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Module 5

CT for STEM Prospective Teachers Specific Features, Approaches and Practical Solutions

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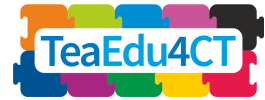
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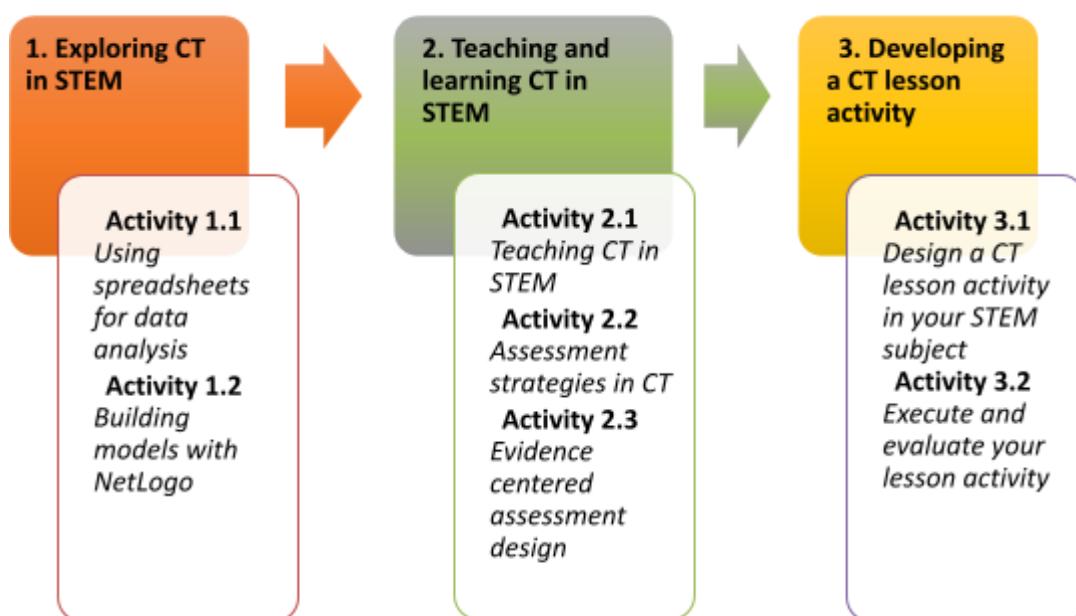


General overview and aim

The aim of this module is to further build on STEM prospective teachers' understanding of computational thinking (CT) and their knowledge of instruction and assessment of CT. After the successful completion of the module, the participants will acquire the necessary knowledge and skills to embed CT into their STEM subjects and therefore be able to design, describe and apply design principles for teaching and learning CT in their lessons.

The module structure

To this end, the module is organised into three units: Unit 1 engages prospective teachers in CT by providing various examples in STEM education; the unit besides data analysis also emphasises modelling and simulation through different tools (e.g., Netlogo, Excel); Unit 2 further highlights design principles for teaching and learning CT, reflective strategies as well as assessment strategies for CT in STEM subjects. The module concludes with Unit 3 which provides prospective teachers with hands-on experience in designing CT activities for their STEM subject.



Target groups and prerequisites

This module is for prospective teachers studying in a teacher education programme for one or more STEM subjects as well as for the professional development of in-service STEM teachers

interested in computational thinking. The module is designed for face-to-face learning, but it can be adapted as a distant learning module.

Students are expected to have completed the introductory module “O2: General Introduction of Computational Thinking: a basic module suitable for all teachers”.



Learning Outcomes and Assessment Methods

A successful learner who has completed the whole module will be able to:

1. describe and recognize applications of CT in STEM subjects
2. apply CT in concrete cases
3. describe and recognize characteristics of instruction and assessment of CT in STEM
4. design learning activities and materials that incorporate CT into their STEM subject

More specific learning goals can be found within the structure of the units.

Assessment Strategy

The assessment includes the evaluation of the tasks presented in Unit 3 using the rubric. The unit tasks, require the design, execution and evaluation of learning activities that combine aspects of CT and the respective teaching subjects of the module participants. To successfully complete the tasks in Unit 3, the module participants are called to apply the knowledge (e.g., design principles) and skills (e.g., working with computational tools like MS Excel and NetLogo) they acquired in the previous units. The lecturer of the module should decide the assessment weight of each task and should evaluate students’ performance in respect to the corresponding learning outcomes of each unit.



Module plan and didactical approaches

The module consists of three units of face-to-face interaction. Each unit comprises several activities which usually start with a warming-up activity and conclude with a reflective activity. The students will engage with a variety of learning approaches which include pairwise exploratory work, reading literature reviews, group discussions, guided problem solving tasks, and reflection activities. In Unit 3: Designing a Computational Thinking Activity, the students will design, execute and evaluate a CT learning activity in their STEM field.



