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TeaEdu4CT

Module 9

Using Constructivism, and Project and Challenge Driven Pedagogy for learning Computational Thinking

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Content

General overview and aim

Teaching CT requires that teachers are well equipped to scaffold the learning processes of their pupils and to motivate them to engage in the learning of CT skills in meaningful situations. In order to achieve this teachers should be capable of exercising these same CT skills themselves in order to both solve problems in a computational context as well as design new learning challenges for their pupils. This module focuses on the use of societally relevant intellectual challenges to stimulate student motivation and engagement in learning CT concepts and skills. In doing so Module 9 uses the definition of what CT skills and competencies involve defined by the work of Dagiene et al. .

Constructionism is introduced as the conceptual basis of learning activities in CT skills development in Unit 1. The remaining units support teachers in the process of designing appropriate learning strategies for CT using a challenge based constructionist pedagogy. The final units provide a set of materials to scaffold the development of challenge based classroom practice and assessment rubrics.

The instructional designs presented in Module 9 draw on the constructionism paradigm proposed and developed by Papert and popularised in the European Computing in Schools movement through relevant conferences and journals (see for instance, https://issep2020.tlu.ee/, https://constructivist.info/). The first half of the material in the module is designed to give teachers relevant background in constructionism as a pedagogical approach. The second half of the module provides training in the application of constructionist models in combination with challenge driven learning and in particular learning challenges with real-world applications which provide pupils with motivating experiences in terms of relevance and opportunity for reflection on computational systems and technologies.

Exercises are designed to give participants direct experience with exercises that they can use in their own classrooms directly. Subsequently the module discusses approaches and presents resources teachers can use to create their own challenges and problem based learning scenarios. Emphasis is placed on integration of CT with other subjects such as Art and Craft, Mathematics, Physics, and Technology in the context of the Swedish school curriculum. In a more general implementation STEAM subjects can be considered to be the target for module activities. Some critical thinking challenges can also provide links to Language instruction as well as reinforcement of grammar.

Target group and prerequisites

Participants are in-service and pre-service teachers with an interest in computational applications in their classroom practice. When using this Module additional benefit can be gained from the additional material covering application of constructivist and constructionist learning theories covered in Module 1. In this module we assume a subject teaching background in an area where CT is to be included in the curriculum, and the level of curriculum theory and interpretation expected of a teacher in the field or a pre-service teacher who already has a strong disciplinary knowledge base.

Prerequisite knowledge

The Project Based Learning content of Module 1 was initially proposed as a prerequisite for Module 9. To facilitate the use of Module 9 as a standalone resource the necessary content from Module 1 on Project Based Learning and constructionism has been integrated as Unit 1, to provide the necessary foundations for Unit 2. The content of Module 2 provides desirable background to Module 9, enhancing the range of resources learners have available to them.

Keywords

Project based learning, challenge driven enquiry, constructivism.

Related competence frameworks

DigCompEdu and teacher's professional competence standard, [Digital Competence Framework for Europe (link)]

Learning Outcomes (LOs) and Assessment Methods

Module 9 develops teacher's competence with challenge based and project based learning methods for scaffolding learner development of computational thinking skills. The use of challenges is developed as a way to increase the relevance of computational thinking activity and to enhance the motivation of pupils. The module delivers empirically validated models and learning activity design guidance to teachers faced with the development of CT content at all levels of compulsory education. In common with other modules we focus on the following areas.

1. conceptual competence: gaining contextualised understanding of computational thinking concepts through engagement with societally relevant challenges, concepts targeted include decomposition, abstraction, algorithms, and parsing and pattern matching in the context of challenge based educational activities in the classroom and online;
2. pedagogical competence: effective design, development and implementation of approaches and tools for integrating computational thinking into curriculum and classroom settings;
3. reflective competence: ability to evaluate the design and development of learning activities and to instrument instructional plans, materials and activities in relation to national grading criteria in respect to the relevant national curriculum.

A successful learner will:

- Demonstrate capability to develop and execute problem and project based learning
- Identify and develop topical societal challenges in contexts relevant to learners
- Scaffold learning in project settings using constructionism and student-centric pedagogies
- Be capable of designing assessment, and assessing learning outcomes in project settings

Learning Outcomes	Assessment Methods
1. Develop constructionist projects	Written design documents and assessment rubrics
2. Identify and refine challenges	Learning design experiments
3. Deploy projects in a classroom	Teaching placements in schools and reflection exercises
4. Develop assessment instruments	Oral presentation of posters and assessment guides.

Module plan and didactical approach

Module 9 includes the minimum 16 hrs face-to-face session (units) and also includes experiments conducted in context in year 7-9 or 10-12 schools. The complete load of the practical classroom intervention (experimental classroom practical work) and the reflection and presentation activities comprise 9-10hrs of student self-study. In total the module requires a minimum of 20 hours of engagement.

The didactic model is presented in Figure 1 below: in summary four phases are explored through explicit instruction, instructional design exercises, classroom practical evaluation and reflection, exchange of pedagogical insights, which are then coupled to assessment approaches in the final phase. Outcomes are reinforced in group discussion and are expected to contribute to an open source repository of challenge based teaching activities for use in schools.

