Second world – Emil the Keeper

Again, we do not want to provide a detailed introduction to Emil's second world given that the readers know it from their PD session. This part should only help with clarifying correct and consistent computational concepts and names for the individual components of the screen. Of course, we do not strictly insist on these words and do not assert that these are standard and well-established concepts of modern computing. The point is rather to get accustomed to a certain "vocabulary", to keep using it and to learn how to specify and comment on solutions, on-screen situations, procedures etc. in a clear and unambiguous way.

This world, too, consists of a "string" of units of tasks — marked by letters from **A** to **H** and **X**. The following picture does not depict the whole screen (we have left out the top part with the navigation elements and a task assignment, which are identical to the first world with the exception of colour, which has changed from green — used in the first world — to blue):

Emil's **stage** contains **positions** again; however, they are not clickable — the whole **control of Emil** has moved outside the stage to the **command buttons**. There are two kinds of them: **arrows** that control the movements (up, right, down, left) and **tools** (a **basket** to collect, a **light bulb** to switch the lights on and off, a **watering can**, a **match** to light a fire, a **house** to build a house, three **colours** to colour a house, and… we'd like to surprise you).

The position may either be completely empty (and unchangeable), or there is a grass circle, a small tree, a red house on a stone circle with the lights off etc. Sometimes, we will reffer to a **state** of a position, which can be changed using a suitable tool — to turn the lights on in the house using the bulb etc. To put it simply, we can **change** a position using a suitable tool (and think about what it was like before and what it will be like afterwards).

Above Emil's stage, there is a dark blue **panel** with a fixed number of empty **places**. Each command given to Emil will be indicated in the first leftmost empty place by a corresponding small picture that represents the command. We will talk about **cards** with commands being placed on the panel. The panel will serve as a **record** of commands given to Emil or as an eventual **plan** or **program** of commands to be later carried out by Emil. Just as we were thinking about the **order of objects collected on the shelf** in the first world, the pupils will now develop their **perception of the order of commands on the panel.** The panel thus represents an opportunity to study a key concept of programming — the **order of commands**.

Starting with the **B** unit of tasks, commands that are identical and directly follow each other will be grouped in **stacks of cards** on the panel; starting with the unit **G**, the pupils will be able to create **double and triple cards** that will be automatically placed in stacks again, as seen in the following picture. Each stack of cards has a number in the top left corner, indicating the **number of repetitions**. Let us also notice that when we start programming in this world, an **eraser** will appear on the right side of the panel, allowing the pupils to clear the last card, or the top card from the stack:

Workbook hard paper supplement

In the workbook, we have inserted a 12-page supplement printed on hard paper. The pages are numbered with Roman numerals; the pages related to the second world are I, II, VII, VIII, IX, and X, and are intended to be cut out. We provide a detailed description of their use later in this teachers' material: the pupils will be able to play these activities only after having completed tasks of the units **A** to **D** and **after D**.

Map of the complete intervention

The second world contains a progression of 12 units of tasks, of which the units **after B**, **after D**, **after F**, and **after G** can be found only in the workbook. With the exception of the unit **D**, all other units are supplemented by one or two pages of additional tasks in the workbook. The following map, which depicts the complete path through the activities in the second world, indicates that with a small notebook icon.

Performance and content standards according to the national curriculum for computing

At the end of this teachers' material about Emil's third world, we provide a table that pairs each unit of tasks with the corresponding items of the content and performance standards defined by the national curriculum. The third column of the table pairs these items with the corresponding concepts and procedures in Emil's terminology. We deem it important to pay attention to this table as it also highlights numerous interactions of this material with many areas of developing computational thinking outside the area of programming.

Limited implementations of the second world

In justified cases, the teacher may opt for an **abridged** or even a **minimal** implementation of the second world. In such case, the teacher and the pupils may still move on to the third world of Emil. However, they would miss an interesting opportunity to discover and explore additional important programming concepts.

In particular, if the teacher adopts the abridged implementation, the pupils may miss an opportunity to gain more experience with creating and carrying out programs with double cards when preparing for the more general computing concept of repetition. They would also skip the extension to triple and quad cards (in unit **H**). Let us notice that in the abridged implementation, the pupils do not work with the **after…** units of tasks; however, they work with the workbook in units **A**, **B**, **C**, **E**, **F** and **G**.

If the teacher adopts the minimal implementation, the pupils will discover that the same cards are grouped in stacks; however, they would not explore the given programs and the repeating patterns in their steps — including the repeating pairs of commands etc. They would thus lose out on an important preparatory stage leading to more general repetitions of several commands. In addition, they would not work with the tables marking the number of occurrences of basic command in the programs — be it with simple stacks or with the double- and triple-card stacks. Let us notice that in the minimal implementation, the pupils do not work with the **after…** units of tasks; however, they work with the workbook in units **A**, **B**, and **E**.

On the other hand, we have to stress that

- compared to the minimal variant, the abridged implementation will provide better support of the pupils' learning process when exploring the basics of programming, and that the minimal implementation is always much more useful for the pupils than no intervention at all,
- the teacher may perform one of the abridged implementations of all worlds, coming back to the skipped units of tasks from the previous worlds later on. However, we do not have real experience with such a model of teaching.

In the picture below, we see a map of the abridged and minimal implementations of our intervention:

- abridged implementation:

- minimal implementation:

Emil the Keeper • A

Learning objectives

- To study the new way of controlling Emil. To explore the possibilities of his movements in this world.
- To learn about the **panel with the record of commands**, to understand it as the **record of steps** that they can work with later.
- To see **the number of available places** on the panel as an important factor and constraint.
- To study the **light bulb** and **watering can** —the first two **tools** that allow Emil to change the **state** (situation) on the stage. To discover that we can sometimes use certain tools for a number of times on the same position.

Computing-specific content

The pupils are introduced to a new way of **controlling** Emil, which allows us to "distance" ourselves more from the controlled character. In the first world, we moved Emil directly on the stage. Now, we will only guide him by providing commands (**arrows** for movement and **tools** for changing the states of positions).

Hand in hand with giving commands to Emil which he immediately carries out (or show that this is impossible), a **record** of these steps is made on the panel. One of the most important objectives in programming at school is this kind of work with similar records — their creation, reading, analysis, execution, comparison, changes etc. In this unit of tasks, the pupils will **look at the records on the panel**, **read** these records from the workbook and **instruct** Emil (i.e. provide commands, copying them from the records in the workbook one after another for Emil to immediately follow). The pupils will also **write down** the records of their solutions in their workbooks and analyse the commands which they used — filling in the **one-dimensional table with the number of uses** of the individual commands. The records that they will be using in this unit of tasks correspond to the computing concept of a simple **sequence** of commands.

In addition, the pupils will view the **record as a whole** — in this unit of tasks, this will include its length (some of the tasks will be impossible to solve due to the constraints in the number of steps; other times, the number of places will simply limit pupils in solving the task).

Apart from the arrow-based commands, the pupils will learn about two other types commands — the commands to use the **light bulb** and **watering can** tools. They will study the places and situations in which they can or cannot be used, their purpose (i.e. the way in which they change the position) and the possibility to use them multiple times on the same position. Another key computing concept is the understanding and use of the tools (to change the state of the stage).

Teacher support and commentaries

The pupils usually have no problems discovering and adopting the new way of controlling Emil using arrows. Some might be surprised that Emil can walk "through" trees and houses. If he is standing on a position with a tree or a house, he is basically positioned "in front of" it. When moving upward (from us) or downward (towards us), he will simply walk through the picture.

Another important new feature of the second world is the **panel** which records every command given to Emil as a small square-shaped card. The number of places available for these cards is usually limited.

A1

S: Get Emil to the house. Then complete the task in the workbook.
WB: Draw your path through the stage in blue. Look at it and answer.
Does the same arrow appear more than once in a row in your path?
This is the path that Vicky gave to Emil. Draw this path in red. Did she take a different path?

In this task, the pupils will only learn to control Emil using the four arrows, with each click representing Emil's "step" (movement) by one place in the corresponding direction. Some of the pupils may think that they have to lead Emil to one of the positions that are next to the house. However, the assignment is to move him *to the position with the house.* The task has many possible solutions.