Units and activities

Unit 1: Exploring Computational Thinking in STEM

Activity 1.1 Using Microsoft Excel for data analysis (*10 hours)

Activity 1.2 Building models with NetLogo (6 hours)

Total hours: 16 hours

Unit 2: Teaching and Learning Computational Thinking in STEM

Activity 2.1: Teaching CT in STEM (1 hour)

Activity 2.2. Assessment strategies for CT (1 hour)

Activity 2.3. Assessment strategies for CT: Evidence-Centered Design (2 hours)

Total hours: 4 hours

Unit 3: Designing a Computational Thinking Lesson Activity

Activity 3.1: Design a CT Lesson Activity in your STEM subject (3-4 hours)

Activity 3.2: Execute and Evaluate your Lesson Activity (3-4 hours)

Total hours: 6-8 hours

*The approximate duration of each task can be found in the respective sections of the described activities. The minimum duration indication for an activity is set at 15 minutes, but in a few cases could be considerably less.



UNIT 1: Exploring Computational Thinking in STEM

In this unit you will explore applications of computational thinking in STEM subjects. More precisely, you will get hands-on experience on statistics and physics learning activities aiming at fostering computational thinking skills through the use of two digital tools (MS Excel and NetLogo).



Contribution to the learning outcomes

Learning outcomes
1. organise and analyse data using a spreadsheet, in particular: <ul style="list-style-type: none">a . Select relevant information to the problemb . Explore, analyse and visualise datac . Use pattern recognition and evaluation to discern trends to answer a (research) questiond . Choose and employ visualisation techniques to plot your data
2. design, program and use agent-based computational models, in particular: <ul style="list-style-type: none">a . Explain the structure of NetLogo models in terms of Interface, Info and Code componentsb . Recognize and explain the NetLogo programming primitives

- c. Implement a given conceptual model by making use of basic NetLogo programming concepts.
- d. Experiment with a NetLogo model to explore a physical phenomenon



Activity 1.1 Using Microsoft Excel for data analysis

Excel is a spreadsheet tool for organising, performing calculations on data, and analyse and represent data as a chart or a graph.

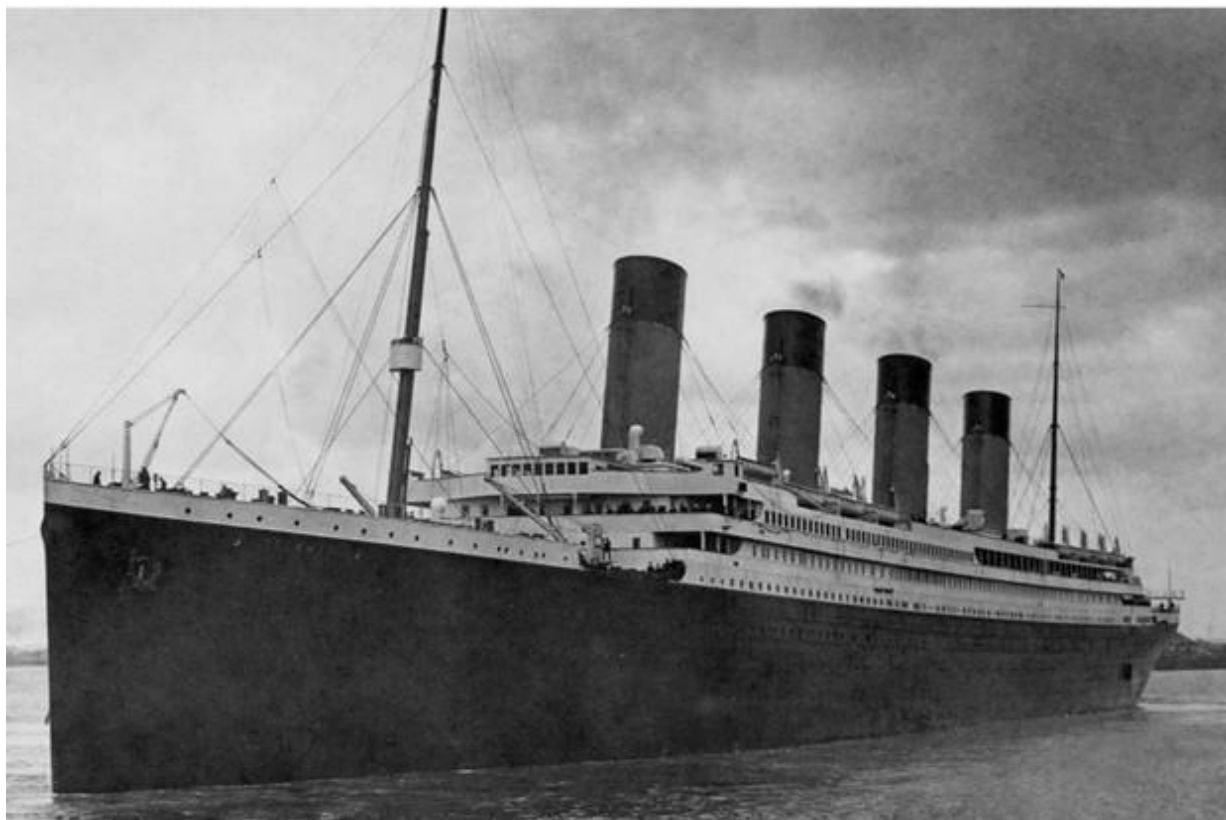
In this activity, you will be guided through an example lesson activity in which a spreadsheet is used to perform elementary (descriptive) statistics operations, with the purpose of answering an overall question. The activity is based on existing materials developed for mathematics lessons.