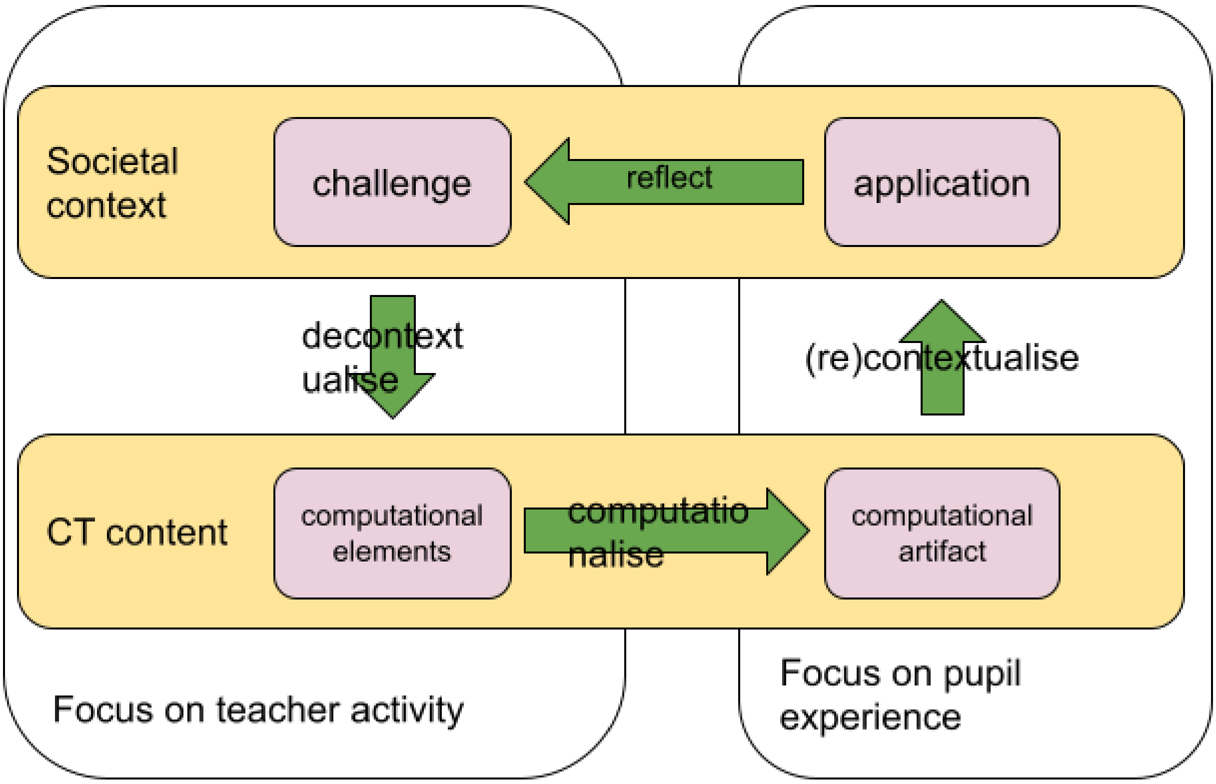


Figure 1. A process model for the construction of CT learning exercises.

Units and activities

Unit 1: Constructionism (5hrs 30minutes)

Introduction to challenge driven approaches and examples of scaffolding challenges in the classroom.

Activity 1.1: Introduction

- Brief introduction : 15 min
- Fundamentals of constructionism: 45 min
- Creative exercises – connection to constructionism: 45 min
- Algorithmics - self-study: 60 min

Activity 1.2: Illustrating the Constructionist Approach

- Foundations of project and semi-structured challenge driven educational activities in the classroom. 45 min

Activity 1.3: Reflection and Self-study

- Poster and discussion. 120 min

Unit 2: Challenge Based Pedagogy (CPB) (3hrs 30minutes)

Introduction to challenge driven approaches and examples of scaffolding challenges in the classroom.

Activity 2.1: Introduction to CBP

- Theoretical background – definitions: 30 min
- Reading - self-study: 60 min

Activity 2.2: Project and Challenge Based Learning

- Overview of theoretical foundations of project and semi-structured challenge driven educational activities in the classroom. 45 min

Unit 3: Problem and Project Based Learning (3hrs)

Activity 3.1: Project and Problem Based Learning

- Introduction to P&PBL
- Models for P&PBL instruction

Activity 3.2: PBL Concepts and Poster

- Group discussion of P&PBL concepts
- Create a P&PBL poster

Unit 4: Developing Classroom Activities (8hrs)

Activity 4.1: Challenges - what can they be?

- Presentation of a sample exercise
- Learner activity to solve the exercise - pairs

Activity 4.2: Exploring outcomes - what was learned? CT conceptual content.

- Reflection and analysis - pairs

- CT concept map

Activity 4.3: Create a challenge

- Developing an exercise - groups of 4 to 5 participants
- Presentation of the exercises developed above.

Homework:

- Review CS unplugged and Bebras resources to become familiar with the content and reflect on how these can illustrate CT conceptual areas.
- Identify one activity to transform into a challenge or project based classroom experience for pupils.

