/watch?v=8_6hVoYXCAI

Readings for educators and students

How SELFIE works. https://ec.europa.eu/education/schools-go-digital/how-selfie-works_en

Digital Competence Framework for Educators (DigCompEdu).
https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/european-framework-digital-competence-educators-digcompedu

Worksheets for students

Each worksheet can be adapted according to the lecturer’s or students’ group needs.

Activity 3.2 Worksheet with areas of digital competencies for group work (docx)

Activity 3.3 Worksheet with lesson description template for self-study (docx)

Tool for students

Activity 3.1 Digital competencies weal https://digital-competence.eu/
Activity 3.3 SELFIE https://ec.europa.eu/education/schools-go-digital_en

References

Oberländer M., Beinicke A., Bipp T. (2020). Digital competencies: A review of the literature and applications in the workplace. Computers & Education, Volume 146.

Falloon G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educational Technology Research and Development.
https://link.springer.com/article/10.1007/s11423-020-09767-4

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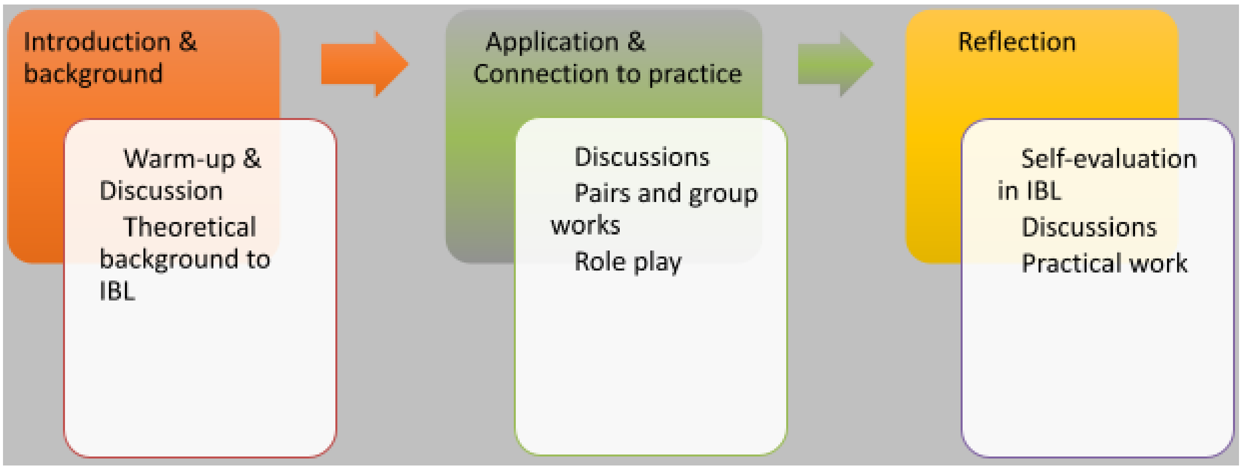
UNIT 4 Inquiry Based Learning



Keywords
IBL, IBL task, inquiry, lesson plan, questioning, role play, structured inquiry,

Contribution to the learning outcomes

Learning outcomes	Assessment methods
Identifies areas of IBL application and understands learning cycle of IBL	Presentation of identified IBL areas of application discussed in groups
Watching video of IBL class activities and taking part in roleplaying, is able to recognize the main principles, strategies and mistakes of questioning	Video analysis, reflection on role plays
Prepares a lesson description promoting IBL in the class	A detailed description of an IBL lesson planned for a chosen class
Designs questions for various lessons following the IBL principles and strategies of questioning	Written set of questions for a chosen lesson following the IBL principles and strategies of questioning

Activity 4.1 Introducing methodology of the Inquiry Based Learning

Aim of the activity: to introduce inquiry based learning (IBL).

15

Warm-up discussion

Ask students to discuss in groups of 3-4 about their understandings of Inquiry Based Learning (IBL). Students should provide concrete examples and discuss features.

Presentation on IBL

Lecturer's presentation of the IBL framework is combined with a 5 min video resource and discussion.
Suzanne Kapelari, talks here about her understanding of IBL:
https://www.youtube.com/watch?v=95rPiLZgug4

An important aspect related to CT and STEAM education using inquiry based learning is a shared understanding of what we mean by 'inquiry'. The Eurydice report *Science Education in Europe: National Policies, Practices and Research* (Eurydice, 2011) explores the notion of inquiry learning in some detail, stating that:

> *"A model to deal with different forms of inquiry approaches is proposed by Bell et al. (2010). They describe a model that includes four inquiry categories which vary according to the amount of information provided to the student. The first category, 'confirmation inquiry', is the most strongly teacher-directed in which the student is provided with the most information, the other levels are known as 'structured inquiry', 'guided inquiry', and 'open inquiry'. At the 'confirmation' level, students know the expected outcome; at the other end of this scale ('open inquiry'), students formulate questions, choose methods and propose solutions themselves."(p.70)*

However, the same report also quotes Barrow (2006), stating that

> *"Inquiry is a huge area of research, and yet it is still without any consensus about what constitutes inquiry" (p.105).*

In terms of learning, **the inquiry-based approach** is about engaging students' curiosity in problem solving in the world and the ideas that surround them. In the workplace, this might mean observing and posing questions about situations. If their questions are too complex, they may try to simplify or model the situation. They may then try to answer their questions by collecting and analysing data, making representations and by developing connections to their existing knowledge. They then try to interpret their findings, checking that they are accurate and sensible, before sharing their findings with others.
This process is often missing in the school classroom because the teacher often points out what must be observed, provides the questions, demonstrates the methods to be used and checks the results. Students are merely asked to follow the instructions.