In the process, you will see how the spreadsheet is used both for representing and for analysing data. You will try to identify trends using graphical representations. The topic of this example is the Titanic disaster in 1912.



Warming Up

The Titanic was a luxury ship that made up much of the transatlantic passenger traffic. On the night of April 14-15, 1912, the Titanic collided on its maiden voyage shortly before midnight with an iceberg. The starboard side was pierced at several places and within three hours the ship had sunk.



The Titanic

In the following assignment, you will get (part of) the passenger list of the Titanic and you are going to investigate how to use this data to answer questions about what happened. The passenger list is provided as a spreadsheet (Titanic.xlsx).

	A	B	C	D	E	
1	pclass	survived	name	sex	age	
2	3	0	Abbing, Mr. Anthony	male	42	
3	3	0	Abbott, Master. Eugene Joseph	male	13	
4	3	0	Abbott, Mr. Rossmore Edward	male	16	
5	3	1	Abbott, Mrs. Stanton (Rosa Hunt)	female	35	
6	3	1	Abelseth, Miss. Karen Marie	female	16	
7	3	1	Abelseth, Mr. Olaus Jorgensen	male	25	
8	2	0	Abelson, Mr. Samuel	male	30	
9	2	1	Abelson, Mrs. Samuel (Hannah Wizosky)	female	28	
10	3	1	Abrahamsson, Mr. Abraham August Johannes	male	20	
11	3	1	Abraham, Mrs. Joseph (Sophie Halaut Easu)	female	18	
12	3	0	Adahl, Mr. Mauritz Nils Martin	male	30	
13	3	0	Ahlin, Mrs. Johan (Johanna Persdotter Larsson)	female	40	
14	3	1	Aks, Master. Philip Frank	male	1	
15	3	1	Aks, Mrs. Sam (Leah Rosen)	female	18	
16	3	1	Albimona, Mr. Nassef Cassem	male	26	
17	2	0	Aldworth, Mr. Charles Augustus	male	30	
18	3	0	Alexander, Mr. William	male	26	
19	3	0	Alhomaki, Mr. Ilmari Rudolf	male	20	

Sample of the spreadsheet with Titanic data



Discussion task

Explore the dataset. As you will notice, the dataset provides information regarding the passengers' names (column *name*), the class they were in (column *pclass*), their age (column *age*), their gender (column *sex*), and whether they survived or not (column *survived*). You will further notice that each of these variables have discrete values. For instance, the passenger's class (*pclass*) is represented by numbers 1, 2, and 3 indicating a first-class passenger, a second-class passenger, and a third-class passenger respectively.

Discuss:

1. What other information is provided for the Titanic passengers?
2. How is this information represented? Be very precise, e.g. distinguishing between text and numbers.



Discussion task

Discuss in pairs:

1. When do you think it is appropriate to represent the values of a variable with binary integer values?
2. What would you expect to be the advantages and disadvantages of using binary integer values instead of text values?



Phase 1: Problem Statement

'Women and children first' is a rule from shipping that states that women and children should first be saved in an emergency and it dates from about 1860. The question we are going to investigate in this task is the following:

To what extent was this principle true in the Titanic disaster and what other factors may have influenced the survival chances?



Phase 2: Investigating Data

To answer the question, we need first to investigate our dataset and the information provided in it.



Discussion Task

Go through your dataset again: which of the data do you expect to need for answering the question? Write down which properties (columns) you will use and briefly sketch your plan to answer the question.



Pair task

As you will have noticed, we do not have direct information regarding whether a passenger is an adult or a child (for the purposes of this exercise we assume that a person until the age of 14 is considered a child and above that an adult). Although we can understand if a passenger is an adult or a child by looking at their age, let us create an extra column that indicates if a passenger is an adult or not.

You will create a new property in column F of the excel-sheet indicating if a passenger is an adult or a child.