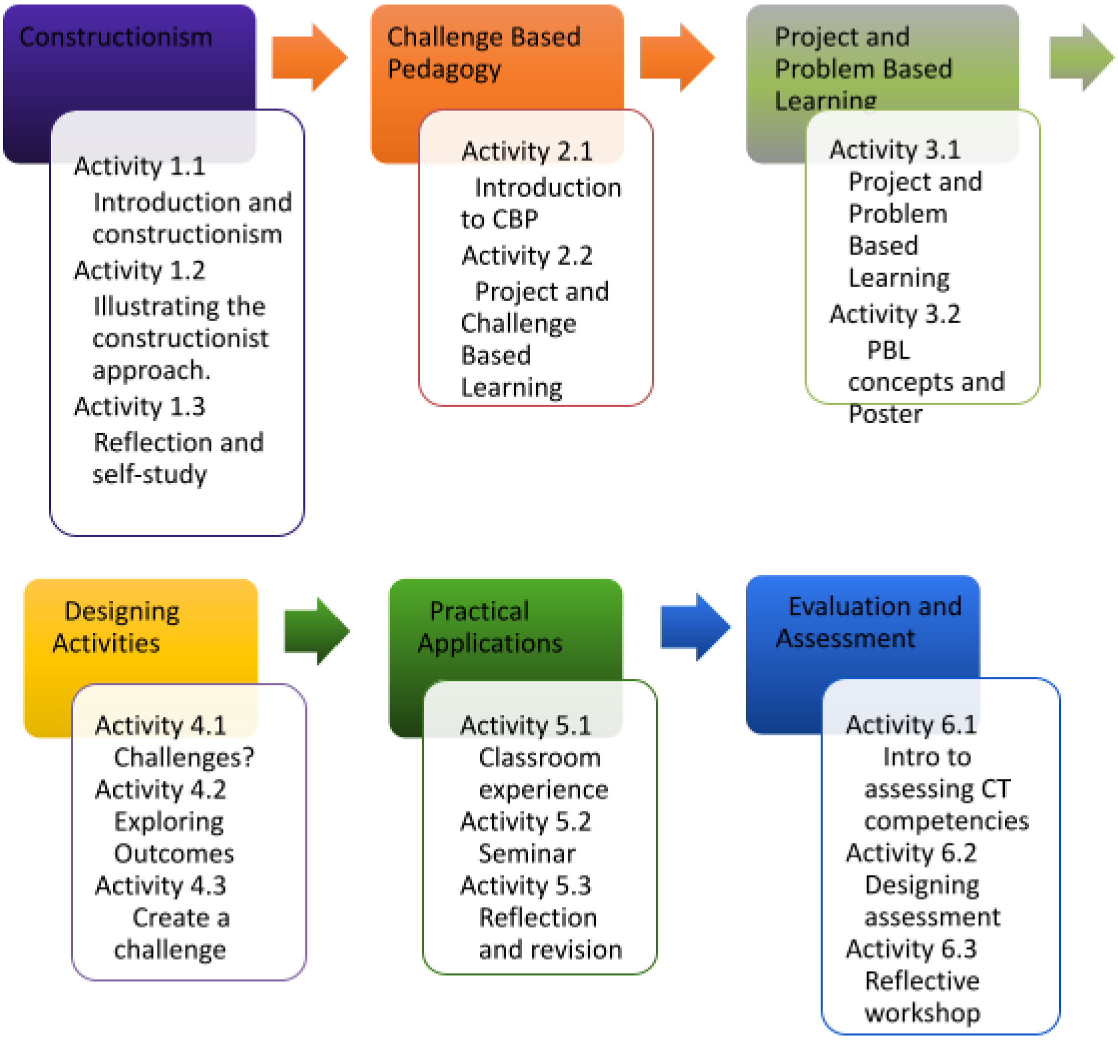
Unit 5: Practical Applications (3hrs)

Activity 5.1: Classroom experience - implement an activity in practice
Activity 5.2: Seminar - presentations of 4.1
Activity 5.3: Evaluation and revision of activity - group work

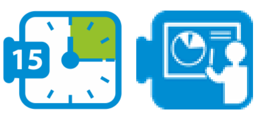
Unit 6: Evaluation of and Assessment Practices (4hrs 15 minutes)

Activity 6.1: Introduction to assessing CT competencies
Activity 6.2: Assessment design presentation and discussion (application to Activity 4.1)
Activity 6.3: Reflective workshop
Homework:

- Assessment scheme development.



Introduction



Presentation: Overview of Module 9

The intention of this session is to provide participants with the complete context and a brief overview of how Module 9 is related to the other parts of the overall initiative and educational strategy. The focus is on direct relationships to other modules that can be easily linked to Module 9, and can provide access to additional useful resources. Module 9 is a stand-alone resource, but participants will find other modules useful, particularly in terms of lists of other relevant online and printed resources. Modules 1 and 2 are particularly relevant as they provide more depth in Constructionism and applications of CT.

UNIT 1: Constructionism

Estimated time investment (5hrs 30 minutes)

Activity 1.1 Introduction to Constructionism

Aim of the activity: to understand the basic concepts and ideas of constructivism and constructionism. An introductory presentation of the foundations of "Constructionism" and "Creativity" is combined with a related discussion and demonstration of CS Unplugged activities. The first activity is instructor lead, and consists of presentations and background exercises which are strongly scaffolded.

Constructionism Theory Presentation

Seymour Papert coined the term constructionism, as a way to represent the ideas he proposed to relate learning to the process or construction of solutions. The notion emerged as a need to distinguish his approach in comparison to constructivism: Constructionism shares constructivism's understanding of learning as 'building knowledge structures' irrespective of the circumstances of the learning. It then extends the idea by observing that this can be especially felicitous in a context where the learner is consciously engaged in constructing a publicly visible artefact, whether it's a sand castle on the beach or a theory of the universe" (Papert & Harel, 1991).

Constructionism shares the main idea of genetic epistemology elaborated by Jean Piaget about the immanence of cognitive development. In Piaget's theory, the immanent algorithm in relation to cognitive development comprises the sensorimotor, preoperational, concrete operational, and formal operational stages.

Constructivists tend to subscribe to the view that the only way children learn is by attaching new experiences to experiences or knowledge they already have. Learning does not occur by transmitting information from the teacher to the child's brain, instead, each child constructs his or her own meaning by combining prior information with new information such that the new knowledge provides personal meaning to the child (Cobern, 1993). The desired cognitive equilibration is achieved by observing around, trying different ideas, doing different things, and checking out findings that seem to be promising. There are many research investigations done with children on activities with various things and physical artifacts. Usually educators present new experiences to children to encourage them to think, and stimulate them to investigate their ideas in the process of constructing personal knowledge. Few research studies have been dedicated to analyzing the processes of underlying pupils' processes of solving computing-concepts-based tasks.

To extend the constructivist paradigm to align with his ideas Papert extended constructivism as a learning theory discussing how this process applies to practical construction and named it as constructionism (Papert, 1980). For several decades the ideas of constructionism have been applied to different activities in education and the results are promising (Brennan & Resnick, 2013; Bruckman, 2006; Resnick, 2014). Constructivism advocates learner-centred (in our case the learners are teachers) discovery learning where learners use information they already know to acquire more knowledge (Aleksandrini & Larson, 2002). Constructionism provides us with the basic idea of an appropriate learning object. Such an object should support the learner's step-by-step understanding of the materials and concepts it represents, allowing users to construct knowledge.