Inquiry-based learning (IBL) has become popular in school education in recent years. The IBL definitions are presented by various aspects in scientific literature:

- "The creation of a classroom where students are engaged in essentially open-ended, student-centred, hands-on activities" (Colburn, 2000).
- "Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations and predictions; and communicating the results" (Maaß & Artigue, 2013).

- "Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations and scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (Maaß & Artigue, 2013).

Inquiry in education literature is defined describing at least three distinct but interlinked categories of activity: (a) inquiry is what scientists do when they use scientific methods, (b) inquiry is how students learn (by pursuing scientific questions and engaging in scientific experiments by emulating the practices and processes used by scientists); and (c) it is a pedagogy, or a teaching strategy, adopted by science teachers, when they design learning activities, which allow students to observe, experiment and review what is known in the light of evidence (Minner & Levyand, 2010).

This definition is often used jointly with the five features characterising inquiry-based learning as expressed by the National Research Council (National…, 2000):
- students create their own scientifically oriented questions;
- students give priority to evidence in responding to questions;
- students formulate explanations based on evidence;
- students connect explanations to scientific knowledge;
- students communicate and justify explanations.

IBL refers to a more student-centred perspective of learning Mathematics and Science that promotes a learning culture in which students are invited to work in ways similar to how mathematicians and scientists work. This means they have to observe phenomena, ask questions, and look for mathematical and scientific ways of how to answer these questions (carry out experiments, systematically control variables, draw diagrams, calculate, look for patterns and relationships, and make and prove conjectures). Students then go on to interpret and evaluate their solutions and effectively communicate their results through various means (discussions, posters, presentations, etc.). This also means that they should try to generalise the results obtained and the methods used, and connect them in order to progressively develop mathematical concepts and structures (Maaß & Artigue, 2013).

This definition embraces different approaches to inquiry-based instruction (Colburn, 2000):
- *Structured inquiry*—the teacher provides students with a hands-on problem to investigate, as well as the procedures, and materials, but does not inform them of expected outcomes. Students are to discover relationships between variables or otherwise generalize from data collected. These types of investigations are similar to those known as cookbook activities, although a cookbook activity generally includes more direction than a structured inquiry activity about what students are to observe and which data they are to collect.
- *Guided inquiry*—the teacher provides only the materials and problem to investigate. Students devise their own procedure to solve the problem.
- *Open inquiry*—this approach is similar to guided inquiry, with the addition that students also formulate their own problem to investigate. Open inquiry, in many ways, is analogous to doing science. Science fair activities are often examples of open inquiry.
- *Learning cycle*—students are engaged in an activity that introduces a new concept. The teacher then provides the formal name for the concept. Students take ownership of the concept by applying it in a different context.

Activities in inquiry class could be as follows: Student led inquiry; Tackling unstructured problems; Learning concepts through IBL; Questioning that promotes reasoning; Students working collaboratively; Building on what students already know; Self and peer assessment.
T. Bell et al. (Bell et al. 2010) summarised the processes of inquiry based learning as follows:

- *Orienting and asking questions*: students make observations or gaze at scientific phenomena that catch their interest or arouse their curiosity. Ideally, they develop questions by themselves.
- *Hypothesis generation* is the formulation of relations between variables. Stating a hypothesis is a difficult task for many students.
- Planning in the narrower sense involves *the design of an experiment to test the hypothesis* and the selection of appropriate measuring instruments for deciding upon the validity of the hypothesis.
- *Investigation as the link to natural phenomena* is the empirical aspect of inquiry learning. It includes the use of tools to collect information and data, the implementation of experiments, and the organisation of the data pool.
- *Analysis and interpretation of data* form the basis of empirical claims and arguments for the proposition of a model.
- *Model exploration and creation* is a fundamental aspect of science learning. Models are used in science for several purposes. Students should learn to explore, create, test, revise, and use externalised scientific models that may express their own internalised mental models.
- In *conclusion and evaluation activities*, students extract the results from their inquiry. Conclusions might be drawn from data and in comparison with models, theories or other experiments.
- *Communication* represents the collaborative element of inquiry learning. Communication is a process that may span all other processes of scientific inquiry starting with the development of a research question and ending with the presentation or reporting of results.
- In a *prediction*, learners express their beliefs about the dynamics of a system, while in a hypothesis the relations of the variables are emphasised. This last category may also symbolise the unfinished inquiry process after reaching a conclusion where new questions and hypotheses arise from the research results.

15 **Discussion**

Discuss together the sorts of teacher and student classroom behaviours that might be expected in an IBL classroom.

Ask teachers to work in pairs and give each pair a handout, on which they should write down their responses to the two questions:

- What do students do in inquiry classrooms?
- What do teachers do in inquiry classrooms?