1. Click on cell F1 and type «adulthood» as the column header.
2. Click on cell F2, and apply the following formula to calculate if a passenger is an adult or a child: =IF(E2<=14, "child", "adult") where E2 is the cell with the age of the first passenger in the list.
The formula =IF(E2<=14, "child", "adult") examines if the value in cell E2 is less than or equal to 14. If that is true, then the value of the F2 cell becomes child and if it's false the value is adult.
3. Apply the formula for all the passengers. Hint: consult your spreadsheet help pages on how to copy a formula to other cells (e.g., [Copy a formula in Google Sheets](#) or [Copy a formula in Excel](#)).



Looking at the dataset, you will notice that there are records with missing data. For example, the age for some passengers is missing as well as the name of some passengers. From these two variables, age and name, the variable age provides important information for answering our question in comparison with the name variable which, in this particular example, does not offer any important information.

Therefore, it would be better to remove the records with missing data for the age variable since these cannot be processed further (when reporting the results, it would be good to report how many records were not included in your calculations).

To 'clean up' the data in an efficient way, it is convenient to *sort* the data with respect to the variable involved, for example age. Select all columns corresponding to properties (A-F) and click Data > Sort range. You can then indicate which property (age, in this case) is taken for sorting the records. The Titanic spreadsheet has column headers, so you will have to check the box indicating so.



Delete all the records with missing data that are important to solve the problem.



Having all the information we need to answer our question, we are going to proceed with calculating the number of survivors per gender and adulthood.



Calculate how many male adults, female adults, and children survived and how many did not survive (Task 1 in the worksheet)

1. Before proceeding with the above calculations, sort the data first so that all passengers that survived are listed in the beginning.

You will notice that the record block of surviving passengers starts on row 2 and ends on row 428.

2. Having sorted the data in a way that the survivors are listed first, click on cell I4 and type the following formula to count the number of men who survived: COUNTIFS (D2: D428, "male", F2:F428, "adult"). With this formula, we count how many adult males survived (The cells from 2 to 428 include all the survivors). Correspondingly, click on

the next cell to count how many men did not survive. Use the following formula: COUNTIFS (D429: D1047, "male", F429:F1047, "adult").

3. Continue using the same formulas to count the number of women and children that survived and those that did not.



Pair task

Now you are ready to perform the first step to determine the extent to which the rule “women and children first” was applied. Calculate the percentages of men, women and children that survived (task 1 in 1A - Titanic.xlsx).



Discussion task

In the above task, you found that around 75% of the survivors were women and children. Do you think that this information is sufficient to answer our question? Discuss your opinions.



Using the COUNTIFS function, you can count survivors without having to sort the data first. For instance, to calculate the men that survived you can use the following formula: =COUNTIFS(B2:B1047,1,D2:D1047,"male",F2:F1047,"adult"). In the same way, you can calculate the number of women and children that survived.



Pair task

Another way to approach the question is to calculate the odds of surviving for each of the groups involved.

1. Calculate the following information (Task 1 in your worksheet):
 - the odds of surviving for men (i.e., the ratio between the number of survivors and the total number of male passengers),
 - the odds of surviving for women,
 - the odds of surviving for children,
 - the odds of surviving for the group of women and children together.
2. Compare the above odds (odds ratio): surviving for men vs surviving for women, etc.

If you did the calculations correctly, you will have found that it was more likely to survive for a woman or child than it was for a man (and this even holds for the groups of women and children separately). So it seems that to a large extent women and children were attempted to be rescued first.



Phase 4: Considering other factors

In the previous phase, you investigated to what extent the rule ‘women and children first’ was applied. In this phase, you are going to investigate what other factors may have influenced the survival chances of the Titanic passengers. The factors we are going to consider are passenger age and class.



Discussion task

Discuss in groups what are possible ways (in mathematical/statistical terms) to investigate if age was a factor influencing the survival odds.



Below, we will guide you through a few of the many possibilities to explore the influence of age.



Pair task

A first step to get an idea about the distribution of the data is to calculate some descriptive statistics for the age variable of survivors and non-survivors.

Creating a histogram is a great way to demonstrate how our data are spread within a range. Create a *histogram* to reflect on the way age is distributed in the overall population of the Titanic passengers.

Hint: Select the age column and insert > chart > histogram. Do the same for the survivors and non-survivors, respectively.

Calculate the mean, median, mode, and standard deviation for the age variable of the survivors and non-survivors (Task 2 in 1A - Titanic.xlsx).

Hint: You can use the following formulas:

- MEDIAN(RANGE OF CELLS), e.g. MEDIAN (E2:E428)
- AVERAGE(RANGE OF CELLS)
- STDEV(RANGE OF CELLS)



Pair task

While these descriptive statistics values may help to get an impression of the variables involved, they do not always suffice to answer questions about the distribution.