The pupils will then shift their focus to the workbook, where they will be guided by the assignments to focus on the record of Emil's path on the panel and to learn to think about it. From the very beginning, we want the pupils to focus on the **varying representations of the task solution**: (a) the exact record of our commands for Emil symbolised by the cards on the panel, and (b) Emil's movs on the stage and, later, the changes in the content of the positions (Emil will turn on lights, water, colour, collect etc.) In this task, the pupils are supposed to draw the path, along which they led Emil, in the workbook, and to deduce and answer the question if they made Emil walk in the same direction several times.

Then, in the second bullet of this task in the workbook, the pupils will read the record of a different solution to this task (but starting in the same position with Emil), carrying out it by drawing the path on the stage in the workbook (or by navigating Emil accordingly in the screen) and to say whether that solution is correct as well.

A2

S: Get Emil to each house. Then complete the task in the workbook.
WB: Draw your path through the stage in blue.
Create another path that avoids the trees, draw this in red.

The pupils have to control Emil on a "roundtrip" to each of the houses. They may take different procedures but if they take Emil on a "walk" that is too long, they may run out of free places on the panel before completing the task correctly. They will then draw their path (solution) on the stage in the workbook in blue colour (and in a way that suits them but also allows them to reproduce their exact steps and re-read and demonstrate them later).

In the case of the workbook extension, they look for another path and draw it in red on the same stage.

A3 ***S: Now try again: get Emil to each house.***

This task uses the same stage, but the number of places (i.e. steps) on the panel is critically low. The pupils will take Emil in one direction, finding out that it is impossible for them to complete the task. Then, they might try another path, and another one… and start thinking that the task is probably impossible to complete. In the final discussion, we will ask them to explain why. If they come up with an explanation, they will, in fact, have successfully completed the task!

A4 ***S: Turn the lights on in each house. Then complete the task in the workbook.***
WB: Try using the lightbulb on the house with the lights on.
Mark what will happen if you click the lightbulb button on this house. Mark the one you think it will look like.
When Emil uses the lightbulb button twice, what the house look like? Write or draw it down.

The pupils will see a new command for Emil for the first time —a tool that can **turn the lights on** a dark house. It will also be the first time that they encounter a situation when some of the arrows are missing in the screen. However, they might not even notice as the whole stage has only one row of positions.

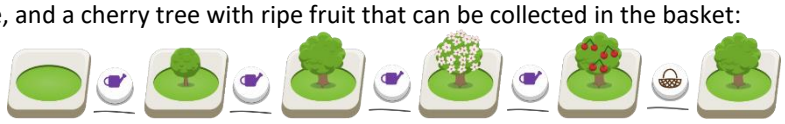
However, when switching to the workbook, they will find out that the light bulb tool can be used to turn the light off as well, even two or more times in a row — working as an actual "switch" on the wall that we use to turn the light both on and off.

A5 ***S: Turn all the red houses lights' on, and the blue houses off. Then complete the task in the workbook.***
WB: Write down your record of commands into the panel.
Count how many times you used the up arrow and write it into the table. Do the same with the other commands.

If the pupils refrain from making too many "redundant" steps when working on the task, they will come to one of several possible (albeit similar) solutions. However, then they have to **redraw the record of their solution in the workbook** and **think about it**: they need to analyse it and count the number of occurrences of the individual commands, filling in the single-line table.

A6 ***S: Try out the watering can. Then complete the task in the workbook.***
WB: Try watering the same position again.
How many waters does it take to change grass into a tree with cherries on?

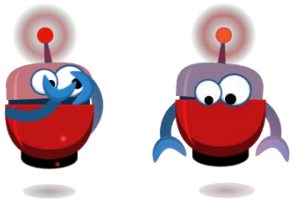
In this task, the pupils will explore the ways and places in which they can use the watering can, including the repeated use of it. They will discover the sequence of "states" of the grass circle to a young green tree, a bigger green tree, a blossoming cherry tree, and a cherry tree with ripe fruit that can be collected in the basket:



A7 ***S: Grow as many trees as possible.***

The pupils now know that they can "plant" a tree by watering the grass circle. However, when solving this task, they should not be distracted by other options such as repeatedly watering trees or turning the lights on in the dark houses as they would not have enough places on the panel.

Group discussion



(comparison with the first world) *How is the second Emil's world different from the first one?* (a different way of controlling Emil and a different environment — there are houses and trees on the stage and Emil walks around, changing the positions — **he changes the state of the positions**; there is a record of every command given to Emil made on the panel; Emil wears different clothes etc.) *Can Emil walk through a position with a house or a tree? Will anything happen to the tree or the house? Has Emil ever blushed to you? Why? In which situation?*

(new way of controlling Emil, movement commands) *How do we navigate Emil now? Why do we need four arrows? What is the number of the same arrows that we can use in a row?* (for example, we can use four right arrows in a row in the first task) *What happens when we use five of the same arrows in a row?*

(tying to the previous knowledge) If we have used other equipment such as the programmable bee Bee-Bot or a software character before, we can discuss the similarities and differences between those experiences and Emil the Keeper regarding the arrow-based way of controlling etc.

(panel with a record) *What is the panel good for?* (we can see how Emil walked and what he did. We can read the record and use the stage to show his final step, the direction from which he came, the number of times he used the watering can etc.) *How many*

places does the record have? How many commands can we record? What will happen if it is full but we give Emil a command anyway?

(**A1**) *Did you successfully read the record of how Viki navigated Emil? Did Viki take different steps than you? Does her record show that an arrow was repeated for a number of times?*

(**A2**) *Did you walk to each house with Emil? Did anyone find a path for Emil that lets him walk without crossing a tree?*

(**A3**) *Who completed the task? And if not, why? Did you try other paths? How many extra places (steps) would we need?*

(**A4**) *Did you use the light bulb on the house which was lit? Did you use it twice in a row, too? Or more times? Would you be able to use the light bulb even six times on the red house? Did anyone miss the up and down arrows? Why not?*

(**A5**) *Which command did you use the most often?*

(**A6**) *Did you try to use the watering can on every position? Maybe even several times? Perhaps on the house? What happened with the grass? Did you water the mushroom as well? Did you use it twice? Or three times? How was the grass changing after watering it with Emil again and again?*

(**A7**) *How many trees did you plant? Did you use the light bulb, too?*

Emil the Keeper • B

Learning objectives

- To understand how several of identical subsequent commands are grouped on the panel into a **stack of commands**.
- To read records of commands with stacks and to be able to draw the corresponding path that Emil took on the stage.
- To write down records with stacks of cards in the workbook. To analyse the records and to write down the total number of occurrences of commands that have been used.
- To explore additional new tools — **build a house** and **paint the house** red, blue and green. To explore the situations in which these tools can be used and if these tools can be used repeatedly.
- To think strategically (algorithmically) when planning steps and solving the problem. To respect the limited number of places on the panel whilst doing so.

Computing-specific content

The pupils will take their first important step on their path toward another key programming concept — **repeating a set of commands** a given number of times. In this particular unit of tasks (and from this unit of tasks onward), the same subsequent commands will automatically be grouped together in a stack with an indication of the number of repetitions. In terms of computing, it is a repetition of a single command (for example, an arrow in one of the directions, or repeated watering) a given number of times.

The pupils will find the **stacking** feature on the panel, they will learn to read and use this notation of the record in their workbooks to instruct Emil and to **follow** them step by step, to **write down** the record of their solutions in their notebooks, and to **fill in the table in the workbook** with the number of occurrences of the individual commands.

The pupils also explore another tool for collecting — the **basket** — and the positions they can use it on, even repeatedly.

When collecting mushrooms, they will create their own solution and use the workbook records to read and instruct Emil with three alternative solutions. They are thus becoming familiar with situations when even a simple task has several alternative procedures that lead to the collection of the same (and, at the same time, the largest possible) number of mushrooms. In the following task, they are to look for alternative solutions that start with various given card stacks. Not every procedure can be successfully completed, though; this is because the pupils face the constraint of the number of places available on the panel.

