Module O4

(v1 - Release 1)

CT for primary education prospective teachers:
specific features, approaches and practical solutions

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General overview and aim

AIM

This module aims at integrating conceptual development with specific practical elements in education of prospective primary school teachers. Therefore, we will draw on the idea of students in designing and testing approaches for CT in primary school classrooms taking into account constructive teaching-learning theories, as a research and experience-based activity, as well as a detailed reflection of the planning and implementation using the example of robots.

Target group and prerequisites

Pedagogical design / Target group

The module is designed for up to 25 primary education prospective teachers (hereafter referred to as 'students'). There are no prerequisites, but basic didactic knowledge is required from the participants, as they should plan their own actions with children. This workshop can also be used for further education of teachers in service. Since many of the texts are written in English, medium language skills are required, if the texts are not translated in the national language.

Keywords

Related competence frameworks
Mapping to DigiCompEdu and teacher's professional competence standard
Prospective primary education teachers
Computational Thinking
Robotics
Research and experience-based activity

Learning Outcomes

It is pointed out, that primary school teachers need to learn about CT as approach in itself, about the computing discipline and educational roles and goals of computing at school to take advantage from the benefits CT offers for classes (Schulte and Budde 2018; Bell and Duncan 2018; Magenheim et al. 2018). Therefore, we aim at learning outcomes in the following three areas:

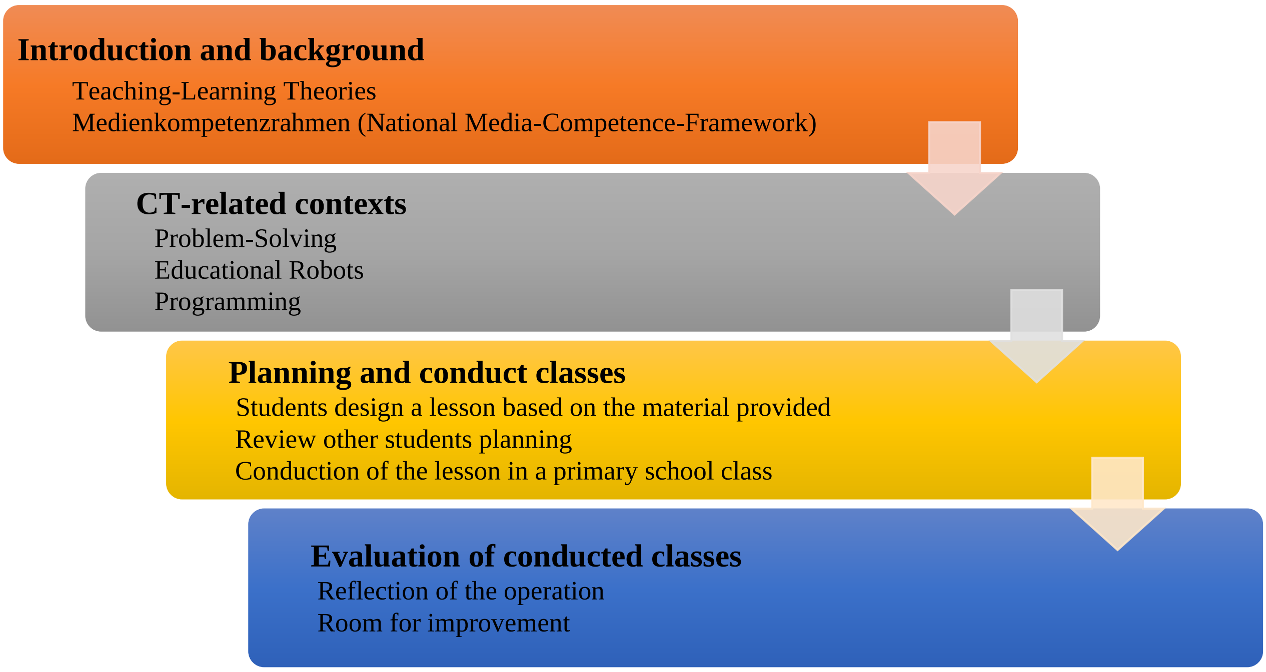
- Conceptual competences
    - The students understand the concept CT, its connection to learning goals and curricula in topics and subjects for primary school.
    - The students know several opportunities and limitations of CT.
- Pedagogical competences
    - The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
    - The students become empowered for a professional and didactic reflection of conducted classes.

- The students are enabled to tie in with previous experience of the pupils by reflecting their own experience.
- The students are aware of the importance of activation of prior knowledge regarding constructivist teaching-learning theories and CT to develop the pupils knowledge using conceptual change.

● Self-efficacy and motivational competences
  - The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Module plan and didactical approaches

This module includes 13 sessions of 90 minutes each. It is recommended to plan a 14th session as a backup if some discussions take more time than stated in the plan.



Session 1: Introduction and pre-test

● Introduction in Computational Thinking and Educational Robots (ER) with political and pedagogical views

Session 2: Problem solving in the digital world

● Overview of current approaches to implement digital education in primary schools

Session 3: Computational Thinking

● Discuss this text: Marquardt & Autenrieth: Neue Formen des digitalen Lernens (new forms of digital learning)

- Discuss this text: Barendsen & Bruggink: Het volle potentieel van de computer leren benutten (Learning to use the full potential of the computer)
- Transform illustrated instructions (KVICK SÖRT) into written instructions

Session 4: Reflection of previous tasks

- Discuss approaches to transform the KVICK SÖRT illustration
- Computer as a problem solver vs. computer as a helper to solve problems, super bug, human-machine interaction
- Different levels to formulate instructions (for humans – pseudo code – code for machines)

Session 5: Introduction to Educational Robots

- View introductory homepage and play the game "LightBot"
  Discuss the concepts "Computational Thinking" and "programming" in the example "Lightbot"

Session 6: Aspects of Educational Robots

- Getting to know different Educational Robots (BlueBot/ BeeBot, Roberta (Ronjas Roboter) or Ozobot)
- Analyze the learning opportunities of the Educational Robots with given aspects (Adamina/ Hild 2019)