Bring the group back together and ask them to share their responses. They may come up with a range of suggestions, but it is generally agreed that in classrooms that use IBL approaches, the following will be seen. Show them this list.

Student led inquiry

Tackling unstructured problems

Learning concepts through IBL

Questioning that promotes reasoning

Students working collaboratively

Building on what students already know

Self and peer assessment

Reading – Self-study

Bell S. (2010). Project-Based Learning for the 21st Century: Skills for the Future The Clearing House, 83: 39–43, 2010, Copyright Taylor & Francis Group, LLC, ISSN: 0009-8655
Colburn A. (2000). An inquiry primer. Science scope, 3, 42-44
http://www.experientiallearning.ucdavis.edu/module2/el2-60-primer.pdf
Maaß K., Artigue M. (2013). Implementation of inquiry-based learning in day-to-day teaching: a synthesis. ZDM November 2013, Volume 45, Issue 6, pp 779–795

Activity 4.2 Questioning in IBL

Aim of the activity: to introduce most important part of IBL lesson – questioning. Students have to get deeper understanding about how to ask learners and how to manage learners' questioning.

Work in pairs

Use the think-pair-share strategy so the group experiences inquiry practices. Groups should record their joint responses to the handout *Thinking about the questions teachers ask*.

Bring the group together again and ask them to share their thoughts. The possible reasons for asking questions might include the following eight:

- to interest, engage and challenge;
- to assess prior knowledge and understanding;
- to stimulate recall, in order to create new understanding and meaning;
- to focus thinking on the most important concepts and issues;
- to help students extend their thinking from the factual to the analytical;
- to promote reasoning, problem solving, evaluation and the formation of hypotheses;
- to promote students' thinking about the way they have learned;
- to help students to see connections.

The following is a list of some of the more common mistakes that are sometimes recorded:

- Asking too many trivial or irrelevant questions.
- Asking a question and answering it yourself.

- Simplifying the question when students don't immediately respond.
- Asking questions of only the most able or likeable students.
- Asking several questions at once.
- Asking only closed questions that allow one right/wrong possible answer.
- Asking 'guess what is in my head' questions, where you know the answer you want to hear and you ignore or reject answers that are different.
- Judging every student response with 'well done', 'nearly there' 'not quite'. 'Well done' can discourage alternative ideas being offered.
- Not giving students time to think or discuss before responding.
- Ignoring incorrect answers and moving on.

Role Play

Introduction video

This activity begins by watching two short videos on questioning, followed by a role play in which teachers experiment with different questions:
https://www.youtube.com/watch?v=E_Ib1YsFkH4&feature=youtu.be
Inquiry-Based Learning: Developing Student-Driven Questions
https://www.youtube.com/watch?v=OdYev6MXTOA&t=106s
Show the video on questioning strategies. Ask the students to think about how the video relates to their own practice and their own subject specialism, if appropriate.

Set up a role play:

Agree with the whole group the classroom context (age of pupils, subject, aim of lesson and so on).
Ask the students to work in small groups to devise some effective questioning to use in this context. For each small group, one participant should act as the teacher and the other students as students. Try out the questions devised by the small group.
Together reflect on why and how the questions were (or were not) effective, possibly using one or more of the following questions:

- Pick a question. What opportunities did it provide for the student? What did it provide for the teacher? In which ways was it an effective question?
- What different sorts of questions were used?
- Did question x get the sort of response that was predicted?

Bring the group back together and ask the small groups to share their thoughts.

Work in Pairs

Ask the students to work in pairs to discuss the questions:

- What types of questions promote inquiry-based learning?
- Give some examples that you have recently used.

They should record their responses to the handout: *What kinds of questions promote inquiry-based learning?*
Bring the whole group together. Share some thoughts from the small group session. Make available copies of the handout: *Five principles for effective questioning*.
This summarises some research findings related to questioning. This shows that effective questioning displays the five characteristics:

- The teacher plans questions that encourage thinking and reasoning;
- Everyone is included;
- Students are given time to think;
- The teacher avoids judging students' responses;
- Students' responses are followed up in ways that encourage deeper thinking.

Group work

Ask the students to discuss the research findings in small groups, perhaps focusing on these questions:

- Which of these principles do you usually implement in your own teaching?
- Which principles do you find it most difficult to implement? Why is this?

Activity 4.3 Reflection

Aim of the activity: to help students to organise IBL lesson in practice.

Practical work

Ask the students to select one lesson in their subject area and plan a lesson that will promote thinking and reasoning. They could do this in the session or at home.
The following questions will help them plan.

- How will you organise the classroom and the resources?
- How will you introduce the questioning session?
- Which ground rules will you establish?
- What will be your first question?
- How will you give time for students to think before responding?
- Will you need to intervene at some point to refocus or discuss different strategies they are using?
- What questions will you use in plenary discussions during or towards the end of the lesson?

Reading – Self-study

Mathematics and Science for Life! (EU project - Mascil) website: http://www.mascil-project.eu/

For additional resources use papers presented in Readings section.

Assessment

Students are asked to present in oral their lesson descriptions (online of face-to-face, depending on study program).