Teacher support and commentaries

In this unit of tasks, the pupils will see a new concept of **stacking** the same subsequent commands on the panel **into one stack**, and with a way how this concept is visually represented — a stack with the **number of repetitions** indicated in the top left corner.

S: Take Emil to every tree with cherries on. Then go to the house. Complete the task in the workbook.
WB: Draw your path through the stage in blue.
Read the record of commands that David gave to Emil. Draw this path in red.
Is David's solution right?

The pupils will solve the relatively simple task (using one of the several available solutions) and notice a new event on the panel — **stacking of the same subsequent tasks in stacks**. In our experience, the pupils are happy to see the event and they quickly realize the benefit of the new feature — saving places in the record panel.

The pupils will draw a line copying Emil's path in the workbook. Then, they **read a record of another solution**, follow it in the head and draw the corresponding path on the stage using a different colour. Some will instruct Emil to take the path and think about whether the second solution is correct as well.

B2

S: Build houses anywhere possible, each a different colour. Complete the task in the workbook.
WB: Draw your record here, with all the commands and the stacks of commands.
Write down how many times you used each command. Count all the times you painted the houses together.

The pupils will discover by exploration that the house can only be built on the grey "concrete" circle. Some will try to turn the lights on in the house and thanks to that, they will also discover that they can only use the light bulb on a painted (finished) house. However, turning the lights on in the houses is not a part of the task and there are not enough places on the panel to do that anyway. The pupils need to arrive at the conclusion that they will complete the whole task correctly only if they do not use the light bulb tool at all.

Then, they will draw their solution in the workbook — this drawing and reading of records represents a preparatory stage of programming, i.e. planning Emil's future behaviour. Finally, they will rewrite their solution in a one-dimensional table with the number of occurrences of the individual commands. It can be surprising that they have to count and write down all colourings into one cell of the table only.

B3

S: Try out the basket. What is it used for?

The pupils will examine their new tool — the basket. They will discover that they can use it to collect ripe cherries and to pick mushrooms as well (and later, they will be able to collect other objects; however, those will come as a surprise). In the case of mushrooms, they will probably notice (no later than at the final discussion after unit of tasks **B**) that they will only take one mushroom in the basket, meaning that they can use the basket repeatedly with a group of two or three mushrooms.

B4

S: Mushrooms! Pick as many as you can. Complete the task in the workbook.
WB: Here is how your friends solved the task. Check their solutions. How many mushrooms did they pick?
Correct? How many mushrooms?

When working on the task, some pupils will discover a way to collect up to six mushrooms. If not, they will certainly discover that when working on the three additional assignments in the workbook — either actually making Emil carry out the given solutions, or only imagining those solutions in their heads. However, they should make sure that all of the solutions are correct and, what's more, the second one is even quite surprising.

B5

S: Wake up, sleepyheads! Help Emil turn on all the lights. Complete the task in the workbook.
WB: Find a path that starts with this stack of commands.
Did Emil turn on all the lights?

In this task, every step is important given that the number of places on the panel is set up in such a way that prevents the pupils from taking "unnecessary" steps. Two additional tasks in the workbook will help them avoid that as well — if they start by moving Emil to the right, they will not be able to complete the task This is because they need a total of six steps only for turning the lights on, leading them to use the arrows carefully — so that every movement leads directly to the house which needs to be lit up.

B6

S: Turn off all the lights. Watch out for the spooks! Complete the task in the workbook.
WB: What has appeared in the houses? Write or draw what you saw.

The pupils may have noticed in the previous tasks that sometimes, a surprise appears in the houses when turning off the lights. This task mostly aims to help pupils meet a ghost, a black cat or a giant spider at least in some cases.

Group discussion

(stacks of commands) *What is completely new in these tasks?* (the same subsequent commands are automatically grouped into stacks of cards) *What are the stacks good for? How are they helpful? How do we record and "read" them?*

(B1) *How many places on the panel did your solution occupy? Did anyone colour fewer positions? Can you colour even fewer? What is the largest number that we can get with a group?* (a maximum of four arrows — if the stage has five columns; up to four for the watering can; even more for the light bulb…) *Who tried the most repetitions for the bulb?* (up to nine can be achieved) *Can you solve the problem without any stacks? Is Dominik's solution correct? If not, what is wrong?*

(B2 – the number of commands) *Where can you build houses? How many houses did we successfully build? What colours can they be?* (red, blue and green; a grey house is not coloured) *Were we able to turn the lights on in the houses? Who tried that and completed the task? How many arrows in total did you use?*

(B3) *What things can you collect in the basket? Can you pick all three mushrooms from a position? Did anyone collect everything that could be taken?*

(B4) *How many mushrooms did you pick? Is it possible to get more? Did anyone use the watering can? How many steps did Emil have to take? Which of the records in the workbook is correct? How many mushrooms did Emil pick then?*

(B5) *Did you turn the lights on in all houses? Which way did Emil have to go first then? Has anyone found a different solution?*

(B5, B6 – spooks) *Did you find a surprise in the houses?*

Emil the Keeper • after B • Without computer

Learning objectives

- To strengthen the knowledge and skills acquired by the pupils in completing the **A** and **B** units of tasks.
- To think about the use of tools and the order in which they are to be used so that we change the position in a given manner.
- To deduce, by reading the record of Emil's path, the state of the stage before following the commands, the exact starting position and Emil's movement.
- To add the missing **numbers of repetitions** for some stacks of commands in the record of the path.
- To repeat the execution of the same record and to draw Emil's path should he begin in different positions on the stage.
- To determine the previous state of a position according to a given resulting state and the **sequence of tools** applied to it.

Computing-specific content

The pupils continue **reading and executing records of commands** for Emil that include stacks of cards with numbers of repetitions. They draw the path on the stage that corresponds the given record, determining Emil's destination. Therefore, they work with two representations of the path: with the **record of commands** given to Emil, and with the **path drawn on the stage.**

The pupils also read the record of the path in the workbook and see the state of Emil's stage after executing the record of the movements and use of tools. Their aim is to trace back his path and to deduce the previous state of the stage, i.e. to perform **backward thinking** on the given program. In another record, they study the position to which it would lead Emil **if he started in different places on the stage**. Here, the pupils are introduced to the fact that together with the record of a path, we also need to know the starting position to have precise knowledge of Emil's destination. Another option is to know the destination position to be able to deduce the place from which Emil set out on his path.

Another important topic presented in this unit of tasks (and from here onward) is the development of the pupils' understanding of **the way in which a position changes** if we apply a particular **sequence of tools** on it (such as watering can, watering can, basket), of the original appearance of the position before applying the given sequence of tools that led to its current appearance. In computing, we sometimes talk about the state of the position, about the change (operation) performed on it and about the resulting state.

Teacher support and commentaries

1

WB: This is Emil's stage and the three records of commands that he could take.
Read each record and draw the path through the stage in blue, red and green. Where would he finish?

In this task, the pupils need to realize and experience the fact that different **ways of navigating Emil** (that result in different records of his movement) lead him to different destinations from the same starting position.

The pupils will have a chance to further explore and test their solutions in task **X1** in the software.

2

WB: If Emil changes the big green tree into a tree with cherries, we know he has watered it twice!
Always check what the position looked like before and after watering. Draw what tools Emil has used to do this.

In this task and in some others (e.g. **after B7**, **after D3** etc.), the pupils develop their understanding of how a tool or a set of tools change a given position. In this case, we are familiar with the original and the resulting states of the position and our task is to draw the sequence of tools that we need to apply. The tasks often have a number of solutions; for example, the lights in the green house can be turned off by one, three, five… uses of the light bulb. In the final task, there is an indication that the last tool to be used is the basket, with the solution being:

3

WB: This is Emil's record of commands that he took.
This is what the stage looks like once he has finished: Draw in the stage where he started and the path he took.

The pupils must now perform a **backward reading** of the record, thinking about the last command, his previous position, the one before that etc.

4

WB: Our task is to lead Emil across each position on the stage to get to the woods.
This is the record, but some numbers are missing. Complete them and draw the path in the stage.