Session 7: Reflection of previous tasks

- different perspectives on the term "programming"
- 5 categories of programming (Thune/ Eckerdal 2009)
- Programming & Computational Thinking
- Personal experiences of the students with Educational Robots

Session 8: Role of the architecture of robots

- Problem solving with deeper focus on technical aspects
- Inform about the future task: develop, review and test lessons for primary school children with Educational Robots

Session 9-11: planning lessons with Educational Robots

- Students develop lesson plans with Educational Robots
- Students review lesson plans from other students
- Students test their plans with small groups of children

Session 12: Analyze developed lessons based on theoretical aspects

- Political/ pedagogical view
- Problem solving circle with focus on technical aspects
- Problem solving with focus on CT models
- Differences & similarities between "programming" and "Computational Thinking"
- Architecture of Educational Robots

Session 13: Reflection and closure of the seminar

- Reflection of developed lesson plans with previous named aspects
- Reflection of the seminar

Units and activities

Due to Covid-19 there were several changes in the original planning. The biggest constrain was that no face-to-face lessons were possible, so the module was changed to a fully digital format, where video-conferences are used to discuss several topics with the prospective teachers and asynchronous lectures, where the prospective teachers had to solve different tasks based on literature. The digital format sessions are described below.

The different parts in each session are categorized in:

- Discussion (students discuss different aspects; lecturer moderates the discussion)
- Input (lecturer shows slides and explains different aspects)
- Presentation (students present their work)
- Task (students work -mostly self-organized- on given exercises)

A time is given for each part, which is roughly needed for the phase. The actual time needed for the phase depends on the students and their discussion behavior.

Sessions are held either synchronously in a video conference meeting or asynchronously, where tasks are provided to the students. In asynchronous sessions the students can decide, where or when they work on the task during the week. They submit their work before the next session starts.
The sessions are organized by a learning management system (moodle platform, where slides and tasks are provided. In addition, the moodle platform can be used to communicate with students via the message function and students can upload their submissions there. In some sessions so called “etherpads” are used. These are plain white documents integrated in the moodle platform, which every student can view and edit. Here the results, questions and ideas of all students can be collected.

Figure 1: moodle platform used for the seminar

TeaEdu4CT
Session 1 (asynchronous)

Main idea of this session:
This session should give a first insight into the topic “teaching for the digital world” based on the students’ knowledge. The topics are already familiar to the students from previous seminars. The students activate their previous knowledge with the jigsaw technique.

This session contributes to the achievement of the following learning outcomes:

- The students are enabled to tie in with previous experience of the pupils by reflecting their own experience.
- The students are aware of the importance of activation of prior knowledge regarding constructivist teaching-learning theories and CT to develop the pupils knowledge using conceptual change.

Input: Organization and Structure (20 min)
At the beginning, the students receive a brief overview about the structure and organizational aspects of the module. Additionally, the students fill in a questionnaire about their interests and personal experiences with robots and programming. The students can ask questions by writing them in the etherpad in the moodle platform. The lecturer answers there directly in the etherpad.

Student arrangement: students work alone

Task: Introduction in different topics related to Computational Thinking (expert groups) (45 + 20 min)
This task is planned in the jigsaw teaching technique (students work on a topic in an expert group and later present their topic in a newly formed core group). The students are divided in five expert groups. Each expert group has a different topic to work on:

1. Research for a first definition of Computational Thinking
2. Digital aspects in primary education (media-competence-framework of the state Northrhine-Westfalia)
3. Digital aspects in primary education (national framework for science in primary education)
4. Personal concept of robots
5. Literature review about learning processes, especially “conceptual change”

Each group member uploads his own submission for the task to the moodle platform. Each student can view the submissions of the other expert group members.

Student arrangement: students work alone, but can communicate within their expert group

As a second task the students read and comment on the submissions of the other expert group members. This approach allows exchanges to take place within the expert group such that the group members are experts in their topic.

Student arrangement: students work alone, but can communicate within their expert group

Session 2 (video conference meeting)

Main idea of this session:
The students' previous knowledge is discussed in five aspects, so that it can be built upon in the further course of the seminar. The discussion will be supplemented by new information on theory and practice from the field of computer science education in primary schools to provide a basis for the discussion of Computational Thinking.

This session contributes to the achievement of the following learning outcomes:

- The students are enabled to tie in with previous experience of the pupils by reflecting their own experience.
- The students are aware of the importance of activation of prior knowledge regarding constructivist teaching-learning theories and CT to develop the pupils knowledge using conceptual change.

Task: Introduction in different topics related to Computational Thinking (core groups) (10 min)
This session starts with the second iteration of the jigsaw puzzle. New groups (so called “core groups”) are formed such that each topic is represented by an expert from session 1. To inform the other core group members about their topic in a short way each student writes a headline with the most important aspects of their topic in a shared channel of their moodle platform.

Student arrangement: students work in their core groups

Discussion: Introduction in different topics related to Computational Thinking (20 min)
The headlines of the different core groups are presented in the video conference tool and are discussed by the whole group.

Student arrangement: in the whole study group

Input: Computer science in primary education (30 min)
The students see an advertising video of the “BlueBot” as an introduction to how you can implement educational robots in primary education. Afterwards the students are given an overview of current approaches to implement digital education in primary schools via presentation.

Student arrangement: in the whole study group

Homework for next Session: Introduction into CT (20 min)
Read given literature about digital media in prospective teacher education (Marquardt/Autenrieth 2019[1]).

Student arrangement: students work alone

Session 3 (asynchronous)

Main idea of this session:
Various concepts of "Computational Thinking" are covered by literature and deepened by further tasks. In these tasks the concepts should be presented in the students’ own words in order to understand the background in detail. In addition, the concepts will be compared and classified in order to identify their relevance.

This session contributes to the achievement of the following learning outcomes:

- The students understand the concept CT, its connection to learning goals and curricula in topics and subjects for primary school.