Appendix 1: Example of IBL task for school teachers to be used in class

Routing school buses

Schools have buses for taking pupils to school in many countries. A school bus picks up pupils in the morning and drops them off at the end of the day at designated stops on the bus route. With school buses, total time on the bus is always the most important dimension (pupils have to get to school on time), and there is a known time of travel between any two bus stops. Since children must be picked up at every bus stop, a tour of all the sites (starting and ending at the school) is required.

Since the bus repeats its route every day during the school year, finding an optimal tour is crucial.

Pupils have to solve a problem of transport management and should make a map sketch of the particular locality, label roads and bus stops.

Discipline: Mathematics
Duration: 2 lessons (90 minutes)
Target Group: Lower Secondary School (can be adopted to Upper Secondary School)
Age range: 12-14

Inquiry Learning Dimensions
- Exploring situations
- Planning investigations
- Interpreting and evaluating
- Communicating results

Work Dimensions
Context: aspects of the Architects' profession are made explicit in the task. It focuses on spatial design (of a car park) within certain constraints.
Role: pupils can choose one of the several roles.
- Role of a planner (for example, school headmaster) should be taken by pupils who need a quick solution (not the best one).
- Role of a mathematician fits those who would like to understand the context of the graph theory and be introduced to several algorithms.
- Role of an information technology specialist also can be chosen for this task: pupils can find algorithms and software to solve some examples of this problem.

Activity: to make a bus route and to estimate travelling time.

Product: the product depends on the pupil's role. For a practical designer the product is a scale drawing of the route with explanations.
Related profession: logistic, planner, mathematician, transport manager.

Material available

- Teacher guide (and lesson plan)
- Student handout
- http://en.wikipedia.org/wiki/Travelling_salesman_problem
- https://www.youtube.com/watch?v=SC5CX8drAtU

Suggestion of questions to be discussed amongst teachers on the web-site

How could this task be related with the World of Work?
What kind of students' skills this task improves?

Potential adjustments to other age groups

Older students can be asked to present a tour map of your school bus(es), which has to gather students by 15 km range from school (you can use google maps). They have to decide by themselves the optimal number of school buses needed to take the students around or from/to school.

Potential adjustments to local country context

The context of this task has to be translated, e.g. by using a local map.
The subtitles in the video can be added.

Extra

This task was developed by the Lithuanian "mascil-team" (https://mascil-project.ph-freiburg.de/classroom-material/problem-of-the-month.html)

Learning resources

Presentations for educator

Each presentation can be adopted according to the lecturer's or students' group needs
Activity 4.1 Inquiry based learning (pptx)

Videos

Activity 4.2
Ted Wragg - questioning: https://www.youtube.com/watch?v=E_Ib1YsFkH4&feature=youtu.be
Inquiry-Based Learning: Developing Student-Driven Questions
https://www.youtube.com/watch?v=OdYev6MXTOA&t=106s

Worksheets for students

Each worksheet can be adopted according the lecturer's or students' group needs.

Lecturer can prepare worksheets for groups with discussed questions, make notes for presenting thoughts.

References

Bell S. (2010). Project-Based Learning for the 21st Century: Skills for the Future The Clearing House, 83: 39–43, 2010, Copyright Taylor & Francis Group, LLC, ISSN: 0009-8655

Bell, T. Urhahne, D., Schanze S. and Ploetzner R. 2010. Collaborative inquiry learning: models, tools and challenges, International Journal of Science Education, 32(3), 2010, pp. 349–377.

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Minner, D. A. Levyand J.J. 2010. Century, Inquiry-Based Science Instruction—What is It and Does It Matter: Results From a Research Synthesis Years 1984 to 2002, Journal of Research in Science Teaching, 47(4), 2010, pp. 474–496.

National Research Council, Inquiry and the National Science Education Standards. A guide for teaching and learning, Washington, DC: National Academy Press, 2000.

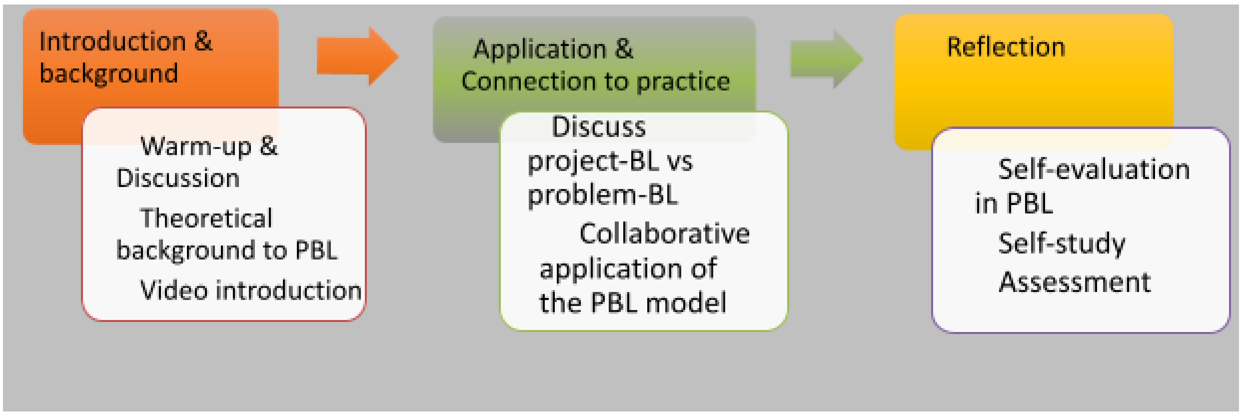
Science Education in Europe: National Policies, Practices and Research. European Commission, Eurydice. 2011. [17-02-2020] http://www.indire.it/lucabas/lkmw_file/eurydice/sciences_EN.pdf