Based on an incomplete record, the task assignment and the situation on the stage, the pupils have to deduce Emil's precise path. If, for example, the first missing number was less than 3, he would not be able to perform the commands

from the third stack of arrows etc. In this case, too, reading the record both left-to-right and right-to-left will help us to draw Emil's final steps.

In task **X2**, the pupils will be able to look for other correct solutions —other paths for Emil that allow him to move past each position on the stage, arriving in the woods.

5

WB: This is Emil's stage and the record of his path.
If he started at ... how many mushrooms did he pass?

The pupils will be given one record of a path and are supposed to execute it from three starting points. For example, if he started at the blue house, he would cross four places with mushrooms on his way and "miss" a total of five mushrooms on this path.

The pupils will have a chance to further check their solutions in task **X3** in the software.

6

WB: Emil's job is to turn on all the lights and water the tree. Hugh told Emil where to go, but his commands have been broken into pieces.
What is the correct order of the pieces? Number them.

The aim is to correctly order (and number) four two-step pieces of a large record. As we know the given task and the initial state of the stage, we can deduce the location of each piece of the path that is suitable for execution. For example, the top part can be executed only from the red house to the tree, the left part in the middle line can only work when walking from the green house to the red house… That way, we can deduce (without any ambiguity) how exactly Emil walked to complete the whole task.

The pupils will have a chance to further check their solutions in task **X4** in the software.

7

WB: If Emil used the basket twice on a position and there is one mushroom left, there must have been three mushrooms at the start.
Always check what tools Emil's used and what position was left. Draw what the position was like before.

Another task to see how one or more tools affect a position. This time, however, the pupils need to think "from the end": what did the position need to be if a tool sequence made it look this way?

Group discussion

(task 1) *What house does the path drawn with the blue pencil finish at? Which colour will finish at the green house? Which path is the shortest? Which is the longest?*

(task 2) *At which positions did Emil have to use two different tools? Which position made him use the most changing commands?*

(task 3) *What steps did you take and what did you think about in this task?* (one can look at the task — i.e. read the record — retrospectively from the end, but also chronologically from the start, if we consider the first commands in the record: one can turn the lights on at one place only; Emil came to the place using three left arrows, which means that he started in the top left corner)

(task 4) *How did you think when working on this task? What numbers did you add to the empty circles? Would you be able to find a different path that would make Emil walk through every position and finish in the woods?*

(task 5) *What were your results?* (extension) *Would Emil be able to start elsewhere and still execute the record?*

(task 6) *Which piece of the record could be the first one? In your opinion, how did Emil go? What order of the pieces did you come up with?*

(task 7) *Which of these assignments was the most difficult for you? Can any of the assignments have different answers, too?*

Emil the Keeper • C

Learning objectives

- To colour houses in two rows with Emil so that the numbers of colours fulfil a certain **condition** or **conditions**.
- Based on the final state of the stage, to **fill in the table** with numbers of house colours in the top and bottom rows, i.e. to fill in a **table with two rows and two** or **three columns.**
- To look for various combinations of house colours in the top and bottom rows that fulfil a given condition.
- To colour houses **according to data provided in the table** with two rows (the top and bottom rows of houses) and three columns for the number of red, blue and green houses.

Computing-specific content

The pupils see the final state of Emil's stage in the workbook and move Emil in such a way that they create the same stage on the computer — the **assignment** of the task is thus **indicated by the picture** of the final stage in the workbook.

The work of the pupils in this unit of tasks primarily revolves around **numeric tables** that have two rows (one for the top row and one for the bottom row of houses) and two or three columns (for the individual colours of the houses). They learn how to **write down** the numbers of houses **into** each cell of **the table** based on the final stage according to two criteria — the position of the house and its colour. The pupils may either fill in the tables according to their results on the stage, or **read** the numeric data **from the table** and control Emil in such a way that the final stage corresponds to the data. By comparing their solutions, the pupils have an opportunity to discuss whether such table unambiguously determines the final stage or not. A part of these tasks is to **understand a simple or a compound condition** that the numbers of individual coloured houses need to fulfil in the top and bottom rows.

By thinking about various house colours that fulfil one or more given conditions, the pupils develop the **basics of combinatorics** and **mathematical thinking.**

Teacher support and commentaries

S: Follow the task in the workbook.
WB: Use this stage to paint in the street with Emil and answer the questions.
How many red houses are there? How many blue houses are there? How many red houses are there along the top row? How many blue houses are there along the bottom row?
Complete the table: Top row... Bottom row...

The pupils navigate Emil in such a way that he can colour the houses in both rows according to the model in the workbook. In terms of computing, there is an even more valuable activity — the pupils are **working with a table**. In the final discussion, this topic will be our primary focus.

S: Follow the task in the workbook.
WB: Use Emil to paint the houses so that the number of red ones is the same along the top and bottom rows. Look for more solutions.
Solution 1: Solution 2:

This task has a surprising amount of solutions. We can see in the final stage that there has to be at least one red house in the top row, perhaps even two. If the pupils decide to have just one red house, they can still select the house and the colour of the other house. Even if we decide to have two red houses in the top row, we still have an opportunity to decide upon the position of the red house and the colour of the other uncoloured house in the bottom row.

In the final discussion, we focus the most on whether the pupils have correctly understood the **condition** in the task assignment and on the completion — and understanding — of the table. We will discuss the meaning of each cell of the table, along with the sums of the individual rows and columns.

S: Follow the task in the workbook.
WB: Use Emil to paint the houses so that the number of red ones is the same along the top and bottom rows. Do the same with the green houses.
Top row... Bottom row...

This is a more difficult variant of the previous task because the pupils now have to **think about two conditions at once** — about the same number of red houses in both the top row and the bottom row, keeping in mind the same number of green houses in both rows as well. Here, we need to think more thoroughly: how many red ones can and must there be in the top row, how many green ones we need to have in the bottom row, and how to colour the remaining house in the bottom row so that we fulfil the compound condition.

Finally, work with the table is in order again, this time working with a **three-column table**. Again, we should place strong emphasis on the various interpretations of the values in its cells, columns and rows in the final discussion, including a discussion about the question if the first column can contain the values 0 and 2, 1 and 2, or 2 and 2, or a discussion about the necessary sum of values in the first row, the second row etc.

S: Follow the task in the workbook.
WB: Use Emil to paint the houses according to the table
Top row... Bottom row...

This task involves further interesting **work with the table** — the pupils are to colour the houses on the stage according to the data indicated in the table, i.e. to correctly interpret each of the values and navigate Emil accordingly.

Group discussion

(C1) *Let's now look at the completed table in your workbooks only and let's ask each other: What does the sum of both positions in the first row mean?* (the total number of houses in the top row) *What does the sum of both positions in the second column mean?* (the number of blue houses on the whole stage) *What does the sum of all positions mean?* (the number of houses on the whole stage)

(C2) *Can we have zero red houses in the top row?* (no, because there is already one red house in the bottom row) *Can there be one red house in the top row? Or two? Or three?* (one — yes, then there will be a red house in each row; two — yes, but we need to colour one more house red in the bottom row as well; three — not possible as there is one green house already…)

(C3) *How many red houses are there in the bottom row? How many houses do we have to colour red in the top row then? How many uncoloured houses will remain in the top row?* (there are two red houses in the bottom row, which means we have to colour two houses red in the top row; however, there will be no house left uncoloured in the top row.) *How many green houses do there have to be in the bottom row? How many blue houses will be there in the top and bottom rows in the end?*

(C4) *Let's now look at the table in the workbook only and let's ask each other: How many green houses should there be on the stage in total? How many red ones? How many blue ones?*

Emil the Keeper • D

Learning objectives

- To study another new tool — the **match** — and its application on various types of positions.
- To solve problems with further constraints — a missing arrow or two arrows. To think about whether a task with this constraint can or cannot be solved.
- To analyse various alternative solutions and think about which leads to a better result.

Computing-specific content

In this unit of tasks, the pupils work with a new type of **constraint** — when navigating Emil, they may find one or even two arrows missing. Due to that, they will have to look for alternative procedures in order to solve the problem, or to choose an alternative that brings "better" results, or to realize that the task is impossible to solve (**D4**).