Task: How to describe an algorithm using KVICK SÖRT (30 min)
The students already read literature as homework. To intensify their understanding of the literature the students are asked to work through the illustration “KVICK SÖRT” which is used in the literature to explain the term “Computational Thinking”. The illustration shows pictorial instructions on how to sort items with the quick sort algorithm. The students are asked to formulate the instructions in their own words.

[1] This text gives general information about Computational Thinking and refers to the Definition by ISTE: https://cdn.iste.org/www-root/ct-documents/computational-thinking-operational-definition-flyer.pdf It is not necessary to use this text and it can be replaced by many others, but the graphic (see Figure 2) is necessary for the tasks.

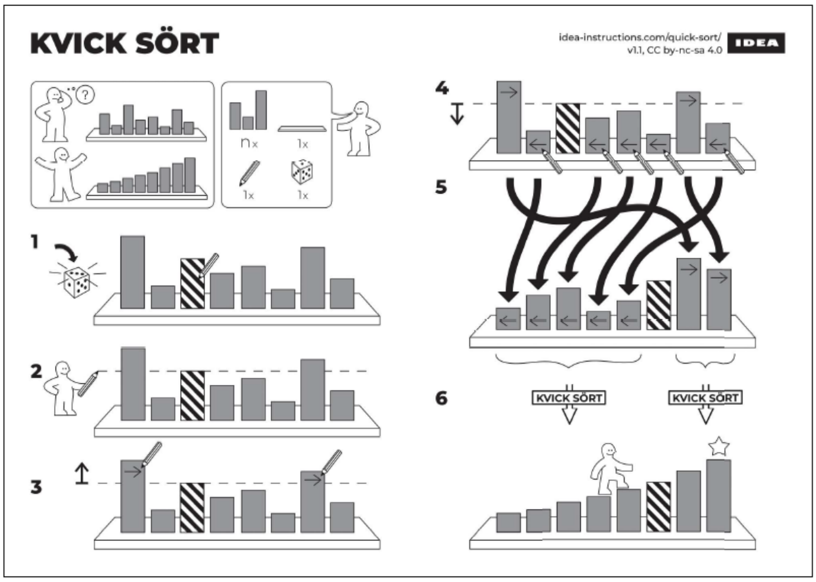


Figure 2: pictorial instruction KVICK SÖRT

Afterwards, the students are asked to decide, which instruction (pictorial or written) is easier to understand. In this exercise the students think about the importance of language and the difficulty of formulating clear instructions.
In a third task the students evaluate their process of the previous tasks and connect their work with the aspects of Computational Thinking given in the literature. They have to submit their written work on the tasks a week later in the moodle platform.

Student arrangement: students work alone or in groups up to three members

Task: Work with new literature about CT (30+20 min)
The students are then asked to read another literature (Barendsen/ Bruggink 2020) to deepen their understanding about Computational Thinking. The core of this literature is an illustration which shows the problem-solving process performed in Computational Thinking.

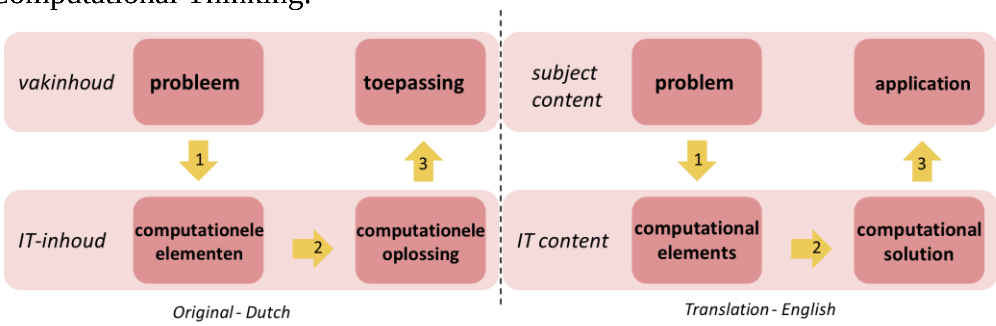


Figure 3: problem.solving model Barendsen/Bruggink

The students are asked to formulate this process in their own words as a first exercise. They are forced to think about the problem-solving process from Barendsen/Bruggink. Possible questions from the students about this theory

become apparent at an early stage while they are formulating the theory in their own words.
After this preliminary work, the students can combine both CT definitions given in the literature from this session by comparing this illustration with aspects of CT mentioned in the literature the students read as homework.
They have to submit their written work on the tasks a week later in the moodle platform.

Student arrangement: students work alone or in groups up to three members

Session 4 (video conference meeting)

Main idea of this session:
The previous activities with the definitions of Computational Thinking will be discussed together in the whole group in order to come to an equal learning level. The discussion of different aspects of Computational Thinking can lead to an extensive exchange on different perspectives on Computational Thinking. Small input units can individually counteract misconceptions that occurred in the submissions from the last session.

This session contributes to the achievement of the following learning outcomes:

- The students understand the concept *CT*, its connection to learning goals and curricula in topics and subjects for primary school.
- The students know several opportunities and limitations of CT.

Discussion: Recap of the written instructions from “KVICK SÖRT” (20 min)
After a general request for students questions the lecturer starts the session with showing the illustration “KVICK SÖRT” to activate the students’ memories about their submitted task about the written instructions. One student explains the sorting process to the other students and the lecturer points out the difficulty about the recursion in the algorithm, which is also marked red in the slides. After this technical clarification on how the quick sort works the lecturer proceeds with more methodical questions. The students are asked to tell the whole group how their working process worked out while working on the written instructions and which difficulties occurred.

Student arrangement: in the whole study group

Discussion: Recap of the Computational Thinking definitions (10 min)
The students can now transfer their own problem-solving process from the previous discussion into the two definitions from the literature given in the last session. The students are asked to describe the definitions for the whole group, and

they classify their problem solving with the KVICK SÖRT instructions into the CT definitions. The lecturer gives room for open questions.