Creativity from a Constructivist Learning Perspective

Creativity is one of the characteristics in constructionist learning. Creativity is frequently connected to learning by doing and needs a high amount of freedom in choice of activities and learning steps. Basically, Computational Thinking denotes thinking processes that are related to problem solving known from computer science. Computational Thinking does not only involve algorithmic thinking skills that are useful in programming and algorithm design but also integrates skills like abstraction, decomposition, generalization and evaluation that are used in problem definition, system modelling and system evaluation.

Since Computational Thinking has become a part of Informatics school curricula in many countries, the paradigm of competence orientation has led to very detailed curricula that describe a large variety of detailed competences. The high amount of details can lead to a kaleidoscopic teaching practice. Although, from a constructionist viewpoint it seems more promising to learn within learning settings that allow creativity, fun and sense of achievement. The creativity in Computational Thinking Learning is not only related to a creative output but also helps to find new ways of thinking while finding solutions to problems.
Creativity has long been associated with learning. What are the implications for creativity and for construction of knowledge?

There are many conceptual and theoretical overlaps between creativity and problem solving (mainly task solving). Both concepts refer to knowledge-construction processes. From a constructivist point of view, new ideas can be generated through a combination of individual and collaborative activities embedded in particular socio-cultural contexts (Craft, 2008). Such approach shapes the constructionist paradigm of learning and emphasizes learner's as designer's role (Papert, 1993; Kafai, 2006).

Constructionism emphasizes the learners' creative performance. Various tools and approaches can be used for such performance, among them there are the construction and deconstruction of short concept-based tasks. When solving short concept based tasks, learners are at the same time representing their ideas and understandings. Digital tools and social environments allow learners to move from inquiry to playful activity (gamification) and foster creativity.
We are in need to understand creativity from a constructionist perspective. The existing literature suggests two special cases of everyday creativity, namely, "Mini-C" and "middle-c". "Mini-c" creativity refers to the learning process, which is inherent in the learners' personally meaningful insights and interpretations of their experiences (Kaufman and Beghetto, 2009). Our perspective also borrows from "middle-c" creativity, assuming that new understandings develop in collaboration and thinking together.

Creativity Using Constructionist and Deconstructionist Approaches

The process of learning through construction can be split into two phases: construction and deconstruction (Boytchev, 2015). Deconstruction is used in terms of decomposition something into reusable components with the goal of understanding them in order to aid construction and build something new. We expand the deconstructive approach to problem solving for both teachers and students in the school classroom.

Our practice of pupils' observation during the solving informatics concepts-based tasks showed that this process can support pupils to generate and share meanings about the informatics concepts involved in the tasks and promote the development of computational thinking and understanding of informatics.

Primary school teachers usually have a very limited background in Informatics. For them, a deconstructionist process of tasks is very important (Boytchev, 2015; Dagiene, Futschek, Stupuriene, 2016). Primary school teachers can improve their Informatics competence through analysing, solving, and explaining the essence of the Informatics concept-based tasks (see Fig. 2 in which this model is presented).

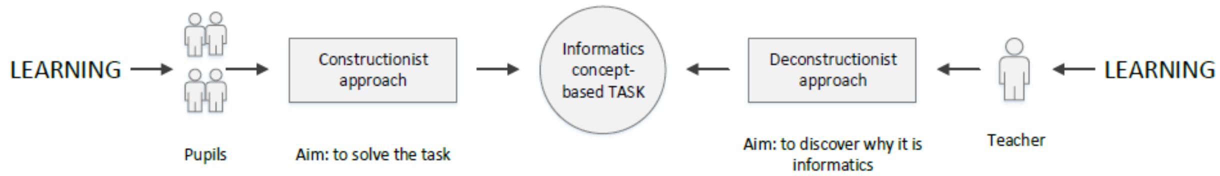


Figure 2. Pupils' and teacher's attitude towards learning by solving tasks

Warm-up discussion

Ask participants to sketch some ideas related to the question "What is constructionism?" "What do they feel that they know now about the application of the constructionism approach practical teaching situations?" Participants brainstorm in small groups and then discuss with the whole class. The idea is to share the constructionist activities they may have previously encountered in their classroom practice.

Discussion

After the warmup discussion of constructionism, participants are asked to consider the following questions:

- How can we support ourselves and our colleagues to engage in constructionism?
- How do we start to think beyond a technocentric view of CT.

Activity 1.2 Illustrating the Constructionist Approach

The goal of this activity is to acquaint pre-service and in-service teachers with practical experience of how constructionism can be integrated into teaching in a variety of disciplines. Depending on the

discipline appropriate exercises should be selected from within the framework of **Computer Science Unplugged Activities**[1]:
http://csunplugged.org/wp-content/uploads/2015/03/CSUnplugged_OS_2015_v3.1.pdf
Activities can be selected from a broad range of resources that target pupils from pre-school to the upper levels of compulsory schooling, based on the interests and classroom interests of the participants. Selection of tasks should be made in advance, or in collaboration with the course participants.

S. Papert extended constructivism as a learning theory by focussing it on how applications can be developed in relation to practical construction; giving the approach the name "constructionism" (Papert, 1980). Over the last several decades the ideas of constructionism have been applied to different activities in education with promising results (Brennan, Resnick, 2013; Bruckman, 2006; Resnick, 2014). Constructivism advocates learner-centred (in our case the learners are teachers) discovery learning where learners use information they already know to acquire more knowledge (Aleksandrini, Larson, 2002).
Constructionism provides us with the basic idea of an appropriate learning object. Such an object provides support for a learner's step-by-step development of understanding of the materials and concepts it represents, allowing users to construct knowledge over time and through experience.

Based on the above coverage an exploration of the concept of constructionism can be facilitated as a discussion exercise among pre-service teachers using questions such as:

- How might we support ourselves and our colleagues to engage more in constructionism?
- How can we start to think beyond a technocentric view?