In addition, they discover another use of the **watering can** tool and a completely new tool — the match — which they can use to light a fire or to turn the lights on funny Halloween pumpkins.

Teacher support and commentaries

D1 ***S: Grow as many pumpkins as you can.***

A part of the task requires the pupils to discover a place and a way for Emil to grow pumpkins. Perhaps they will try it out on the position directly in front of Emil; however, then they will realize that they will never be able to reach the position in the top row on the right side, which will make them think more carefully about the direction of Emil. The pupils usually realize that they can move through the positions with pumpkins despite the constraints — however, they need to resist the temptation to water other small pumpkins.

D2 ***S: Play with the tools.***

In this task, the pupils need to find out how to use the **new match tool**, the fact that the basket can be used with small and large pumpkins as well, and that we can put out a campfire using the watering can. There are only two arrows available here, but this time, the pupils may not even notice it as the whole stage has only one row.

D3 ***S: It's Halloween! Help Emil carve as many pumpkins as you can.***

Again, there are two arrows missing. As the pupils have to create as many Halloween pumpkins as possible, they will find out that this time, **the constraint is serious**. Therefore, they will have to decide which starting direction — down or left — leads to a better result. They will realize that they will certainly not be able to create funny pumpkins in all pumpkin positions.

D4 ***S: Turn all the lights on.***

It is a situation with a similar constraint. However, this time, the assignment requires us to turn the lights on in each of the houses. The very first step will thus determine the places that will remain unreachable for Emil. This means that the task cannot be completed; however, we can still try and decide the steps that would provide the "best possible" solution.

Group discussion

(missing arrows) *What was the most difficult thing about these tasks? What was missing on the stage? How did you need to proceed and what did you need to be careful about?*

(D1) *Which positions can you grow pumpkins on? How many times can Emil use the watering can on these positions? How many positions did you manage to grow pumpkins on? How many times did you use the down arrow in total? Would you be able to use it more times?*

(D2) *Which tool is new here? What did you find out about the tools? To what positions can we apply the match?* (the fire pit and large pumpkins) *And the watering can?* (the burning fire pit, too)

(D3) *Did you make do without the two missing arrows? On how many positions did you carve funny pumpkins? Is it possible to get more? How did you think? How did you proceed?*

(D4) *Can you turn the lights on in an uncoloured house as well? How many houses on the stage need to have the lights turned on? How many did you manage to turn the lights on? Why not all? If we started with the down arrow, in how many houses would we be able to turn the lights on?* (either in two, or — if proceeding cleverly — in three) *If we started with the left arrow, how many houses would we be able to turn the lights on?*

Emil the Keeper • after D • Without computer

Learning objectives

- To strengthen the knowledge and skills acquired by the pupils in completing the previous units of tasks.
- To add the missing numbers of repetitions for some stacks of commands in the record of the path based on the initial state of the stave and the task that Emil fulfilled.
- To indicate the pieces of ungrouped records that could be placed in stacks.
- To determine the resulting state of a position based on the type of the position itself the sequence of tools applied to it.
- To determine the final state of the stage based on the initial stage and a given record of steps.

Computing-specific content

In this unit of tasks, the pupils **think about the records of commands** for Emil and work with them: they **read** these commands and **think about their structure**; based on the initial situation on the stage and the task that Emil had to complete, they **complete the record with the missing numbers of repetitions** in some stacks, or, in the case of a stackless record, they **mark** the cards that should be grouped. They read the given record and, based on the initial situation on the stage, they **execute it in their head**, determining which of the three alternatives corresponds to the resulting situation on Emil's stage.

Furthermore, the pupils develop their understanding of how a given tool sequence changes a given position — they choose an alternative from a set of possible solutions, selecting the one that correspond to the resulting position.

Teacher support and commentaries

1

WB: This is the stage at the start:
The record below shows what Emil did to collect all the mushrooms, but something is missing.
Add in the missing numbers into the circles.

The pupils see the initial stage and the record of how Emil moved to collect all mushrooms on the stage. Their task is to **execute the record** step by step **and realize** the exact position of Emil when collecting mushrooms — and how many of them he can take.

The pupils will have a chance to further check their solutions in task **X5** in the software, with an opportunity to use the available tools to create a program which makes Emil collect even more mushrooms.

2

WB: Some commands are stacked together, like below:
Below mark the cards that can be stacked together in these records:

In this task, the pupils think about records, reading them and marking which cards could be placed in stacks. It is a simple task, but it is very important as it helps us to make sure if all pupils in the class understand the concept of stacking a set of repeating cards in a stack.

3

WB: Emil will follow the instructions below, this will change the positions. What they will look like once he is done?

Another task that develops their thinking in terms of the state of position, one or more tools applied to it, and the resulting state. In this case, the sequence of tools (operations) is also expressed by stacks of repeated tools such as  or  .

4

WB: This is Emil's stage at the start:
Emil then followed these commands:
What will his stage look like after he is done? Mark the right one.

This is another task suitable for use as a tool to evaluate the pupils at the end of the first half of the second world; the pupils are to read a record with cards and card stacks, execute it in their heads with Emil for a given initial stage, and to mark the final stage that corresponds to the execution of the whole record.

The pupils will have a chance to further check their solutions in task **X6** in the software.

Group discussion

(task 1) *How did you think when working on this task? How did you proceed? What numbers did you write down in the workbook and how are they related to Emil's stage? What will his stage look like after executing these commands?*

(task 2) *Which cards in these records do not stack? Which record will be the longest after having grouped cards into stacks? Which one will be the shortest?*

(task 3) *At the end, some of the positions in the bottom row will not be connected to any position or tools in the top row. What assignment would you create for these positions?*

(task 4 — extension) *Only one of the solutions on the right side is correct. Are you able to create such a record of commands for Emil so that the first option becomes the correct answer? And the same for the second option?*

Emil the Keeper • cut-out appendix at p. I

Cut out your Memory Game and play with Emil

[Do not perform this activity before the pupils complete the tasks from unit of tasks **D** or **after D**. After that, you can play it anytime you find it suitable.]

It is the well-known Memory Game with 20 cards (10 pairs). However, the pairs are quite unusual: the first card of the pair is always a position from Emil's stage, together with a picture of a tool, e.g. a blooming flower and a watering can, or three mushrooms and a basket. The second card of the pair is the position that results from the application of the tool on the first position by Emil. For the first example, this would be a cherry tree with ripe fruit; for the second example, it would be a position with only two mushrooms.

The pupils cut out the cards from the workbook (on the first page of the pasteboard appendix in the middle of the workbook). They will become familiar with the cards by pairing them correctly and realizing that the "first" card of the pair always bears the initial state of the position and the tool, and the "second" card of the pair bears only the resulting state of the position:

Then, they can play according to the well-known rules of the memory game, playing in pairs: they place the cards with the wrong side up in a regular arrangement of 5 x 4 or 4 x 5 cards. Then, they make moves. One turn consists of turning two cards. If they match, the player takes them and takes another turn. If they don't match, the player turns both cards to the wrong side again and the other player takes a turn. The goal is to collect as many pairs as possible.

Computing-specific content

In a playful way, the pupils strengthen their perception of the change of state which the individual positions on the stage undergo after applying a tool to them — for example, watering a mushroom using the watering can tool will cause another mushroom to appear on the position, which will then contain two mushrooms. Given that the pairs of the "same" cards in this game are quite unconventional, the pupils develop their **perception of states and tools** in two directions: if we turn the card with the position and tool first, then we know that we are looking for a card with a position that will show the resulting state. If we turn the tool-less card first, we know we are looking for a picture of the original position and the tool that will change its state to this result.

Emil the Keeper • cut-out appendix at p. VII — IX

A board game with Emil, a die and counters.

[Do not perform this activity before the pupils complete the tasks from unit of tasks **D** or **after D**. After that, you can play it anytime, at various occasions.]