Student arrangement: in the whole study group

Input: The super bug (10 min)
Especially in the submitted task about the CT illustration from Barendsen/Bruggink the students showed a misconception about how "intelligent" the computer as an "independent problem solver" is. It seems like some students think that you only must "speak the same language as the computer" so that you can tell the computer properly what your problem is, and the computer solves it for you. This input should point out and resolve these misconceptions.
A slide with two different statements is shown to the students:

- One shows the misconception mentioned above: The computer solves the problem for you
- The other statement describes the CT process how it is meant: The computer is used as a supporter in the humans' problem-solving process. The students name the different conceptions behind these two statements.

Afterwards this misconception is explained from a theoretical point of view with an input slide about the "super bug" (Pea, 1986).

Student arrangement: in the whole study group

Discussion: Extend the Computational Thinking model (10 min)
In the previous discussions the students became familiar with the CT model from Barendsen/Bruggink and possible misconceptions are cleared up. This groundwork can be used to extend this illustration to make it a closed-up problem-solving circle like the students know it from their science/ technical problem-solving circles and add another arrow between the application and the problem. On the one hand you need to reflect, if the solution really does solve the former problem and you eventually need a better solution. On the other hand, maybe new problems occur with the given solution, so a new turn of the problem-solving process may be needed.
To direct the discussion, several questions about the process may be asked. It is recommended to take an example and try to match the steps that are required to create a solution with the aspects of the problem-solving model. It is – for example – possible, to talk about writing a homework assignment using word. After (or even while) the program has been used to create the text, there will be several additional passes of the circle, because you have to fix mistakes likes typos or change the presentation of important parts, format quotes, check borders and footnotes and so on.

Student arrangement: in the whole study group

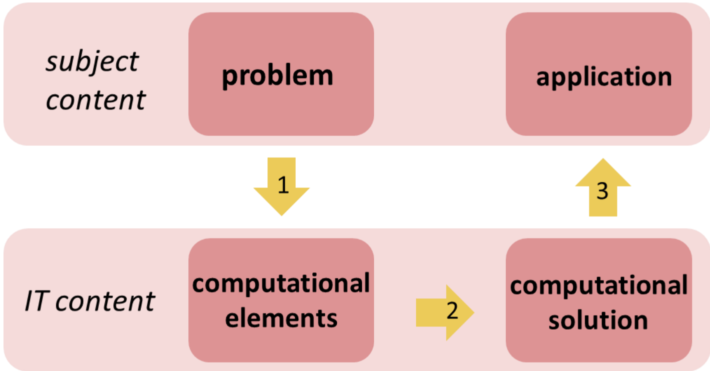


Figure 4: problem-solving model Barendsen/Bruggink (English Translation)

Activity and Discussion: Two different views about CT (humans and computers as computational agents?) (20 min)

The students are asked to rate given statements in the voting tool "PINGO" [2]. The statements are based on the model of Curzon et al. about what Computational Thinking should be.

Example: *Rate the following Statements. Which side do you rather agree with?*

1 Humans and Computers can be computational agents
2
3
4
5 Humans are not computational agents

The voting tool can be used from the students via smartphone and the results are shown in a graph automatically:

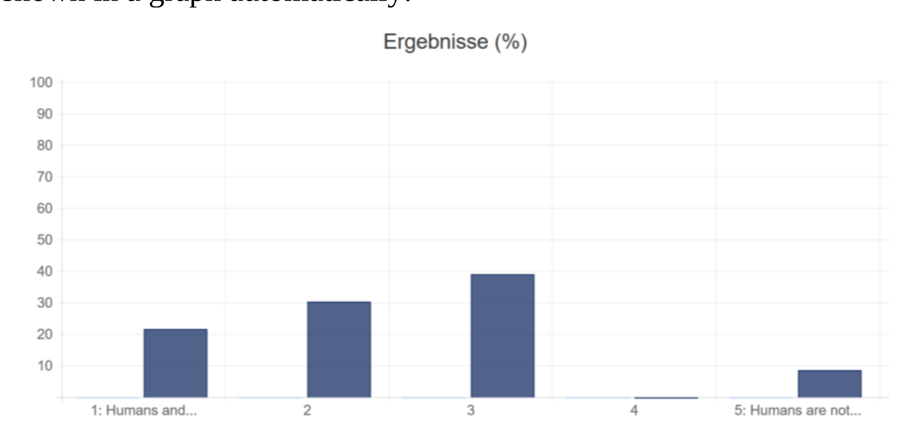


Figure 5: students voting results

This activity can be used as a groundwork for deeper discussions about what Computational Thinking is, and what it is not.

Student arrangement: alone (voting activity) and afterwards in the whole study group (discussion)

[2] https://pingo.coactum.de/ - It is not necessary to use this tool – every other survey tool you have access to and presents the results in a graphical way is possible

Input: The use of language in instructions (10 min)
The last part of this session ties up with the written KVICK SÖRT instructions from the students again. The previous parts considered the KVICK SÖRT instruction task from the CT perspective. While reading the tasks it was noticed that different levels of language were used to describe the algorithm properly as shown in the table below. Reasons, conclusions and further explanations are given within the instructions when they are formulated for a human reader. Computers do not need this kind of instructions. The lecturer presents the different use of language in instructions depending on the recipient of the instructions in a slide. Instruction manuals are somehow of both kinds. On the one hand they focus the procedure, but there may be also reasons explained.