Granularity

For deeper understanding students can learn using the Mascil material:

Mathematics and Science for life (Mascil) (2013-2016). Teachers PD Tools. https://mascil-project.ph-freiburg.de/professional-development/teacher-pd-toolkit.html

UNIT 5: Project Based Learning (PBL)



Keywords
Project based learning, Project-BL, problem-BL, PBL

Contribution to the learning outcomes

Learning outcomes	Assessment methods
Identifies areas of application of PBL, recognizes design elements of PBL	Concept-map of PBL
Working in group, is able to conduct a comparative analysis of project-based and problem-based learning	A comparative analysis of project-based and problem-based learning (similarities and differences)
Is able to design a project following PBL design steps and elements	Presentation of a designed project
Prepares a lesson description promoting PBL in the class	Description of a project in details
Is able to critically analyse videos illustrating the PBL use at schools	Written analysis of a chosen project

Activity 5.1 Introduction to methodology of the Project Based Learning

Aim of the activity: to understand the basics of the project based learning (PBL)

15

Warm-up discussion

Ask students to think about “What is a project?” Do they know an example of a project? Ask students to discuss in groups of 3–4 about project examples they know.

What pedagogical theories you already know fit best to work with these tools during the lessons?

Theoretical background: Definitions of important concepts

Lecturer’s presentation of the PBL (Project Based Learning) framework is combined with a 15 min video resource and its discussion.

Theoretical background to PBL

Project Based Learning (PBL) is a teaching method in which students learn by actively engaging in real-world and personally meaningful projects by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.

Video introduction

Ask students to watch a video “Tiny house project”
https://youtu.be/B2gBFlPEZ2Q
The “Tiny House Project” done at Katherine Smith Elementary School, San Jose, US.

https://youtu.be/JMNwh-hWWzQ
Finance project
Watch “Financial Planning ” of a PBL project in action. The “Financial Planning” project done at Northwest Classen High School, Oklahoma City, US.

The Buck Institute for Education is dedicated to improving 21st Century teaching and learning throughout the world by creating and disseminating products, practices and knowledge for effective PBL. The Institute website PBL Works has great resources including videos, research, forums, and more: https://www.pblworks.org

The PBL Works website promotes a research-based model named by the Gold Standard PBL which encompasses two guides for educators:
1) Seven Essential Project Design Elements provide a framework for developing high quality projects for your classroom (Figure 5.1), and
2) Seven Project Based Teaching Practices help teachers, schools, and organizations measure, calibrate, and improve their practice (Figure 5.2).

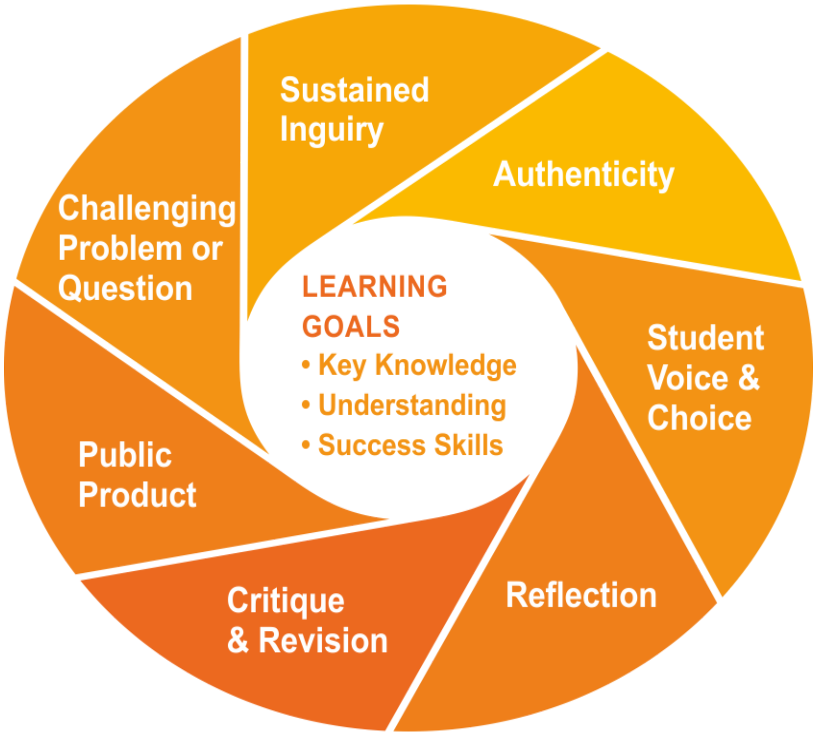


Fig. 5.1. Gold Standard PBL: Seven Essential Project Design Elements (by PBL Works is licensed under CC BY-NC-ND 4.0).