This is a board game for two players. The players will need:

- a game board with 5 x 4 empty positions — they can use the workbook if they open it on pages VII – VIII of the appendix on the pasteboard pages in the middle, or they can cut out the board and place it on a hard surface (from any side they wish.
- 20 playing cards from page IX —four mushrooms, five trees, four positions with pumpkins and seven houses. Let us notice that there is a corresponding number of positions on the board — four positions ready for mushrooms, four for growing pumpkins etc. The pupils can cut out these cards from one of the workbooks (a pair needs exactly 20 cards, i.e. cards from one workbook),
- a paper figure of Emil that they cut out from page IX, fold it and glue it together — that will be their playing figure,
- **two paper dice** — both players will cut out, carefully fold and glue the playing die from their workbooks on page IX. Let us notice that there are three pages showing moves (with one, two or three steps and three tools — a watering can to water, a basket to collect, and a house to build.

Attention: when cutting out page X, keep the bottom part, which will be used in the third world.

The goal of the game is to **place** or **take** as many playing cards on or from the stage as possible — for each such action, the player who executed it will be awarded one point. The first player to **reach ten points wins**. We play like this:

- the pair will place the game board in the middle and set the 20 playing cards — pictures up — on the table next to the board.
- They place Emil on his starting position in the top left position,
- taking the turn, the pupil **rolls two dice** which will display either steps or tools:
  - **if the player rolls two tools**, he or she will attempt to apply them (in any order). This is possible if Emil is standing on the position which allows the use of the tool and a card with the resulting state is available. If the die rolls a watering can and Emil is standing on an empty position for pumpkins, the player places a pumpkin counter under Emil and **gets a point**. If the player rolls a basket and Emil is already standing on a position with the card of a mushroom, the pupil takes the card, places it back among others and **gets a point** (Note: if Emil is standing on a card with a mushroom and the player rolls a watering can, we cannot use it as we have no card with two mushrooms),
  - **if the player rolls steps and a tool**, he or she will attempt to apply them (in any order). However, the steps do not mean a movement in one direction, but taking one, two or three steps in any direction on the board — from a position to another position. The player will probably try to take Emil to such a position where he or she will be able to use a tool,
  - **if the player rolls steps twice**, the player will use them all with Emil; again, the order and directions are up to the player,
- the pupils make moves.

Some possible variations

- If the player rolls two tools and neither of them can be used on the current position, the player rolls both dice again — until he or she can take at least one set of steps or use at least one tool.
- 20 cards are shuffled and each player gets ten random cards. The player now has only the ten given cards at his or her disposal. If the player can take a card from the game board, it is then placed into his or her stack.
- We turn the 20 playing cards next to the game board with the wrong side up and randomly turn around five of them; only those will be now available. When the player is able to place one of the cards on the board, he or she turns around another card from the remaining cards.

Computing-specific content

Similarly to the Memory Game, this game also helps the pupils to develop their understanding of the relationships between the positions and tools — when and with what tool can a position be changed and what the resulting state will be.

Emil the Keeper • E

Learning objectives

- To plan in advance — i.e. to **program** — the whole path for the sleeping Emil. Then, to wake him up to **carry out** our plan.
- To plan various solutions of the task in such a way that we fulfil additional supplementary conditions.
- To discover the eraser on the panel when planning the path as a new tool to correct wrong steps (before waking up Emil).
- To plan a solution of a task with other constraints, e.g. with one of the movement arrows missing.

Computing-specific content

Instead of working with the command record, the pupils are starting to **plan future steps** (commands) **for Emil** that will lead him to the completion of a given task. They compose their plan in the same way that they used to directly control Emil, i.e. by clicking the arrow and tool buttons. However, these are not carried out immediately and are only **recorded on the panel**. Together with that, the pupils need to **execute** the individual steps **in their head** in order to know where Emil would be located (the position and the type of a position), and **what is the next command** to be given. Just like in the first world, they will wake up Emil in the end and have him **execute** the whole program — if that is possible.

For a given task, they also plan various alternative solutions and extensions (e.g. *to also take two mushrooms on the way*).

The pupils will learn to **correct** the program input continuously **using the eraser** — a new tool on the right side of the panel (but only until they wake up Emil to run the program).

The pupils need to respect the limited number of places on the panel whilst planning their solution. Whilst for some tasks, there are several possible solutions that will fit into the places on the panel, for others, there is only one correct solution with the same number of steps.

Teacher support and commentaries

This is the first unit of tasks in the second world where the sleeping Emil gives the pupils a hint that direct control is going to be replaced by real **programming** — the pupils first have to **plan the whole solution** and only then do they wake up Emil to **follow** their program. What is important is the fact that the planned solution, i.e. the program that is being composed on the panel above Emil's stage, is recorded in the same way that the pupils already know from the previous tasks.

E1

***S:** Follow the task in the workbook.*
***WB:** Emil has to turn the light off in the blue house. Program his path and then wake him up.*

Try again but this time Emil needs to turn off the light AND... pick one mushroom on his way, pick two mushrooms on his way, pick all three mushrooms on his way

The pupils complete the first part of the task by simply moving Emil to the blue house — either starting by moving right and then up to the house, or first moving up and then right. However, the additional extensions in the workbook are more interesting — we suggest that the pupils look for such a solution that allows Emil to collect mushrooms whilst on his path: one, two or three. When looking for a solution for three mushrooms, the pupils face the constraint of the number of places on the panel.

E2

S: Follow the task in the workbook.
WB: Program the path for Emil to turn all the lights on, write it down below:

The pupils will plan Emil's whole path so that he can walk to each house and turn the lights on, execute the program and record it in their workbooks. The task has several solutions and in some cases, the pupils will not need to use all of the places on the panel.

E3

S: Follow the task in the workbook.
WB: Now Emil is to pick all the mushrooms and turn off all the lights. Write the program below.

In this task, a lot depends on whether we decide to plan Emil's path in such a way that he first collects the mushrooms to his right, or walks up and then right… Whilst the pupils will successfully plan the whole first solution, they will not be successful with the second one due to the number of places on the panel.

E4

S: Follow the task in the workbook.
WB: Emil needs to light all the campfires he can. Emil lit up ... campfires.
Now: what if a different arrow was missing? In each picture, draw your path. Count how many campfires Emil can light.
Emil lit up ... campfires.

The pupils complete the first task on the computer, noticing that they do not have the left arrow. Therefore, they need to look for such a procedure (algorithm) that will only require Emil to walk up and down in each row and move between the columns from left to right.

Then, they complete three variants of the task in the workbook; the stage is the same, but the arrow which is missing is different.

Group discussion

(programming Emil) *What does it mean when Emil sleeps? Have we ever seen him sleep? How do we solve a problem in that case? How do we use the commands and the panel now?* (Until now, Emil always executed each command immediately — if possible — and a record of that was made on the panel. Now, we will be planning all of his steps ahead and the whole program will be executed only after we wake Emil up. We use the words **record** and **plan** or **program**.) *Has anyone noticed the eraser at the end of the panel? How can we use it?* (to remove the last planned step of the plan)

(**E1**) *How many places on the panel are enough for Emil to turn off the lights in the blue house? Can he do that using more places? Can he do that with fewer places? Did anyone make a program (plan) that would let Emil collect one mushroom on his path as well? What about two? What about three? If not, why? Can anyone collect all the cones from the fir tree in the bottom right corner instead of mushrooms?*

(**E2**) *Has anyone found a solution that starts with Emil moving left? And right? And then?* **Extension:** *Can anyone plan Emil's path in such a way that the last house where he turns the lights on will be the green one? What about the blue one?*

(**E3**) *Has anyone found a solution that starts with Emil moving right? And up?*

(**E4**) *Which fire does Emil have to start first? Answer the same question for each extension assignment in the workbook.* **Extension:** *For each of the four assignments, say: Which fire can you start as the second one?*

Emil the Keeper • F

Learning objectives

- **To analyse a program** on the panel and study its **structure**. To recognize command pairs that repeat for several times in a row within the program.
- To plan a program in such a way that it repeatedly uses a given pair of commands, such as the combination of basket and right arrow.
- To plan a program and identify a trio (or quadruplet) of commands that are repeated immediately after each other.
- For a given situation on the stage, to look for solutions that repeat various pairs of commands.