Relationship between description type and recipient

		Human (e.g. conversation)	Formal (instruction manual)	Code (e.g. computer)
Description	Procedure (what and how)	Contains both	Contains both, but focusses the procedure	Contains only description of procedure
Explanation	Reasons (why)			Just in comments – not necessary at all

Student arrangement: in the whole study group

Session 5 (asynchronous)

Main idea of this session:
This seminar is designed to introduce students to teaching with Educational Robots and Computational Thinking. Therefore, the conceptual and technical foundations must now be laid since knowledge about robots and programming is necessary to plan lessons with them. This knowledge can be built up by experimenting and then reflecting on actions with robots. In this session, the learning process of the students is supported using an informative homepage, so that they are aware of this type of information gathering, as it is common in the field of teaching about the digital world.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Technical information

Students can try out robots themselves in this session. They use the App "LightBot", because everyone can access this robot easily at home via Smartphone or computer. The task is to control the Lightbot in different virtual environments and to light it up at defined points. The Lighbot can be programmed by putting programming-blocks together. After the player passes the first levels with linear programming the tasks are getting harder and the player has to define specific procedures and loops. The App can be played for free: https://lightbot.com/hour-of-code.html

Task: Review a homepage with teaching examples (45 min)
The students are asked to visit a homepage about a teaching example with the App "LightBot". Which LightBot-related side is used to perform this task isn't important, (even the LightBot site itself can be used: https://lightbot.com/resources.html), because the students should critically and constructively deal with this exemplary homepage in order to practice a reflective approach to the numerous offers on the Internet for computer science-related lessons. On the one hand the students get to know the "LightBot" and lessons with educational robots by reading the information on the website. On the other hand they submit a review by rating the website and the worksheet given on the website.

Student arrangement: students work alone

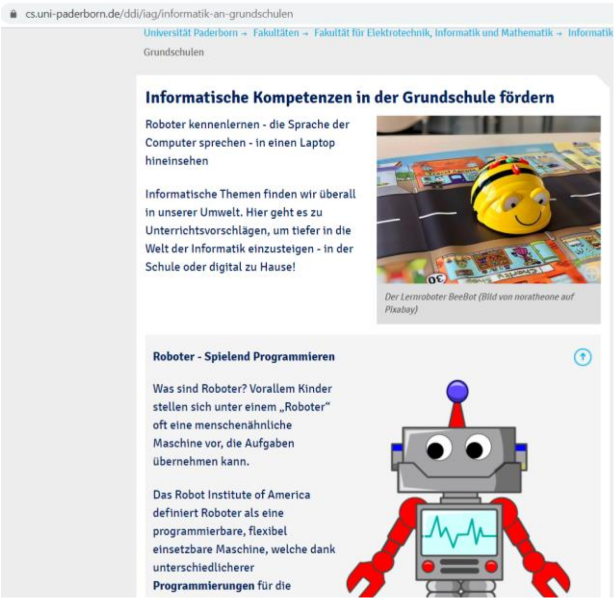
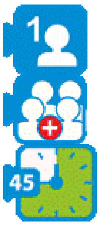


Figure 6: example of the homepage the students are visiting



Task: First steps in programming – getting to know the “LightBot” (45 min)

The second task consists of five exercises. Most of the students are not experienced in programming. Therefore, they need to gain experience in programming robots like playing the App “LightBot” before they continue to think about planning lessons with programming.

After the students tried out the “LightBot”, they submit (in groups up to 3 members) their answers to the following questions and exercises:

1. Rate the difficulty of the “LightBot”.
2. Can the “LightBot” be used in self-planned learning for grade 3 or 4 pupils?
3. Analyze the exercise structure on the worksheet given on the website.
4. Which CT related concepts can you find in the App?
5. Describe in your own words what “Programming” is.

Student arrangement: students work alone (playing the app “LightBot”) and in groups up to three members (answer questions about “LightBot”)

TeaEdu4CT
Session 6 (asynchronous)

Main idea of this session:
In this session, students try out educational robots themselves to find out how they work, the problems, advantages and disadvantages. This experience helps students to better assess the extent to which the robots can be used in class.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school

Technical information

After the students get to know the digital robot in session 5 they get in this session the opportunity to use a “real” robot. According to their own interests, students can choose between the BlueBot/BeeBot and the Ozobot. They can borrow the robots from the university to get some practical experiences. Those students who cannot come to the campus to borrow a robot can use another digital robot (“Roberta”). If there are other digital robots in your country, you can use them as well.

The *BeeBot/BlueBot* are easy to understand robots who can be programmed with buttons on their back. The buttons are labeled with arrows. After a command sequence is entered via these buttons, the robot moves in the corresponding directions. This robot is suitable for primary school aged children. The students can explore the robot themselves to get an idea of using it in a primary school lesson. It is possible to add a programming-bar which sends planned programs to the robot (see Figure 7).[3]

Figure 7: BlueBot and programming-bar (picture from GenerationRobots 2020)

The *OzoBot* is a small robot with light sensors on the bottom. The robot can follow black lines. It can be controlled by color-codes on the black line. With these codes, the OzoBot is programmed to go faster, slowly, turn right at the next turnoff, etc. It can also be programmed

[3] Further information: https://www.betzold.de/prod/E_755769/

via a block-based programming language on the computer or tablet. It is possible to use this robot for primary-school-aged children, but the whole complexity of the robot can just be experienced by older children.[4]

Figure 8: lines with colour codes (left) and ozobot with programming environment (right) (picture from Ozobot & Evollve, Inc. United States 2020)

The LightBot is a digital robot whose aim is to turn on lights in a maze. In different levels of increasing difficulty the robot is programmed by the player by arranging icons for different actions, like walking, turning, jumping or switching a light on.[5]

Roberta is another digital robot who can be played on a German website. The robot needs help with reaching the glass house. In different levels the robot must be programmed by showing it the right way via buttons labeled with arrows.[6]

Other digital robots can be used as well, for example the little games at http://www.kidlocoding.com/.

Figure 9: digital robot "Roberta" (Picture from: Stiftung Haus der kleinen Forscher 2019)

Task: Getting to know other educational robots (45+45 min)
The students familiarize themselves with their robot. They can choose between analogue robots (BlueBot/BeeBot, Ozobot) and a digital robot (Ronia's Robot-Roberta). They should also consult other literature or instructions for their robot and collect them in a shared literature list.