You will have discovered, for example, that the average age of survivors and non-survivors, respectively, do not differ much. Discuss why we can't conclude from this the surviving chance is independent of the passenger's age.



Another approach to investigate the age dependency is to split ages into categories with equal ranges and identify the age category with the highest percentage of survivors and the one with the lowest (Task 3 in your worksheet: 1A - Titanic.xlsx) and compare the odds of surviving per category.

In Task 3 in your worksheet, we have created eight age categories. For example, by [10,20) we denote ages bigger than or equal to 10 but strictly smaller than 20.

1. Calculate the odds of surviving per age category.
2. Which age group has the smallest odds of surviving and which the biggest?
3. Formulate a conclusion about the relationship between age and survival in terms of the age categories.



Let us now consider another factor that may have contributed to surviving: a passenger's class.

1. Calculate the odds of surviving per class (Task 4 in 1A - Titanic.xlsx).
2. Compare the odds you found and discuss your observations.



Data visualization is an efficient way to help us understand data.

1. Visualize the survival odds per class using the chart facility. Try out two possible graphs. Hint: Select the data you want to represent in the graph in Excel > insert > chart
2. Discuss in groups which one of the graphs is a better fit for visualizing this information and why.
3. Discuss in groups the advantages and disadvantages of presenting information using graphs rather than tables.



In the previous phase we investigated the age and class as possible factors that may have contributed to the surviving chance of the Titanic passengers. In this task we are going to combine, age, and class to explore a combination of factors that may have affected the chances of surviving.



Pair task

1. Investigate if age was a possible factor of surviving per passengers' class.
2. Discuss what other possible combinations of factors may have influenced the surviving chance.



Phase 6: Create a presentation



Pair task

Having answered all the questions in this study, create a presentation to demonstrate your findings. Think about how you are going to present your findings, the graphs that you will use, and the statistical information necessary to support your findings.



Activity 1.2 Building Models with NetLogo

Computational models and simulations can make scientific concepts more accessible, enhance student understanding of phenomena, and serve as powerful learning tools. Modelling and simulation are productive approaches to integrating CT within STEM classrooms. They can be integrated into science classrooms to support student learning of core science concepts and increase exposure to CS while preparing students for professional STEM practices.

NetLogo is a multi-agent programmable modelling environment for simulating natural and social phenomena and demonstrate how these develop over time. With this tool, you can create a world made up of rectangles or patches and parameterise agents (or turtles) that move around and interact with each other and their environment.

In this unit you will construct a NetLogo model and use it to explore a physical phenomenon. This unit builds upon Activity 2.2 of Module O2: Modelling and Simulation through NetLogo, and we will assume you completed that activity or something equivalent.

First, you will get further acquainted with the NetLogo environment and with NetLogo programming. This can be accomplished doing the following tasks.



Self-practice task

Go through the following tutorials in the [NetLogo user manual](#) and watch the video (before starting Tutorial #3):

1. [Tutorial #1: Models](#), where you will learn about the components and features of NetLogo models.

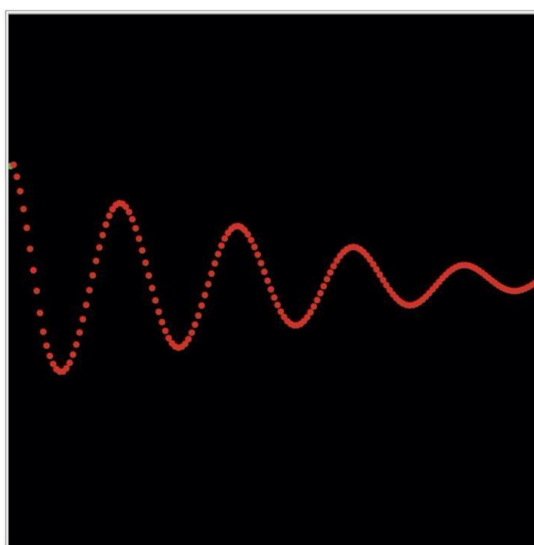
2. [Tutorial #2: Commands](#), in which you will start to see the inner workings of the models and be able to change how they look.
3. [Video: Our First NetLogo Model](#), in which the construction of a simple model is shown.
4. [Tutorial #3: Procedures](#), which leads you through the process of building a complete model, built up in stages, with every step explained along the way.

By now you have sufficient background knowledge about NetLogo to be able to perform the remaining activities without any problems. In the remainder of this unit you will implement a complete model of a phenomenon in physics in NetLogo yourself. We will not ask you to come up with the physics properties yourself, but we expect you to be able to translate the provided rules into executable NetLogo code.



Pair Task

The aim of the task is to simulate a wave moving along a string or rope. The right end of the string is fixed whereas the left end moves up and down in which it triggers and maintains the movement of the string.