Computing-specific content

An important aim of primary-school computing is to learn how to **perceive a program as an object** that has its **features** (such as the length) and can be examined, read, run, modified etc. It is also important to examine its structure such as pairs of steps (cards) that are repeated several times next to each other in the program. By becoming aware of such a repeating pair of commands (later also triples or fours of commands) in the program, the pupils familiarize themselves with an important programming concept, the **repetition of several commands**.

In this unit of tasks, the pupils will develop their skills in their perception of the structure of a program, e.g. in perceiving pairs (or groups of three, or four) repeating commands.

Teacher support and commentaries

F1

S: Get Emil to put out all campfires. Then complete the task in the workbook.
WB: Write the program and circle the pairs of commands that are next to each other.
This pair of commands is repeated ... times in my program.

The panel with the program contains the first two steps that have to be repeated three more times. They will then record their program in the workbook and think about its structure, i.e. **which two commands are repeated in it.** In the discussion, we return to this task to think about whether we can label other elements as repeating pairs in the same program.

F2

S: Help Emil pick all the cherry trees. Complete the task in the workbook.
WB: Draw the pair of commands that keep repeating:
Now plan a path where this pair will repeat. Solution:

Here, we see that the pre-made commands on the panel lead Emil two positions down, allowing him to start performing repeated steps: go left and harvest cherries; this can be repeated four times. We then ask the pupils in the workbook whether they can come up with a solution that allows for a repetition of a different pair of commands, namely basket and right arrow. This variant of the task also has solutions — two solutions, in particular. In the first solution, we keep the two down arrows on the panel, then we move Emil to the opposite side of the stage by using four left arrows, and start harvesting cherries from left to right.

However, someone in the class may find out that the prearranged down arrows can be removed from the panel using the eraser tool and that they can start moving Emil in a different way, say, to lead him to the opposite side of the stage horizontally.

F3

S: Help Emil paint all the houses the same colour and turn the lights on. Complete the task in the workbook.
WB: These three commands repeat themselves in the program:
This group of three is repeated ... times.

In this task, the pupils choose one of the colours and will execute four repetitions of the following three commands: colour, turn the lights on, and move right. They may even try a solution that allows Emil to move to the first border of the stage, to paint and to turn the lights on in the houses from right to left.

F4

S: Help Emil turn on all the lights and light the campfires. Complete the task in the workbook.
WB: Draw the group of commands that repeat in the program:
Try to find another solution. I found one: Yes No

The first arrow on the panel suggests that the pupils need to start their search with Emil by walking upwards, perhaps repeating the four commands **up, turn the lights on, right, start the fire**. In the workbook, we suggest that they look for a different solution. Therefore, they will try to move to the top right corner, turn the lights on, and start the fires from the other side. However, they will face the constraint in terms of the number of free places on the panel.

F5

S: Help Emil turn on all the lights. Complete the task in the workbook.
WB: Find the solution where this pair is repeated.
I found one: Yes No
Which pair of commands repeats itself in the program?
Find the solution where this pair is repeated.

The pupils also try to navigate Emil in such a way that he visits the unlit houses “clockwise” or “counter-clockwise”. In both solutions, various commands will appear, but there will be at least two occurrences of **repeated movements in the top row and turning the lights on** — the exact groups of cards that we ask about in the workbook.

F6

S: Help Emil grow cherry trees everywhere he can. So let him water! Complete the task in the workbook.
WB: Which pair of commands repeats itself in the program?
Find another solution with a different pair that repeats.

If Emil wants to have only ripe cherries everywhere in the garden, he has to walk through the trio of small cherry trees and to water them well either from the bottom to the top, or from the top to the bottom.

Group discussion

(**F1**) *How many times do you repeat the command pair **step right** and **watering can** in your solution? How many places does your program occupy? Look at your program again and say: does the command pair **watering can** and **step right** repeat in it, too? How many times?* **Extension:** *Start over and remove the two commands on the panel using the eraser tool. Now, try to complete the task in such a way that Emil first walks all the way to the right and then he puts out all the campfires from right to left. Which card pair is now repeating on the panel?*

(**F2**) *Did you complete the task successfully? What are the two commands that keep repeating in the program? Why do you think there are two steps down pre-written on the panel? If we want to make a completely different solution, can we get rid of them?* (Yes, using the eraser. However, we can still complete the workbook extension with them — after walking two steps down, the pupils just need to move Emil by four steps to the left and start collecting cherries from left to right.) *Did you make a solution that repeats the commands **basket** and **step right**?*

(**F3**) *Which three commands repeat in your solution for a number of times?* **Extension:** *Has anyone found a different solution that lets Emil move from right to left?*

(**F4**) *Which group of commands is now repeating on the panel? Has anyone found a different solution?* (No, and it is not possible either, because if we want to start from the top campfire and move to the right and down, we will not have enough free places on the panel.)

(**F5**) *Did you complete both assignments? Can you find a solution that repeats the **double right arrow** and the **light bulb**? And the second assignment from the workbook?*

(**F6**) *Which group of commands repeats in your solution? Does Emil go from the bottom to the top? Has anyone found a different solution? Can he go from the top to the bottom instead? What group of commands repeats in such solution? How many times?*

Emil the Keeper • after F • Without computer

Learning objectives

- To strengthen the knowledge and skills acquired by the pupils in completing the **F** unit of tasks, i.e. to think about the structure of the planned solution and notice if there are repetitions of commands next to each other.
- To realize that some of the card pairs in the program are repeated next to each other and that some repeating pairs are separated by other cards.
- To realize that the same card can create a pair either with the preceding card or with the following card in the program.

Computing-specific content

Furthermore, the pupils strengthen their **perception of the structure of a program** (either provided in the workbook, or created by themselves). In terms of computing, it is important for them to understand that the pairs (or groups of three…) cards can be repeated in the program either **next to each other** or **separated by other cards**. The former situation **prepares them for repetitions** in programs that we start creating precisely in this world, whilst the latter **prepares them for the use of procedures** that we will start building in the third world and in both worlds for Year 4.

In addition to noticing the pairs of cards that repeat next to each other in the program, they also focus on **determining the number of repetitions** in to prepare for using repetitions of a sequence of commands certain number of times.

Teacher support and commentaries

1

WB: Emil has to collect his washing according to the program.
Read and complete: This pair is repeated ... times in the program.

The pupils read a simple program that contains a recurring pair of the cards **step right** and **basket** — i.e. **collect washing**. (The pupils have to deduce this use case for the basket tool as they have not experienced it before.) Then we want them to study the program in detail and to look for repeating card pairs.

2

WB: This is Emil's program. Read it and answer.
This pair of commands is repeated right next to each other in the program. Yes No
Note that this pair of commands is repeated but are not next to one another in the program.

In this task, we want the pupils to develop their understanding of the fact that **some card pairs in the program are repeated immediately after each other** and **other pairs might be repeated, but not next to each other**. This is because in the following unit of tasks, the pupils will discover an option to create a joint double card from a card pair and discover that if there are several double cards next to each other, they will become grouped in a stack. Therefore, it is important for them to realize the difference between repeated "pairs going one after another" and "pairs not going after one another".

3

WB: This is another program for Emil.
Draw the pair of commands that is repeated three times next to each other in the program.

Draw the pair of commands that is repeated only twice next to each other in the program.
Which of these pairs of commands is repeated in the program but not next to each other?

This task further elaborates upon the same event — that some of the card pairs in the program are repeated next to each other and others are not.

Group discussion

(task 1) *Has anyone found a different card pair that is repeated in the program?*

(task 2) *Is the first card pair from the workbook repeated in the program? How many times? What about the second one? How many times does the pair **step up** and **watering can** repeat in the program? Circle them and say how many cards divide these pairs.*

(task 3) *Which card pair is repeated immediately after one another for three times in the program? Which pair is repeated, too, but only twice? Which pair is repeated in the program, but the pairs don't follow each other?* (**step up** and **light bulb**) *How many cards divide the pairs?* (seven)

Emil the Keeper • G

Learning objectives

- To discover how the individual cards that immediately follow each other can be joined in a double card.
- To discover that when the same double cards are repeated next to each other in the program, it is automatically grouped in a stack of double cards.
- To read a program with stacks of cards and double cards from the workbook, to build it in the computer and to execute it.
- To create programs for Emil that utilize stacks of double cards. To realize that it is only possible to plan a complete solution thanks to the stacks of double cards, even if the number of places on the panel is severely limiting.