[4] Further information: https://ozobot.com/

[5] Further information: https://lightbot.com/

[6] Further information: https://www.meine-forscherwelt.de/spiel/ronjas-roboter

Student arrangement: students work alone

In order to be able to analyze the robot after getting to know it, the students will use analysis aspects from Adamina/Hild 2019. Afterwards pro/contra arguments of their educational robot will be collected in an etherpad in the moodle platform. Finally, a conclusion is drawn by indicating the essential learning statements in another etherpad. The tasks should be worked on individually.

Student arrangement: students work alone

Session 7 (video conference meeting)

Main idea of this session:
After the students themselves have gained practical knowledge about robots and programming in the last sessions, the different experiences are collected in the whole group. Here questions can be clarified, and misconceptions can be discussed. The students' own experiences and reflections are substantiated by theoretical models in order to dovetail theory and practice. Furthermore, the topic is again linked to Computational Thinking.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.
- The students understand the concept CT, its connection to learning goals and curricula in topics and subjects for primary school.

Discussion: What "Programming" means (20 min)
The session starts with a fictitious argument, which is intended to illustrate two different views on programming. One point of view is very narrow and defines programming as the use of a programming language, which is reserved for "insiders". The other point of view considers programming more broadly than giving commands, which can be started with simple learning/educational robots. These two views result from the students' statements on the topic of programming in Session 5 question 5, where some of them defined "playing the robot game" as programming, while others did not. The students discuss the term once again with the help of the fictitious argument.

Student arrangement: in the whole study group

Input: categories of Programming (Thuné, Eckerdal) (10 min)

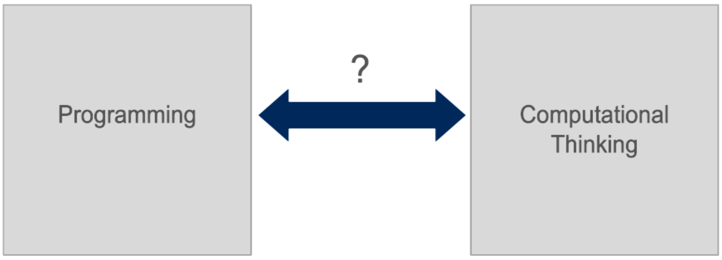
The previous discussion is rounded off with a definition of several levels of the programming term given in Figure 10.

Student arrangement: in the whole study group

1. Computer programming is experienced as to use some programming language for writing program texts
2. Computer programming is seen a way of thinking that relates instructions in the programming language to what will happen when the program is executed
3. Computer programming is seen as a way of thinking, as above, and in addition computer programming is experienced as producing computer programs such as those that appear in everyday life
4. Computer programming is seen as described above with the addition that computer programming is experienced as a 'method' of reasoning that enables problem solving
5. Computer programming is seen as a way of thinking, to solver problems, leading to the production of computer programs such as those that appear in everyday life. In addition, computer programming is experienced as a skill that can be used outside the programming course, and for other purposes than computer programming

Figure 10: Summary of categories of description of students' qualitatively different ways of experiencing computer programming (Thuné, Eckerdal)

Discussion: Programming and Computational Thinking (10 min)
The connection between programming and Computational Thinking can be justified from different directions. Moreover, some concepts are very similar. The students discuss the connection between programming and CT with this illustration:



Student arrangement: in the whole study group

Presentation: Introducing the robots (45 min)
The students report in the plenum about their experiences with the robot they have tried out. The reports may be based on the following questions:

- What do you like most?
- What do you like least?
- Was it difficult to manage the robot following your instructions?
- How did you feel when you saw that the robot followed your instructions?
- What problems occurred?
- Can you imagine to use the robot in class?

Student arrangement: in the whole study group

Session 8 (video conference meeting)

Main idea of this session:

This session concludes the first block of the seminar on the acquisition of technical basics about CT and robots. After having already made experiences with the use of robots, the components of the robots are now explicitly discussed. On the one hand this knowledge can help to solve problems with robots in class, on the other hand components of robots can be part of the lessons for primary school. In addition, the further procedure for planning the lessons is made transparent in this session.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Input: Video - The football playing robot (10 min)

At the beginning, students are shown a video about a humanoid robot that can play football. This example allows a closer look at the components of robots. It needs motors to move its legs and a control unit. The students should list components that robots need to function properly. They can refer to the robot in the video or generalize it. It is not necessary to use the German video about the football playing robot, other videos in the language of your choice can be used as well, as long as the components are visible and a discussion about their function is possible. Some (english-based) alternatives are given in the chapter granularity.

Student arrangement: in the whole study group

Discussion: Architecture of educational robots (20 min)

In this session, the components of the robots presented in “Session 7” will now be examined more closely. The sensor of the OzoBot is interesting from a technical point of view, because its color sensors give information about the roadway, so the robot can drive along the line. The components of digital robots like LightBot, on the other hand, are difficult to name, because only a computer and software/app is needed to display the robot and see its "movements".

Student arrangement: in the whole study group

Discussion: Architecture of educational robots and CT (10 min)

The theming of components can then be linked to CT in an open question: *Why should the components of the robot be thematized in CT-oriented lessons?* On the one hand, the problem-solving process can be initiated by identifying the components required for a desired function of the robot. On the other hand, any problems that arise with the robot can only be solved by using the knowledge of the architecture. In addition, knowledge of the robot's architecture leads to a high acceptance of why the robot does something "different" than expected.

Student arrangement: in the whole study group

Input: Problem-solving circles as an introduction to plan a lesson (20 min)
Two models are presented that structure the handling and teaching of technical/digital equipment such as robots.

Computer Science didactic approach (PRIMM Sentance/Waite/Kallia 2019): Structure the lesson in five elements: Predict – Run – Investigate – Modify – Make

Technology didactic approach:

Figure 11: Problem-solving cycle by "Haus der kleinen Forscher (https://www.haus-der-kleinen-forscher.de/)" and our English translation

Student arrangement: in the whole study group

Input: Organize the upcoming sessions – plan lessons with educational robots (30 min)
The organizational framework for planning lessons with robots in the next sessions is shown in a presentation. In groups (up to 3 members) the lesson plans of 2-3 teaching hours should be recorded in a table. One of the phases in a lesson should

be described in detail. Afterwards a feedback from other groups and a partial testing should take place.