Modeling a wave as a chain of beads

The string is modeled by a bead chain with each bead connected to its left and right neighbor bead. See the figure above. The horizontal position of each bead is fixed: it can only move vertically. In its assertion, each bead follows the movement of its immediate neighbors. Specifically, each bead tries to take the average position of its left and right neighbor.

In NetLogo, each bead is represented by a *turtle* (you have learned about these in Tutorial #2). Besides the predefined attributes of the turtle, we give each turtle two extra properties (variables): the vertical position and the vertical speed. By combining these two properties, the new position and the new speed can be calculated at any time. Finally, we also add damping to the model to make the simulation even more realistic.

To be able to experiment with the model, it is useful if we can easily set and vary the various parameters of the model. It is obvious to use sliders and / or switches for this. The parameters affecting the model are the following:

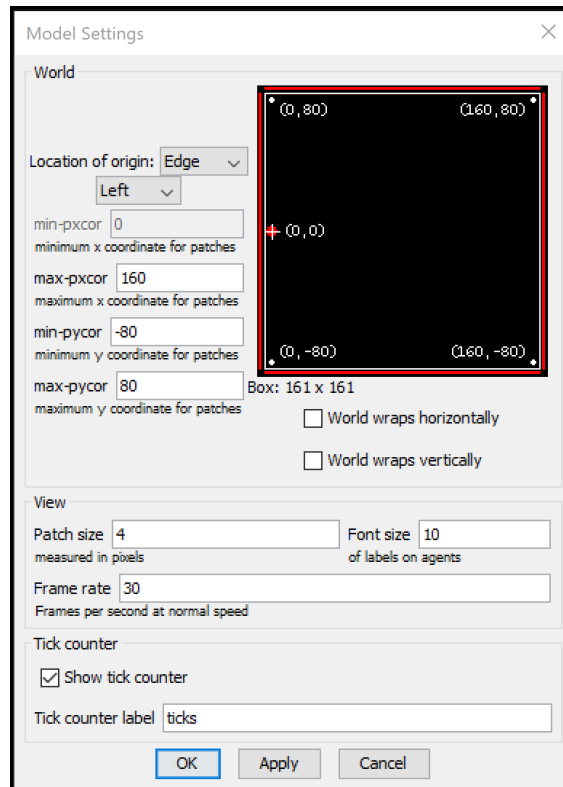
1. The frequency (F) and amplitude (A) of the driver.
2. The degree of damping (D) (possibly the option to switch damping off and on).
3. The mass of the beads and the elasticity of the connection between the beads. We can combine these two into a single parameter we call traction factor (T) for convenience.

You are now able to construct the NetLogo ‘Interface’.



To start a new model, select “New” from the File menu. Then begin by creating the setup and go buttons.

- Add two buttons to the interface, as you practiced in Tutorial #3. You don't need to add the corresponding procedures to the code part yet; you will do that later.
- Expand the interface further with 4 sliders for setting the parameters of the model and a switch to turn damping on or off. Use as maximum values for F, A, and D the values 32, 60, 50 and 20, respectively. As to parameter T, take 0.1 as the unit and 0.1 and 2.0 respectively as the minimum and maximum value.
- Adjust the view so that the origin is centered on the left side of the window. The width and height are both 160, with x coordinates between 0 and +160 and y coordinates between -80 and +80.



Interface after adjusting the view

You will now construct the NetLogo ‘Code’. For each bead, we keep track of its position and speed. Because the x coordinate of beads remains unchanged, this only needs to be done for the y direction.



Pair Task

Open the code tab of your project and add these variables (vertical position and vertical speed) using a turtles-own declaration.

The reason for explicitly keeping track of the ypos in addition to the already existing variable ycor is that the bead can disappear from the view during the simulation (and thus exceed the limit values). ycor then no longer contains the real y position of that bead which would lead to an inconsistent state of the model.



Group Task

Present your visualisations and outcomes. Discuss: how can simulations be used to enhance understanding in your STEM subject? What have you learned in this unit?



Define the setup procedure in which you create the beads (in total world-width pieces) and place them in the correct position. (Hint: use the turtle variable [who](#)). Color the first bead green, the last bead blue and all others red.

The trickiest part of the code is of course the go procedure in which the movement of each bead must be specified. We make a distinction between the one and only green bead and the red beads (the position of the blue bead remains unchanged).