Note: the S. Papert's book "Mindstorms: Children, computers, and powerful ideas" (Papert, 1980) is translated into many languages. Check availability (if not translated you can contribute the project by translating some activities).

Hands-on: Collaborative Application of the Orange Game

Video Introduction
Watch introduction video about Orange Game on YouTube: https://youtu.be/WforXEBMm5k

The introductory session is followed by a group learning exercise focussed on the practical applications of the "orange game" as a scaffolded exercise. Each student needs:

- Two oranges or tennis balls labelled with the same letter, or two pieces of fruit each (artificial fruit is best)
- Name tag or sticker showing their letter, or a coloured hat, badge or top to match their fruit

[1] These resources are available under a Creative Commons licence.

Interactive Scaffolded Exercise

1. Groups of five or more students sit in a circle.

2. The students are labelled with a letter of the alphabet (using name tags or stickers), or each is allocated a colour (perhaps with a hat, or the colour of their cloths). If letters of the alphabet are used, there are two oranges with each student's letter on them, except for one student, who only has one corresponding orange to ensure that there is always an empty hand. If fruit is used, there are two pieces of fruit for each child e.g. a child with a yellow hat might have two bananas, and a child with a green hat may have two green apples, except one child has only one piece of fruit.

3. Distribute the oranges or fruit randomly to the students in the circle. Each student has two pieces, except for one student who has only one. (No student should have their corresponding orange or colour of fruit.) 4. The students pass the oranges/fruit around until each student gets the one labelled with their letter of the alphabet (or their colour). You must follow two rules:

a) Only one piece of fruit may be held in a hand.

b) A piece of fruit can only be passed to an empty hand of an immediate neighbour in the circle. (A student can pass either of their two oranges to their neighbour.)

Students will quickly find that if they are "greedy" (hold onto their own fruit as soon as they get them) then the group might not be able to attain its goal. It may be necessary to emphasize that individuals don't "win" the game, but the puzzle is solved when everyone has the correct fruit.

Follow up discussion

- What strategies did we use to solve these problems?
- Where in real life have we experienced deadlock? (Some examples might be a traffic jam, getting players around bases in baseball, or trying to get a lot of people through a doorway at once.).

Extension Activities

Try different configurations such as sitting in a line, or having more than two neighbours for some students.

Creating Algorithms in a Constructionist Manner.

To prepare for this session we recommend that participants are asked to read Phillip's article for teacher educators (or similar articles about algorithms in multicultural context) as a background:

Philipp, R. A. (1996). Multicultural mathematics and alternative algorithms: Using knowledge from many cultures. Teaching Children Mathematics, 3(3), 128-135.

In this article, algorithm is defined as process by which we compute or a convention used to manage the process of computation. By solving a mathematical problem, students obtain elementary knowledge about mathematics methods and challenge the belief that these algorithms work universally.

We suggest that the teachers collect information about algorithms that are used by students in their local community. Identification of algorithms and description why the algorithm works empower students to rethink mathematical ideas.

To enhance discussion use the background from Philipp (1996) where examples are given of algorithms (add, subtract, multiply, divide) invented by a third-grade child and described by people from various cultures.
Learners can be divided into six different groups. Each group performs a search about an encoding process. The goal of the exercise is to compile a set of viable explanations and examples, then present the results in the class or as a wiki/blog page connected to the learning activity in which the participants are using the module contents.

45 **Compare solutions in groups. Discuss following aspects:**

- An explanation of the solution of the particular task.
- Do you notice differences, similarities when comparing your solution with the solutions of others?
- What methods were used to arrive at a meaningful answer?
- Have you noticed any cultural aspects regarding the formulation of the exercise?

Activity 1.3 Reflection and Constructionist Learning Documentation

Aim of the activity: to reflect on cognitivism and the cognitive approach

60 **Poster making**

Make a poster about the cognitive approach to learning including strengths and weaknesses. The poster can be electronic and include visuals, videos and podcasts also.

Participants discuss what is the constructionist approach, and what criteria need to be applied

60 **Self-study**

Module participants work on a home assignment:

Assessment: Presenting the report

Students present in oral their home assignments/posters (online or face-to-face, depending on the study program).

Unit 1: Learning resources

Video Resources

The Orange Game on YouTube: https://youtu.be/WforXEBMm5k

Reading – Self-study

Narayan, R., Rodriguez, C., Araujo, J., Shaqlaih, A., & Moss, G. (2013). Constructivism—Constructivist learning theory. In B. J. Irby, G. Brown, R. Lara-Alecio, & S. Jackson (Eds.), The handbook of educational theories (p. 169–183)

Olusegun B. S. (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning. IOSR Journal of Research & Method in Education (IOSR-JRME) e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 5, Issue 6 Ver. I (Nov. - Dec. 2015), PP 66-70

Papert S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Philipp, R. A. (1996). Multicultural mathematics and alternative algorithms: Using knowledge from many cultures. Teaching Children Mathematics, 3(3), 128-135.

UNIT 2: Challenge based pedagogy

Estimated time investment (3 hrs 15 minutes)

Activity 2.1 - Introduction

Presentation: Introduction to Project and Problem Based Learning

An overview of the P&PBL approach, advantages and issues with development of learning materials. The presentation is developed by Annette Kolmos and is supported by two background articles for the student who wants to get a deeper understanding of the issues at hand

Self study exercise

Participants should read the articles in the reading resources and make notes as background in order to participate in the group discussion activity.

Group Discussion and Concept Mapping Exercise

In groups of five to eight discuss the main ideas in the Reading materials, followed by group discussion and a concept mapping exercise. The concept mapping exercise is designed to provide a concrete learning activity and to stimulate reflection on the main elements of the project and problem based learning pedagogical approach and the role of scaffolding in order to make the project experience meaningful.