A Challenging Problem or Question. The project is framed by a meaningful problem to be solved or a question to answer, at the appropriate level of challenge
Sustained Inquiry. Students engage in a rigorous, extended process of posing questions, finding resources, and applying information.
Authenticity. The project involves real-world context, tasks and tools, quality standards, or impact, or the project speaks to personal concerns, interests, and issues in the students' lives.
Student Voice & Choice. Students make some decisions about the project, including how they work and what they create.
Reflection. Students and teachers reflect on the learning, the effectiveness of their inquiry and project activities, the quality of student work, and obstacles that arise and strategies for overcoming them.
Critique & Revision. Students give, receive, and apply feedback to improve their process and products.
Public Product. Students make their project work public by explaining, displaying and/or presenting it to audiences beyond the classroom.

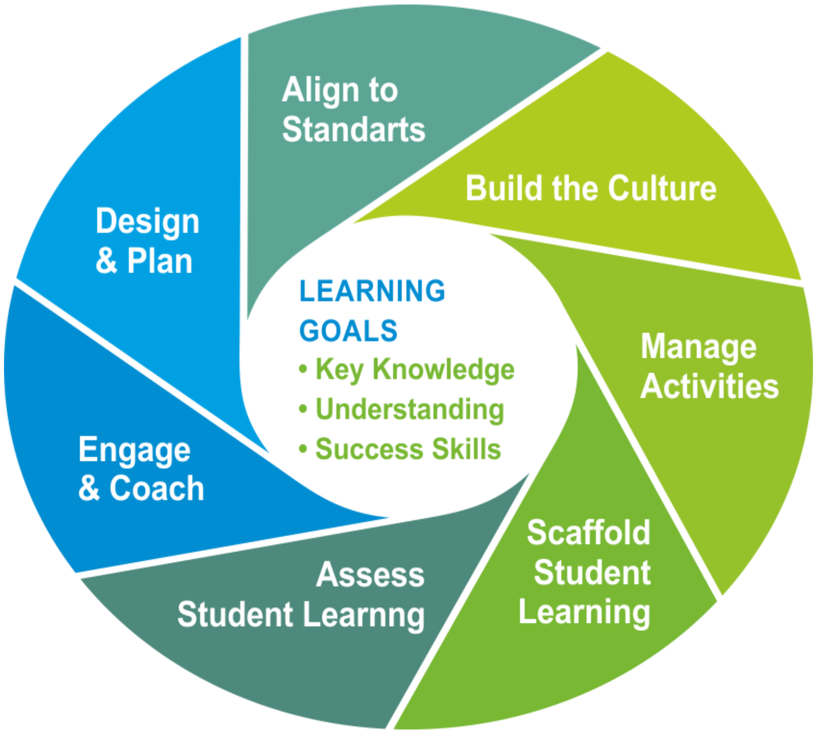


Fig. 5.2. Gold Standard PBL: Seven Project Based Teaching Practices (by PBL Works is licensed under CC BY-NC-ND 4.0).

Design & Plan. Teachers create or adapt a project for their context and students, and plan its implementation from launch to culmination while allowing for some degree of student voice and choice.
Align to Standards. Teachers use standards to plan the project and make sure it addresses key knowledge and understanding from subject areas to be included.
Build the Culture. Teachers explicitly and implicitly promote student independence and growth, open-ended inquiry, team spirit, and attention to quality.
Manage Activities. Teachers work with students to organize tasks and schedules, set checkpoints and deadlines, find and use resources, create products and make them public.
Scaffold Student Learning. Teachers employ a variety of lessons, tools, and instructional strategies to support all students in reaching project goals.
Assess Student Learning. Teachers use formative and summative assessments of knowledge, understanding, and success skills, and include self and peer assessment of team and individual work.
Engage & Coach. Teachers engage in learning and creating alongside students, and identify when they need skill-building, redirection, encouragement, and celebration.

Group Work

Ask the students to work in small groups to devise some effective questioning on PBL to use in this context. For each small group, one participant should act as the teacher and the other students as students. Try out the questions devised by the small group about Seven Essential Project Design Elements and Seven Project Based Teaching Practices

Together reflect on why and how the questions were (or were not) effective, possibly using one or more of the following questions:

- Pick a question. What opportunities did it provide for the student? What did it provide for the teacher? In which ways was it an effective question?
- What different sorts of questions were used?
- Did question x get the sort of response that was predicted?

Bring the group back together and ask the small groups to share their thoughts.

Reading: Self-study

Bell S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House, 83: 39–43, 2010, Copyright Taylor & Francis Group, LLC, ISSN: 0009-8655 print DOI: 10.1080/00098650903505415

Grossman P., Pupik Dean C. G., Schneider Kavanagh S., Herrmann Z. (2019). Preparing teachers for project-based teaching. Phi Delta Kappan, Volume: 100 issue: 7, page(s): 43-48

Activity 5.2 Implementing Project Based Learning

Aim of the activity: to understand the basics of the project based learning (PBL)

Introducing to Problem Based Learning

We decided to call problem-based learning a subset of project-based learning -- that is, one of the ways a teacher could frame a project is "to solve a problem." But problem-based-learning does have its own history and set of typically-followed procedures, which are more formally observed than in other types of projects.