Student arrangement: in the whole study group

TeaEdu4CT
Session 9 (asynchronous)

Main idea of this session:
Analogous to trying out the robots themselves, it is also important for the students to carry out the planning of lessons practically themselves. Building on the knowledge gained in previous sessions and accompanied by online resources, students can realize their ideas for teaching with educational robots and CT.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Task: Plan lessons for primary education (45+45 min)
The groups organize their work themselves and together they create a tabular sequence of lessons with robots. They should use at least one robot that they have tried out in previous sessions. The students are supported by a collection of links with teaching ideas. They can access the collection of links in the moodle platform.

Student arrangement: students work in groups up to three members

After the lessons have been roughly planned, one phase of them will be examined in more detail. The following points should be described:

- How are tasks and questions/statements/impulses precisely formulated?
- What should the children exactly perform and how do you expect them to perform it?
- What are expected student responses?
- What technical problems can occur? (Alternatives for action?)

The groups submit their edits to the moodle platform.

Student arrangement: students work in groups up to three members

TeaEdu4CT
Session 10 (asynchronous)

Main idea of this session:

The framework for creating lessons was broad and therefore different groups took different approaches to integrate the topic "Educational Robots" and "Computational Thinking" into a lesson plan. By reading other plans, the students get further inspiration for teaching and can expand their repertoire. By explicitly reviewing another lesson plan they learn to reflect on lessons.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students become empowered for a professional and didactic reflection of conducted classes.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Task: Review lessons (45+30 min)

Each student reads the work of another group and writes feedback on it. The following points can be addressed:

- Which ideas are particularly motivating/ successful?
- Imagine that you still have to plan Computational Thinking classes for tomorrow. Which of the ideas would you adopt immediately?
- Which aspects of the planning stand out (negative/ positive)?
- Are the content and timing appropriate? Are there specific phases in which you would plan more or less time?

The students submit their reviews a week later in the moodle platform.

Student arrangement: students work alone

Afterwards, students can read the feedback on their lesson plans and further reflect on their own planning. They also get feedback from a tutor.

Student arrangement: students work alone

TeaEdu4CT
Session 11 (asynchronous)

Main idea of this session:
Teachers must not only plan lessons, but also carry them out. In addition to the feedback the students already received from other students in the review, the groups can get direct feedback from the practice by testing the lesson plans with children. This allows them to reflect on their teaching ideas on a different level and generate knowledge about teaching with educational robots, which can be helpful later as a teacher.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for effective design, development and implementation of approaches and tools for integrating CT into the classroom.
- The students become empowered for a professional and didactic reflection of conducted classes.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Task: Try out planned lessons (45+20 min)
Originally, each group had to try out parts of their planning in a primary school that cooperates with the university. However, due to Covid-19, the schools were closed. So, the groups had to look for a suitable test group. This could be children from relatives, the neighborhood or other childcare facilities. However, if contact with children was not possible, the students could also fall back on a test group with adults to gain practical experience.

Student arrangement: students work alone or in groups up to three members

In group work, the students give a short report about their test and upload the report to the moodle platform.

Student arrangement: students work in groups (with the same group with which they have planned the lessons before)

Session 12 (asynchronous)

Main idea of this session:

After the participants of the seminar have been working in groups for several weeks, this session is intended to prepare the meeting of all students of the seminar to discuss their experiences together. In order to avoid that each group presents its planning in a linear and tedious way, the students should decide in this session which of five given perspectives is particularly important in their lesson planning. This way, the students reflect from different perspectives and, by dealing with the perspectives, repeat the main aspects of the seminar.

This session contributes to the achievement of the following learning outcomes:

- The students become empowered for a professional and didactic reflection of conducted classes.

Task: Reflect on the planned lessons (45+20 min)

Five perspectives are presented, which were discussed earlier in the seminar:

1. Framing (example: media competence framework)
2. Technology didactic approach
3. Computer science didactic approach (CT definition)
4. Programming vs. Computational Thinking
5. Architecture of robots

Students should look at their lesson plans from the various perspectives and highlight which perspective stands out in their teaching. Thereby they give an overview about several aspects of the five perspectives and discuss, in what way these are taken up in their lesson planning.

Student arrangement: students work alone

This should be recorded in an etherpad in the moodle platform. This way, students can reflect on their planned lessons on the one hand and repeat the previous topics of the seminar using the different perspectives on the other hand.

Student arrangement: students work alone

TeaEdu4CT
Session 13 (video conference meeting)

Main idea of this session:

Based on the perspectives established in the last session, the experiences of all students can be discussed in an aspect-oriented manner. The aspect-oriented approach makes it possible to structure the session without having to go through all the lesson plans in a linear and tedious way. In addition, this last session gives room to resume and reflect the whole seminar.

This session contributes to the achievement of the following learning outcomes:

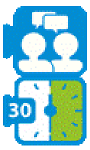
- The students become empowered for a professional and didactic reflection of conducted classes.
- The students get motivated and become more self-effective to use digital possibilities for future projects through successful practical experiences with CT approaches and digitalization in the primary school.

Input: Look back of previous sessions (10 min)
A seminar plan for all sessions is shown and an overview is given of what has already been done in the seminar.

Student arrangement: in the whole study group

Discussion: Reflection of the planned lessons with different perspectives (45 min)
The perspectives presented in the previous session are briefly repeated and the students' work from the last session is shown and discussed.

Student arrangement: in the whole study group



Discussion: Reflection of the seminar (30 min)
The whole seminar is reflected together. The students have the opportunity to give feedback and ask questions. They will also be invited to participate in an online questionnaire to evaluate the seminar.