Activity 2.2 - Introduction to Challenge Driven Education

Presentation: Introduction to Challenge Driven Learning Concepts

Building on the supplied learning resources, present and discuss with the participants the fundamentals of Challenge Driven education and how that can be translated into micro-challenges in the school classroom. In particular this part of the module introduces the Bebras card system as a source of useful challenges. An approach to using Bebras challenges, especially those that involve representations of physical systems, is presented. The presentation clarifies how such exercises can be combined with other materials and resources to create engaging experiences for pupils. This activity lays the groundwork for Activity 3.1

Self study exercise

Participants should review the websites in the reading below in order to prepare for Activity 2.2. Each course participant should select a small resource or exercise from the sources provided in the Reading List to present and ideate around as their active contribution to the session.

The goal is that every participant should analyse an activity, and reflect on it in terms of the learning of CT concepts, and how/which concepts might be developed through engagement with their chosen activity. This activity focusses on the left hand part of Figure 1, in particular the "decontextualisation" of a challenge in order to identify the computational elements that can be experienced through engagement with the challenge.

Each participant should present some CT development goals/highlights linked to their chosen exercise as a part of activity 3.2. They can also explore the further implications of Figure 1, using the bottom part of the figure to focus attention on "computationalisation" and the construction of a learning artefact liked to the challenge they had chosen.

Unit 2: Learning resources

Presentation: Challenge Based Learning

https://www.edsurge.com/news/2017-12-27-what-s-the-difference-between-project-and-challenge-based-learning-anyway

Video Resources

Overview of Challenge Driven Education KTH Resource.https://play.kth.se/media/0_gf0q2mjl

ESU resource https://www.youtube.com/watch?v=MH0xbc-xMNI

Problem and project based learning, https://www.youtube.com/watch?v=RGoJIQYGpYk

Reading List

(1) A teacher perspective on project and problem based learning approaches, https://www.teachermagazine.com.au/articles/problem-based-learning-and-project-based-learning
(2) Comparing Two Approaches For Engineering Education Development: PBL And CDIO, K. Edström, A. Kolmos (2012). 2012 8th International CDIO Conference, Queensland University of Technology, Canada, http://www.cdio.org/knowledge-library/documents/comparing-two-approaches-engineering-education-development-pbl-and-cdio
(3) https://www.challengebasedlearning.org
(4) KTH Guide to Challenge Driven Education, Magnell and Högfeldt, https://www.researchgate.net/publication/309423487_Guide_to_challenge_driven_education

UNIT 3: Project and Problem Based Learning

Estimated time investment (3 hrs)

The activity focuses on introducing the main concepts of PBL and giving the participants some perspectives on the implementation of PBL in school classrooms. This unit expects participants to have reviewed some online materials prior to commencing the activities.

Activity 3.1 - Introduction

Presentation: Project and Problem Based Instruction

Using existing online materials in the form of presentations and research summary articles introduce the main features of P&PBL. This also provides the contextualisation of Activity 2.1:

Presentation: Models for PBL instruction, Kolmos and background reading.

Activity 3.2 - Development of PBL insight

Group discussion of PBL concepts - based on the concepts presented and the background reading that the participants should have completed before the session facilitate a group discussion in breakout groups of 3-5 participants to consolidate the PBL concept.

Create a PBL poster - Participants work systematically in pairs to create a P&PBL approach poster listing major attributes of a P&PBL experience for students and how these are related. Materials required include an A1 flip chart page, coloured pens, or, alternatively the participants can collaborate in a virtual environment (e.g. padlet.com). The resulting posters should be displayed and discussed between groups of 2-3 pairs, depending on the size of the participant group..

Unit 3: Learning resources

Presentation P&PBL (pptx). Overview of Project and Problem Based Learning - Annette Kolmos. https://youtu.be/6iS7DiA_gNg

Introduction to P&PBL. https://www.youtube.com/watch?v=RGoJIQYGpYk

(1) Comparing Two Approaches For Engineering Education Development: PBL And CDIO, K. Edström, A. Kolmos (2012). 2012 8th International CDIO Conference, Queensland University of Technology, Canada,

http://www.cdio.org/knowledge-library/documents/comparing-two-approaches-engineering-education-development-pbl-and-cdio
(2) Characteristics of Problem-Based Learning, Kolmos, DeGraff, Int. J. Engng Ed. Vol. 19, No. 5, pp. 657-662, 2003 0949-149X/91 $3.00+0.00 Printed in Great Britain, https://www.ijee.ie/articles/Vol19-5/IJEE1450.pdf

UNIT 4: Developing Computational Thinking Activities

Estimated time investment (8 hrs)

Activity 4.1 - Challenge exercise

Participants are presented with a sample exercise based around the analysis of a Bebras challenge. The original Bebras challenge is based on analysis of a two process system executing in lockstep parallelism simulating execution in a synchronised clocked environment with a single global clock controlling the execution of simple instructions. See Figure 1 for the details of the instructions[2], and a sample live setup of the challenge using a BlueBot and electrical tape to reproduce the environment depicted on the card.

Group work - The materials and worksheet are then distributed to participants. The participants are asked to role-play as pupils and complete the exercise described on the worksheet. The idea is to approach the challenge of implementation of key learning aspects of the card. In order to do this we propose the following steps.

1. Ask the student-teachers to identify CT and constructionist aspects of the Bebras card.
    a. what CT concepts might be possible to illustrate?
    b. what reflective opportunities should the teacher create to explore CT content in the context of constructing a solution?
2. How can a concrete implementation support learning of the CT concepts in focus?

[2] These Bebras challenge cards are available in translation into many languages to facilitate their use with pupils who may not yet have mastered the English language.