Problem-based learning typically follow prescribed steps:

1. Presentation of an "ill-structured" (open-ended, "messy") problem
2. Problem definition or formulation (the problem statement)

3. Generation of a "knowledge inventory" (a list of "what we know about the problem" and "what we need to know")
4. Generation of possible solutions
5. Formulation of learning issues for self-directed and coached learning
6. Sharing of findings and solutions

If you're a project-based-learning teacher, this probably looks pretty familiar, even though the process goes by different names. Other than the framing and the more formalized steps in PBL, there's really not much conceptual difference between the two PBLs -- it’s more a question of style and scope.

One could argue that completing any type of project involves solving a problem. If students are investigating an issue -- say, immigration policy -- the problem is deciding where they stand on it and how to communicate their views to a particular audience in a video. Or if students are building a new play structure for a playground, the problem is how to build it properly, given the users' wants and needs and the various constraints of safe, approved construction. Or even if they're writing stories for a book to be published about the Driving Question "How do we grow up?", the problem is how to express a unique, rich answer to the question.

Discussion: Project Based Learning vs. Problem Based Learning

So the semantics aren't worth worrying about, at least not for very long. The two PBLs are really two sides of the same coin. What type of PBL you decide to call your, *extended learning experience* just depends on how you frame it. The bottom line is the same: both PBLs can powerfully engage and effectively teach your students!

<table>
<tr><th colspan="2">Project Based Learning vs. Problem Based Learning</th></tr>
<tr><td colspan="2">Similarities</td></tr>
<tr><td colspan="2">Both PBLs:
● Focus on an open-ended question or task
● Provide authentic applications of content and skills
● Build 21st century success skills
● Emphasize student independence and inquiry
● Are longer and more multifaceted than traditional lessons or assignments</td></tr>
<tr><td colspan="2">Differences</td></tr>
<tr><td>Project Based Learning</td><td>Problem Based Learning</td></tr>
<tr><td>Often multi-subject</td><td>More often single-subject, but can be multi-subject</td></tr>
<tr><td>May be lengthy (weeks or months)</td><td>Tend to be shorter, but can be lengthy</td></tr>
<tr><td>Follows general, variously-named steps</td><td>Classically follows specific, traditionally prescribed steps</td></tr>
<tr><td>Includes the creation of a product or performance</td><td>The “product” may be tangible OR a proposed solution, expressed in writing or in a presentation</td></tr>
</table>

May use scenarios nut often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as “illustrated problems”

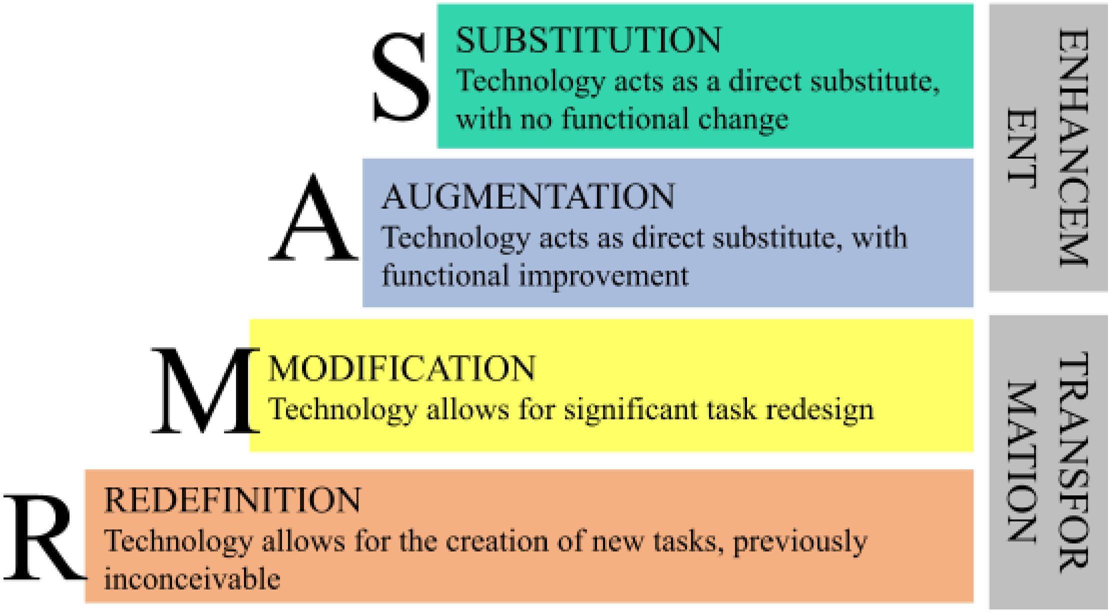


Fig. 5.3. The SAMR model can help educators think about the role of technology in supporting learning (developed by education researcher Ruben Puentedura, 2010, Creative Commons)

Substitution

“Substitution” means replacing traditional activities and materials like in-class lectures or paper worksheets with digital versions. There is no substantial change to the content, just the way that it is delivered.