- The green bead performs a sinusoidal motion. The position is determined by time (ticks), frequency and amplitude. In a formula:
$$y\text{-pos} = A * \sin (F * \text{ticks})$$
- A red bead moves toward the middle of its two neighbors. The acceleration (the change in speed per unit of time) is proportional to the difference between this middle and the current position of the bead Expressed in a formula:
$$y\text{-acc} = T * ((y\text{-pos-left} + y\text{-pos-right})/2 - y\text{-pos})$$



Define the go procedure. A few additional hints:

- Adjust the speeds of all red beads before updating the positions.
- As soon as you detect that a bead is out of sight, you should explicitly make it invisible by means of `hide-turtle`. Don't forget to make it visible again (`show-turtle`) if the coordinates of the bead are within the limits again.
- You can make calculations easier to understand and verify by saving intermediate results in local variables. [Let](#) explains how to introduce such a variable

Now the model is complete and you are ready to use it to experiment.




Change the values on the sliders and observe what happens to the waves on the rope.

- Note that there is a relation between the frequency with which the left end of the rope goes up and down and the number of peaks that emerge.
- Try to create a "standing wave", in which some points on the rope do not move at all.



Unit 1 - Titanic.xlsx



UNIT 2: Design principles for teaching and learning CT in STEM


In this unit you will explore assessment strategies and pedagogical principles for computational thinking.



Contribution to the learning outcomes

Learning outcomes

- Describe and recognize common instructional strategies for CT in STEM
- Describe and recognize common assessment strategies for CT in STEM
- Given a specific CT element and content matter, make a justified choice for instructional and assessment strategies



Activity 2.1: Teaching CT in STEM

The integration of CT into STEM classrooms has the potential to enhance STEM learning by placing students in the role of young scientists and engage them in authentic STEM practices.

It has been suggested that students who learn to develop computational solutions and use computational tools, resources, and methods deepen their understanding of subject area content, while they engage with modern uses of computation across STEM fields.

In this activity you will study various approaches for teaching CT within the STEM domain.



Pair Task

- Read the summary on the teaching CT in STEM (see learning resources: A. TeachingCT.pdf).
- Analyze the computational thinking activities you carried out yourselves in this module. Discuss in groups which of the strategies/approaches outlined in the overview document do you recognize? How were they incorporated in the activities?
- Reflect on your teaching practice by discussing which of the approaches outlined in the overview document do you find more relevant for teaching CT in your subject area. Which one is not applicable (if any) and what are the main reasons for this?



Activity 2.2: Assessment strategies for CT

Assessment plays a critical role in education; demonstrating knowledge and understanding of a subject is a fundamental part of students' learning process and essential for teachers to monitor their students' progress and determine whether the learning goals have been met. Introducing computational thinking in a subject requires teachers to present new learning goals regarding skills and knowledge that students should demonstrate and are linked with computational thinking competencies.

However, assessing computational thinking is challenging; first, the relationship between assessment and instruction and therefore, the content that needs to be assessed, requires a clear definition; secondly, it has been pointed out by researchers that to reach a total and comprehensive understanding of the computational thinking of our students, different types of complementary assessment tools must be systematically combined.



Pair Task

- Read the summary on assessment for computational thinking (see Resource: B. AssessmentCT.pdf). It highlights different approaches for assessing students' computational thinking skills (e.g., response tests, portfolio, surveys etc).
- Discuss which of the approaches outlined in the summary would be suitable for the activities you carried out in Unit 1. What challenges do you recognise in each of these approaches for your subject?



Activity 2.3: Evidence Centred Assessment Design

At the end of the overview document on assessment for CT, the Evidence-Centred design (ECD) is described as an approach to design assessment tasks. In this activity you will practice with the ECD approach.



Pair Task

- Study the table on page 4 of the overview document that describes the five layers of the ECD approach (see document B. AssessmentCT.pdf).
- In the first activity in Unit 1, you engaged with a problem regarding the Titanic accident. One of the aims of this unit was to engage students with Data analysis and Representation. Work in groups to express assessment arguments (domain modelling) in written form (short descriptions) that reflect the above general aim. In this process focus on reporting:
 - the *knowledge, skills and other attributes* to be assessed (e.g., ability to judge the sufficiency of the data for solving the problem)

- *performances* that can evoke evidence of students' knowledge and skills (e.g., use different representations of data)
- for each assessment argument, discuss and write down *tasks, tests or any other approach* that you would use to assess students. Create a task template for one or more of the assessment arguments you listed above and indicate a rubric measurement model.



Group discussion

Compare your findings in class. Which aspects did you find easy, which ones were difficult? What did you learn?



Learning Resources

Unit 2 - A. TeachingCT

Unit 2 - B. Assessment in CT



UNIT 3: Designing a Computational Thinking Lesson Activity

In this unit you will design, execute and evaluate a lesson activity involving computational thinking in your subject area. Your activity may span multiple lessons, but you will focus on one lesson when planning teaching and learning activities in detail.

In your design you will use your experience with computational thinking, as well as the theoretical background for teaching computational thinking obtained through Module 2 and the skills with computational tools like MS Excel and NetLogo that you practiced in units 1 and 2 of this module. The execution of your activity will be done with your fellow students as a 'class'. Depending on the available time, you will select an interesting part of the design rather than teaching the whole lesson. Three forms will guide you through the design and evaluation process.