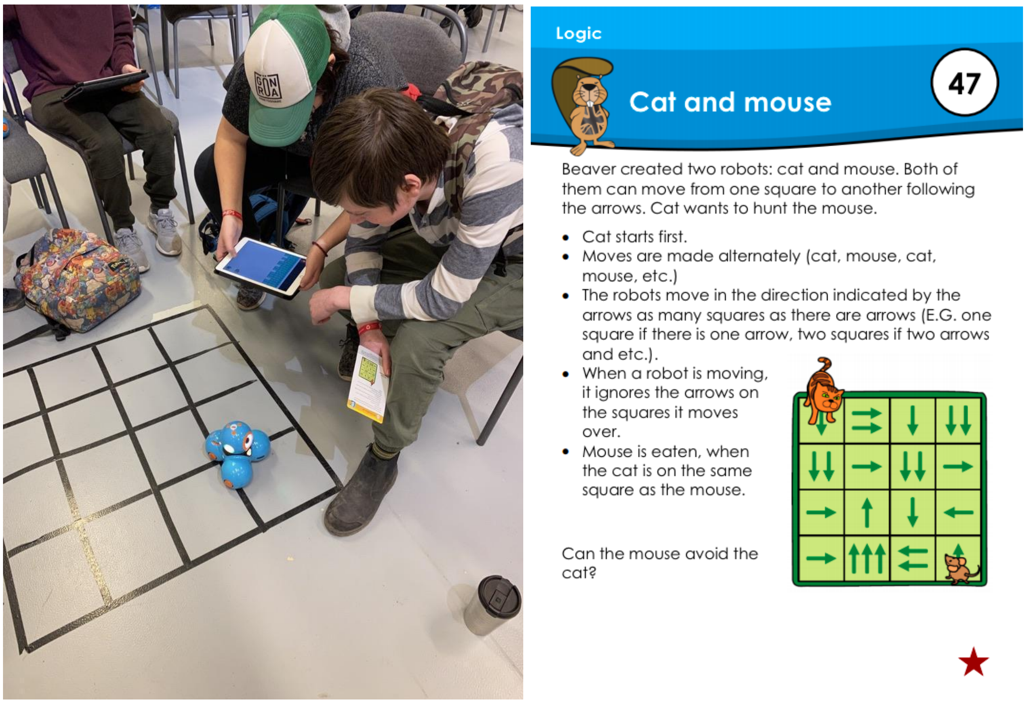


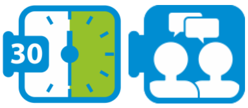
Figure 3. The challenge using a BlueBot and Bebras cards

Activity 4.2 - CT Conceptual Content

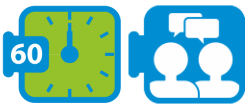
Activity 3.2 explores the outcomes that might be expected from the exercise in Activity 3.1 The activity is guided by two questions.

What was learned?

What is the CT conceptual content?



Reflection and analysis - pairs - discuss the activity in relation to the concepts presented in the resources.



Developing a CT concept map - discussion and use of a concept mapping tool to connect CT concepts from the taxonomy presented by Dagiene.

Background reading of the paper on CT content and concepts. See the paper by Dagiene in the resources.

Activity 4.3 - Create a Challenge

Developing an exercise - groups 4 or 5 - 60 min

Break the participants into groups and introduce the exercise to design a new challenge based on resources from CS unplugged or from Bebras cards or other challenges in the Bebras Lodge. Participants produce a worksheet from the template provided in the Appendix. The pedagogical model should be used to help explain the CT concepts that are developed by the activity.

Present and analyse - group presentations based on analysis according to the overarching pedagogical model for the Module (see above). Each group should present their lesson plan and explain it in terms of the four steps shown in pink in the figure.

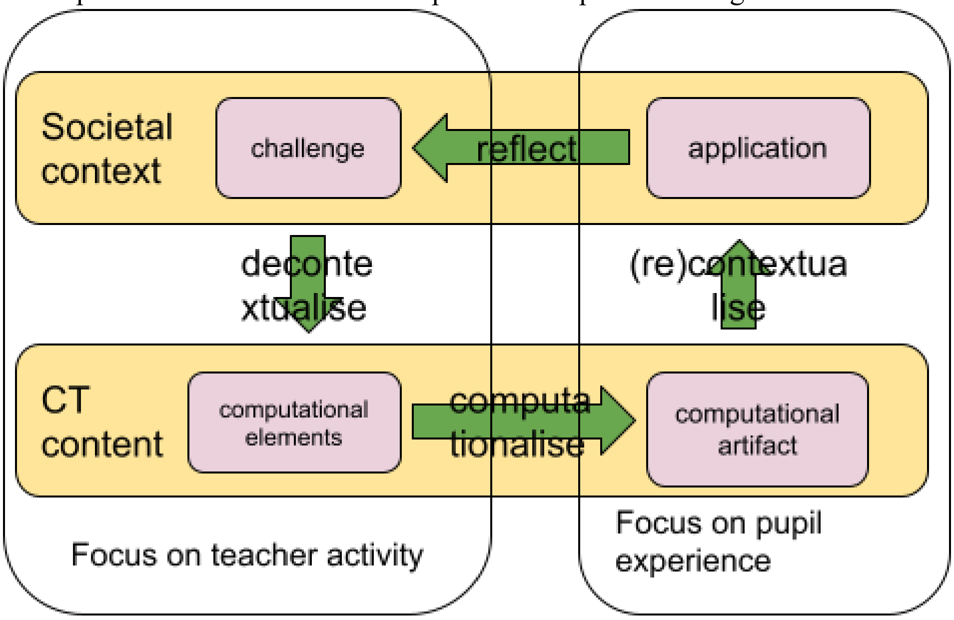


Figure 4. The pedagogical model for the Module

Homework

Prior to Activity 3: Review CS unplugged and Bebras resources to become familiar with the content and reflect on how these can illustrate CT conceptual areas. (See the links in the learning resources)

Prior to Activity 3: Identify one activity to transform into a challenge or project based classroom experience for pupils. Develop a worksheet for that activity based on the example exercise included in the Module.