Student arrangement: in the whole study group

Learning resources

	Presentation	A PPP with input slides and tasks is provided in each session.
	Readings	For the technical basics, the following literature was used for reading: **Session 1:** Duit, Reinders (2003: Alltagsvorstellungen und Physik lernen. In Kirchner, E.; Schneider, W. (Hrsg.), Physikdidaktik in der Praxis (S. 1-26). Berlin und Heidelberg: Springer. GDSU (Gesellschaft Didaktik des Sachunterrichts) (2013); Perspektivrahmen Sachunterricht. Bad Heilbrunn: Klinkhardt. Medienkompetenzrahmen NRW (2018). Der Medienkompetenz-rahmen NRW. Online: https://medienkompetenz rahmen.nrw.de/ (abgerufen am:21.01.2019). Möller, Kornelia (2007): Genetisches Lernen und Conceptual Change. In: Kahlert, J. et al. (Hrsg.), Handbuch Didaktik des Sachunterrichts (S. 258-266). Bad Heilbrunn: Klinkhardt. **Session 2:** Marquardt, Anja; Autenrieth, Daniel (2019): Neue Formen des digitalen Lernens–fächerübergreifender Unterricht mit dem iPad. In: Thorsten Junge und Horst Niesyto (Hg.): Digitale Medien in der Grundschullehrerbildung. Erfahrungen aus dem Projekt dileg-SL (Medienpädagogik interdisziplinär Band 12), S.60-S.64. **Session 3:** Barendsen, E., & Bruggink, M. (2019). Het volle potentieel van de computer leren benutten: over informatica en computational thinking. (translated into German) **Session 6:** Adamina, Marco; Hild, Pitt (2019). Mit Lernaufgaben Kompetenzen fördern. In: Hild, Pitt (Hrsg.), Fachdidaktik Naturwissenschaft. 1.-9. Schuljahr (3. Aufl., 119-134). Bern: Haupt.
	Access to computers for internet research and collaborativ e work	Access to the computer and the internet is necessary in every session. The students need access to the video conference system to attend synchronous sessions and they need access to the moodle platform for getting and submitting tasks and for collaborative work.
	Videos	**Example of a Bluebot:** Blue-Bot|Betzold (Arnulf Betzold GmbH) https://www.youtube.com/watch?v=_D2J3xWnS0o **Example of a humanoid robot to discuss a robot's components:** Westdeutscher Rundfunk (2017): Lach- und Sachgeschichten – Fußballroboter. Online abrufbar

		unter: https://www.wdrmaus.de/filme/sachgeschichten/fussballroboter.php5
	Others	● Pingo (real time voting tool, students attend by QR-Code) ● Educational Robots ○ LightBot (https://lightbot.com/) ○ BlueBot/BeeBot (https://www.tts-international.com/bee-bot-programmable-floor-robot/1015268.html) ○ "Ronjas Roboter - Roberta" (https://www.meine-forscherwelt.de/spiel/ronjas-roboter) ○ Ozobot (https://ozobot.com/) ● Website with basic information about computer science in primary education ● Link list with useful websites for planning lessons with robots

Granularity

Learning resources presented on 2 levels:

- For future teachers
- For their students in school

- Instead of educational robots (BlueBot/BeeBot, Ozobot) learners could make experiences with virtual robots, e.g. Lightbot, Ronja's Roboter Roberta
- Instead of Marquardt & Autenrieth use only a definition of CT, e.g.: Computational Thinking (ISTE) https://id.iste.org/docs/ct-documents/computational-thinking-operational-definition-flyer.pdf
- The introduction to conceptual topics in sessions 1 and 2 can be supported by English literature (e.g. Kleickmann et al. (2007). Learning environments in primary school science – Scaffolding students' and teachers' processes of conceptual development).
- Instead of the video of the soccer playing robot (session 8) there are several (English) options of humanoid robots on YouTube, e.g.:
  - Honda's Asimo: the penalty-taking, bar-tending robot: https://www.youtube.com/watch?v=QdQL11uWWcI
  - Humanoid Robots Playing Soccer, Part 2: How They Work: https://www.youtube.com/watch?v=9ULcsecoZ2g
  - Robot Soccer Goes Big Time: https://www.youtube.com/watch?v=KfNRXTS55nY
  - Robots playing Soccer for Robocup 2019 | Sydney, Australia: https://www.youtube.com/watch?v=Bam9WzQbtfM
- If it is not to test the planned lessons with a whole class one alternative is to test it on other kids, e.g. in the neighborhood or brothers and sisters. If this is not possible either, the lessons can be tested on adults (e.g. parents, grandparents, friends, students) in the role of school pupils. It is possible to test only parts of the lessons planned with small groups, too.

Assessment requirements and methods

Submissions are uploaded to the moodle platform and read by the tutors. The submitted tasks should have been completed in full. There are very open task formats in which there is no direct "right" or "wrong". By switching between assignments and video conferences, there is always the possibility of discussing assignments and addressing possible misconceptions.
For the lesson planning, conditions were given that had to be adhered to. Groups that did not comply with these conditions were encouraged to adjust their plans.
All submissions were not graded.
At the end, an exam was written in which tasks on the use of educational robots and the teaching of CT are solved. The exam consists of four tasks:

1. Name reasons for or against using educational robots in primary schools based on personal experiences with robots used in the seminar.
2. Name aspects of Computational Thinking based on the literature used in the seminar.
3. Describe your own lesson plan with one out of five given perspectives. Name two problems that can occur when using a specific educational robot.
4. Read a fictional scenario where a teacher uses the "LightBot" in a lesson. Evaluate the teachers action and name one aspect you would do differently.

Implementation ideas

- Feedback from the students shows that one should not shorten the first sessions capturing the technical basics. Students, who are not familiar with computer science, robots and CT need time to explore this new field by themselves like it is planned in sessions 1-8. Some students even said that more time should be taken to discuss the robot's components, which was packed up in session 8.
- If there is more time than 13 sessions, the sessions about planning and testing lessons with educational robots should be extended to give the students more possibilities to think the lessons through and getting new experiences by testing it out.
- The task about planning lessons is broad formulated to give the students enough space to be creative with their own ideas. It is possible to formulate this task more narrowly, e.g. give out a planning template, such that the students' plans are more comparable in their structure.

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