Contribution to the learning outcomes

Learning outcomes

- design a lesson activity on computational thinking, with special focus on combining computational thinking and subject matter in the learning objectives, choosing appropriate instruction and formative assessment strategies;
- execute your designed activity;
- evaluate the activity.



Activity 3.1: Design a CT Lesson Activity in your STEM subject

Choose a topic in your area that you think combines well with computational thinking.

For inspiration, you may have a (second) look at the activities in this module and in Module 2, such as:

- using simulations to analyze infection spread (Module 2)
- using spreadsheets to investigate climate factors (Module 2)
- using N-gram analysis (Module 2)
- programming in Scratch (Module 2)
- unplugged exploration of algorithms (Module 2)
- using a spreadsheet for statistical analysis (this module)
- building an agent-based model and simulate a physical phenomenon (this module)

For more examples, we recommend:

- [Google's resources on computational thinking](#), including lots of examples
- Modeling natural selection and bacterial resistance in biology (unplugged):
 - Peel, A., Sadler, T. D., Friedrichsen, P. J. (2019). Learning natural selection through computational thinking: Unplugged design of algorithmic explanations. *Journal of Research in Science Teaching*, 56, 983-1007.
 - Peel, A., Zangori, L., Friedrichsen, P., Hayes, E. & Sadler, T. (2019). Students' model-based explanations about natural selection and antibiotic resistance through socio-scientific issues based learning. *International Journal of Science Education*, 41, 510-532.
- [CSTA Computational Thinking Teacher Resources](#)

In the above examples, we can recognize three ways to combine subject matter and CT:

1. Using CT and tools to *automate or accelerate* existing operations and learning activities in your subject area (e.g., spreadsheets for statistical operations, collecting and analysing experimental data).
2. Exploiting CT and tools to *enrich and extend* (i.e., go beyond) existing operations and learning activities in your subject area (e.g., building computational models, using simulations for predictions, using N-grams).
3. Applying CT and tools to *deepen or assess students' understanding of concepts* in your field (e.g., modelling biological mechanisms using algorithms, exploring a physical law using a simulation).



Pair task

Brainstorm about candidate subject matter topics and suitable computational thinking elements. List possible learning activities for these combinations, using the above sources for inspiration. Choose an idea you will elaborate in this task.

In this first design step you will analyze, for your activity (1) the learning goals, (2) your expectations about students' understanding and difficulties, (3) appropriate instructional methods and (4) ways to monitor students' learning progress. You can make use of the Pedagogical Analysis Form (see learning resources: A. Pedagogical Analysis Form) in which the above four elements are addressed together with their mutual coherence.

It is a good idea to work in an iterative way, drafting (1) to (4) and stepwise refining them while checking their mutual consistency.

Keep in mind that the learning goals will be a combination of subject specific goals and computational thinking goals. Sometimes the two areas can appear in one integrated learning goal. Moreover, as it is important to monitor your students' progress during the activity, formative rather than summative assessment methods will be crucial.



Exchange your preparations (the completed Pedagogical Analysis Forms) within groups consisting of three pairs. Give feedback on your colleagues' plans. Adjust your own preparation based on the feedback.



Make a global planning of your activity. Then construct a detailed planning of one lesson, distinguishing the students' learning activities and your actions as a teacher. You can make use of the Activity Planning Form (see the learning resources for the respective file).



Carry out (a selection of) your activity with the other students in your group as 'class'. Each of the 'students' in class provides short written feedback in terms of a few TOPs (aspects that went well) and TIPs (suggestions for improvement). After each teaching round there is a short round of oral feedback.



Evaluate your activity, using your own experiences and impressions, as well as the feedback provided by your fellow students and possibly your instructor. The Activity Evaluation Form (see learning resources for the respective file) supports your evaluation process.



Group task

Discuss your experiences in class: what was successful, what did you find difficult? What have you learned?



Learning Resources

Unit 3 - A. Pedagogical Analysis Form

Unit 3 - B. Activity Planning Form

Unit 3 - C. Activity Evaluation Form



Overview of Learning Resources of Module O5

Unit 1

Unit 1. - Titanic.xlsx

Links:

- A. [NetLogo user manual](#)
- B. [Tutorial #1: Models](#)
- C. [Tutorial #2: Commands](#)
- D. [Video: Our First NetLogo Model](#)
- E. [Tutorial #3: Procedures](#)

Unit 2

Unit 2 - A. TeachingCT

Unit 2 - B. Assessment in CT

Unit 3

Unit 3 - A. Pedagogical Analysis Form

Unit 3 - B. Activity Planning Form

Unit 3 - C. Activity Evaluation Form