Unit 4 Learning resources

Module materials - Bebras challenge worksheet and worksheet template

Web resources - Bebras cards in English http://www.bebras.uk/junior-school-cards.html

Web resources - CS Unplugged website and resources, teacher information and teacher guides. https://www.csunplugged.org/en/

Video - introduction to the Unplugged approach https://www.youtube.com/watch?v=6iPfSIxrP18

Reading

Erik Barendsen, Linda Mannila, Barbara Demo, Nataša Grgurina, Cruz Izu, Claudio Mirolo, Sue Sentance, Amber Settle, and Gabrielė Stupurienė. 2015. Concepts in K-9 Computer Science Education. In Proceedings of the 2015 ITiCSE on Working Group Reports (ITICSE-WGR '15). Association for Computing Machinery, New York, NY, USA, 85–116. DOI:https://doi.org/10.1145/2858796.2858800

Cruz IZU, Claudio MIROLO, Amber SETTLE Linda MANNILA, Gabrielė STUPURIENĖ, Exploring Bebras Tasks Content and Performance: A Multinational Study, Informatics in Education, 2017, Vol. 16, No. 1, 39–59, https://files.eric.ed.gov/fulltext/EJ1140704.pdf

Linda Mannila, Valentina Dagiene, Barbara Demo, Natasa Grgurina, Claudio Mirolo, Lennart Rolandsson, and Amber Settle. 2014. Computational Thinking in K-9 Education. In Proceedings of the Working Group Reports of the 2014 on Innovation & Technology in Computer Science Education Conference (ITiCSE-WGR '14). Association for Computing Machinery, New York, NY, USA, 1–29. DOI:https://doi.org/10.1145/2713609.2713610

UNIT 5: Practical Applications

Estimated time investment (3hrs)

Activity 5.1 - CT Activity in a Classroom

Practical teaching activity - Participants implement a challenge based CT exercise that was developed in Activity 3.2 in their teaching practice, or in a test environment. An example of a relevant environment might be a centre for STEM outreach (e.g. www.vetenskapenshus.se), a non-formal learning group (such as code-dojos, e.g.)

Activity 5.2 - CT Activity in a Classroom

Seminar - presentations of the activities conducted in 4.1 and reflections on student engagement with CT concepts, skills and competencies.

Activity 5.3 - CT Revising the Challenge

Pairwise collaboration - Participants work in pairs to revise their activities based on observations and reflections from the classroom experience. The method builds on the model used in Activity 2.2 in which a challenge is analysed and computational artefacts developed. In this final activity the participants refine the use of Figure 1 processes for analysis of challenges and formulation of computational thinking learning activities. After testing in classrooms this final stage works on refining the computational learning artefacts in order to focus the attention of pupils on the desired CT learning outcomes.

The final exercises are collected on a web-site for the Module and contribute to building an open source repository of challenges and associated worksheets.

Unit 5: Learning resources

No additional learning resources are required for this Unit of the Module.

UNIT 6: Challenge based pedagogy

Estimated time investment (4 hrs 15 minutes)

Activity 6.1 - Fundamentals of Assessment Practices

45 Presentation - Participants are introduced to some key aspects of assessment research, and also provided with references to a number of important books on STEM assessment practice. See the learning resources for the Unit (currently incomplete prior to review).

Activity 6.2 - Assessing CT Competence

30 Background preparation and reading on assessment practices, constructive alignment and student-centric assessment and feed-forward approaches.

60 1 Assignment - Participants develop an assessment approach to assess learning outcomes mapped to the activity the participant developed in Activity 3.2 and competency mapping derived from Activity 4.2 and 4.3.

60 1 Poster development - The poster should present the assessment approach and provide clear motivation and also explain the links to assessment research underpinning the design.

Activity 6.3 - Assessment Workshop

60 Participants present and discuss assessment schemes and design ideas

Unit 6: Learning resources

Presentations

Assessing the Intended Object of Learning - theory presentation on assessment practices (Assessing Learning Presentation (google_presentation)) - Arnold Pears

Reading

Black, P., Wiliam, D. Developing the theory of formative assessment. Educ Asse Eval Acc 21, 5 (2009). https://doi.org/10.1007/s11092-008-9068-5

Module Level Resources

Granularity

This module is primarily focused on teacher educators and future teachers. Classroom activities are designed to assist individual teachers in their practice.

Assessment requirements and assessment strategy

Assessment template for use in Unit 6.

Assessment task should measure and provide evidence about the achievement of learning outcomes of the challenge	**Assessment criteria and method** Connection to CT knowledge, skills and competencies and how these might be performed and evaluated.
1.	
2.	
3.	

Module References

Black, P., Wiliam, D. Developing the theory of formative assessment. Educ Asse Eval Acc 21, 5 (2009). https://doi.org/10.1007/s11092-008-9068-5

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York, NY: Basic Books.

Pears, A., Dagiene, V., and Jasute, E. (2017). Baltic and Nordic K-12 Teacher Perspectives on Computational Thinking and Computing. In International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, Springer, Cham, 141–152.

Smith, M. (2016). Computer science for all. Washington, DC: Office of Science and Technology Policy, Executive Office of the President. Retrieved from https://www.whitehouse.gov/blog/2016/01/30/computer-science-all

Mannila, L., Nordén, L.-Åke, & Pears, A. (2018). Digital Competence, Teacher Self-Efficacy and Training Needs. In Proceedings of the 2018 ACM Conference on International Computing Education Research (pp. 78–85). ACM.

Mannila, L., Dagiene, V., Demo, B., Grgurina, N., Mirolo, C., Rolandsson, L., and Settle, A. (2014). Computational Thinking in K-9 Education. In Proceedings of the Working Group Reports of the 2014 on Innovation & Technology in Computer Science Education Conference (ITiCSE-WGR '14). Association for Computing Machinery, New York, NY, USA, 1–29. DOI:https://doi.org/10.1145/2713609.2713610

Additional resources

Bebras Cards, link to web resources in all available languages

Appendix 1: Material for students - future teachers

Worksheet template - worksheet template