The goal here is to keep things simple: there’s no need to reinvent the wheel. Scan your lessons and worksheets, convert them into PDFs, and post them online using Microsoft OneDrive, Google Drive, or a similar file-sharing service. Think about the information you have on your walls, such as the classroom norms, the daily schedule, or vocabulary lists, and convert them into digital formats that students can easily reference.

It may also help to provide synchronous as well as asynchronous versions of your lectures. If you’re holding class meetings over a videoconferencing service like Zoom or Skype, provide a recording for students who can’t attend. You can also create your own instructional videos for students to view at their own pace.

Augmentation

This level involves incorporating interactive digital enhancements and elements like comments, hyperlinks, or multimedia. The content remains unchanged, but students can now take advantage of digital features to enhance the lesson.

For example, students can create digital portfolios to create multimedia presentations, giving them more options to demonstrate their understanding of a topic. And instead of handing out paper quizzes, you can gamify your quizzes with tools like Socrative and Kahoot.

Teachers can also create virtual bulletin boards using an app like Padlet where students can post questions, links, and pictures.

Modification

At this level, teachers can think about using a learning management system like Google Classroom, Moodle, Schoology, or Canvas to handle the logistical aspects of running a classroom, like tracking grades, messaging students, creating a calendar, and posting assignments. Teaching online opens up new channels of communication, many of which can help students who have traditionally been marginalized. Research shows that girls may be less likely to speak up in class, for example, so they may benefit from backchannels alternative conversations that can run alongside instruction that encourage participation.
Zoom's text chat feature, meanwhile, gives students an opportunity to write their questions out, which can feel less intrusive if there are dozens of students participating in the call. Also, students who prefer to collect their thoughts may benefit from slower-paced, asynchronous discussions in an online forum or email threads.

Redefinition
Learning is fundamentally transformed at the "redefinition" level, enabling activities that were previously impossible in the classroom, e.g. virtual pen pals can connect students to other parts of the world, whether it's with other students or experts in a field. Virtual field trips enable students to visit locations like the Amazon rainforest, the Louvre, or the Egyptian pyramids. After reading a book in class, you can invite the author to chat about their work and answer questions.

Technology also provides an opportunity to bring authentic audiences into your virtual classroom, and can make publishers out of your students. Kids can write their own wikis or blogs for public consumption and feedback and platforms like Quadblogging can connect distant classrooms together so students both write and respond. Students can tackle local problems like investigating the water quality of a nearby river and invite members of the community to assess their digital proposals.

60 **Reading – Self-study**

Sardars A. S. (2019). Problem Based Learning: A Student-Centered Approach. English Language Teaching, vol.,12 No5, p.73-78.

Savery, J. R. (2015). Overview of Problem-based Learning: Definitions and Distinctions. Interdisciplinary Journal of Problem-Based Learning, 1(1) https://doi.org/10.7771/1541-5015.1002

Activity 5.3 Reflection

Aim of the activity: to help students to organise PBL activities in practice.

60 **Practical work**

Ask the students to select a question and plan a project. They could do this in the session or at home.
The following questions will help them plan.

- How will you organise the project and the resources?
- How will you introduce the questioning session?
- Which ground rules will you establish?

Students can use the Project Planning Sheet (Fig 5.4)

Project Planner

1. Project Overview

Project Title		**Public Product(s) (individual and Team)**	
Driving Question			
Grade Level/Subject			
Time Frame			
Project Summary			

2. Learning Goals

Standards		**Literacy Skills**	
		Success Skills	
Key Vocabulary		**Rubric(s)**	

Fig. 5.4. A planning sheet

Reading – Self-study

John Larmer and John R. Mergendoller (2010). Seven Essentials for Project-Based Learning. *Educational leadership,* vol.68, No 01
http://www.ascd.org/publications/educational_leadership/sept10/vol68/num01/Seven_Essentials_for_Project-Based_Learning.aspx

Teach Thought Staff: 3 Types Of Project-Based Learning Show Its Range As A Learning Model.
https://www.teachthought.com/project-based-learning/5-types-of-project-based-learning-symbolize-its-evolution/

Assessment

Students are asked to present orally their lesson descriptions (online or face-to-face, depending on study program implementation).

Learning resources

Present a list and a very short description of each resource. Include icons dependent on main typology of resource, for example: presentation, handouts, video or another kind of media, and readings. One icon for each. Examples of materials.

Presentation (pptx). PBL presentation.

Readings (included in Worksheets and/or listed in the Reference section)

References

Bell S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House, 83: 39–43, 2010, Copyright Taylor & Francis Group, LLC, DOI: 10.1080/00098650903505415

Grossman P., Pupik Dean C. G., Schneider Kavanagh S., Herrmann Z. (2019). Preparing teachers for project-based teaching. Phi Delta Kappan, Volume: 100 issue: 7, page(s): 43-48

Learning, 1(1). Available at: https://doi.org/10.7771/1541-5015.1002

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Savery, J. R. (2015). Overview of Problem-based Learning: Definitions and Distinctions. Interdisciplinary Journal of Problem-Based