Computing-specific content

We use the **repetition of a group of commands for a number of times** in programming in order to cut the **length of the program** and to emphasize a certain **regularity in the steps of the planned procedure**. In order to make the pupils realize this, we have selected the number of available places for the program on the panel for all tasks of the **G** unit of tasks in such a way that it does not suffice unless we make use of repetition.

The pupils will learn how to merge two cards into a **double car**d. If such double cards repeat for a number of times next to each other in the program, they are grouped in a stack of double cards. Therefore, if we needed eight steps to put out the campfires in task **F1**, now we only need a stack of four double cards to do the same in task **G1.** However, to be able to create them, we need a total of four empty places on the panel — the first two to stack the already-created double cards and the other two to allow us to enter two more repeating steps until we merge them into a double card.

The pupils also read programs from the workbook that include stacks of cards and double cards, **creating** the same programs for Emil and improving their **perception of a repeated structure of steps** in the planned solution to a problem.

Teacher support and commentaries

G1

S: Follow the task in the workbook. Note that you can connect two cards in one.
WB: How to merge two cards into one:
With Emil, put out all the campfires. Solve the task and answer: How many double cards did you stack? ... How many free places on the panel do you have left?

First, the pupils learn to merge two neighbouring cards on the panel according to the picture guide — on the panel, they first click on one of the two cards, subsequently clicking on the other one as well. (Sometimes we see that they attempt to merge the cards by dragging them on the panel; however, this is impossible.) Some of the pupils will solve the task having only a stack of four double cards on the panel, others will have a stack of three double cards and the last two cards left unmerged on the panel. Both solutions are correct. However, we should point out a small difference in the discussion — the stack of four double cards indicates more clearly that the very same activity is repeated for four times: go right and put out the campfire using the watering can; in addition, two more places are left empty on the panel, which would allow us to use them if needed.

G2

S: Follow the task in the workbook.
WB: Emil needs to pick all the cherries. Try these programs:
Does Emil pick all the cherries? Yes No

The importance of this task lies in the fact that the pupils practice reading the programs with stacks of cards and double cards along with their creation on the computer. They execute each program and see if it solves the given problem correctly. They also see that there are actually several ways to solve the problem, but given the number of places on the panel, it is always impossible to do so without making a stack of double cards.

G3

S: Follow the task in the workbook.
WB: Use Emil to grow the pumpkins, solve the task and answer:
Which double card is repeated in your program? Mark it.
How many times is this pair repeated?

The task is quite unusual thanks to the fact that Emil also needs to change his starting position, which may remain unnoticed by some of the pupils. All of the three double cards found in the workbook seem suitable for completing the task — if we think about it
with the knowledge from the previous task. However, the first option is impossible to complete due to the fact that we would need one more empty place on the panel. Some pupils might struggle with the option on the left side as well; however, there is a solution to it (see right):

The third option is simple if the pupils realize that they can use the watering can to water the position below Emil at the very beginning of the program and that they only need to water the fifth position at the end.

G4

S: Put Christmas lights on the fir tree by following the pinecones.

This task only prepares the pupils for the next task — the pupils need to make a "deal" in which they agree that the green rings with cones represent a "forest path" and it serves as the only way for Emil to reach the fir tree. Another new feature is the use of the light bulb on the fir tree.

G5

S: Follow the task in the workbook.
WB: Follow the path of pinecones to the fir trees and light them up.
How many times is this double card repeated in your program?

To program this task, the pupils need to create a stack of three "zigzagging" steps using double cards and another group of double cards to move and turn the lights on the fir trees.

Group discussion

(double cards) *What do we use the double cards for and why do we want to use them? How do we join two neighbouring cards together? When do we do that?* (when two of the same cards are repeated at least twice) *Which card do we need to mark first on the panel?* (it does not matter, either the first one or the second one) *Can you split a double card? Can you erase a double card using the eraser?*

(G1) *How many double cards have you got on the panel? How many empty places were you left with? Can you program Emil in such a way that he puts out the fires from right to left?* (yes, but we need to remove the four prearranged commands on the panel using the eraser tool)

(G2) *Have you made these three programs on the panel and tried them out? Which one completed the task correctly?*

(G3) *Which double card did you mark in the workbook? Has anyone found two different solutions? Can you complete the task using the double card which is in the bottom left part of the workbook page?*

(G4, G5) *Which positions represent the forest path on Emil's stage? Did you turn the lights on the fir tree (or all three of them)? How many stacks of double cards have you got in your programs?*

Emil the Keeper • after G • Without computer

Learning objectives

- To strengthen the knowledge and skills acquired by the pupils in completing the **G** unit of tasks (planning with double cards).
- To deduce whether we can use a given double card (or a given pair of double cards) when completing a task.
- To repeat the execution of a given double card to perform a zigzag movement and to deduce Emil's destination.
- To read a program made of simple cards and to mark the cards that could be grouped into stacks of cards and stacks of double cards.
- To deduce the number of steps that a given program would have if it was impossible to group cards or double cards in stacks.
- For a given program with stacks, to complete a table with the number of occurrences of each command.

Computing-specific content

The pupils further develop their **perception of recurring double steps** in the task solution plan. For a given double card in the workbook, they have to decide whether they can use it in their programs. They repeat the activity with various pairs of double cards — it is as if we offered them two small reusable structures (double steps) to help them express their solutions.

To deepen their understanding of the stacks of cards and double cards, the pupils may either group cards in stacks or ungroup the stacks in order to think about the difference in the **length** of the program with stacks and without them; they will be counting the occurrences of the individual commands in the program. They are also learning to read **programs with stacks of cards and stacks of double cards** and by executing them on paper, they deduce the destinations to which these lead Emil in his stage.

Teacher support and commentaries

1 ***WB: Emil needs to turn all the lights on. This is his stage:***
Which of these double cards will help you to plan the solution?

The pupils might combine two procedures in their thinking: they will complete the tasks in their head and look among the alternatives for a double card that will correspond to their solution. Subsequently, they may think about whether they are able to imagine a solution that would make use of different suggested double cards.

As we do not see any constraint in the number of places on the panel, even the first card, which is otherwise quite useless, could be used; however, this would be completely unnecessary and the work itself would have to be performed by a stack of the second or third double card presented. In order to refuse such "unreasonable" procedure, we should certainly mark the second and third option.

The pupils will have a chance to further explore and test their solutions in task **X8** in the software.

2 ***WB: Now Emil needs to turn all the lights on and collect the washing.***
What pair of double cards could you use to solve the task? Yes No

Now, we ask the pupils if they can imagine a solution to the task that would contain stacks of double cards **A**, or **B**, or **C**. The first two options quite naturally correspond to the strategies when Emil moves clockwise (option **A**) or counterclockwise (option **B**). Double cards from the option **C**, however, are completely useless; the second double card cannot be used in any situation.

The pupils will have a chance to further check and develop their solutions in task **X9** in the software.

3 ***WB: Look at these double cards for zigzagging.***
If Emil started at the blue house and repeated this double card, where would he end up? Draw in the stage and write down.
If he started at the red house? ... If he started at the green house? ...

This task represents a preparation of sorts for a new form of repeating two commands (in this case, walking zig-zag) which the pupils will encounter in Year 5 or 6, i.e. *repeat while possible*, i.e. an unknown number of times. It is possible to zigzag to the right and down from the blue house three times and finish at the red washing. However, some pupils will mark the green fir tree in the bottom right corner saying that in the fourth repetition, only the first command from the double card will be executed; **this is impossible**, though.

In the case of the second zigzag, they finish at the green washing. Starting at the green house, the zigzag path will lead them to the blue washing.

4 ***WB: Copy this program into the panel below, but shorten it by stacking cards and double cards.***

A repetition of what the pupils have already done — they are to redraw a stackless program into the same program, but utilizing stacks of cards and double cards as well.

5 ***WB: Emil is going to carry out these programs. Draw his path and mark the houses that he would turn the lights on in.***

This task serves to practice reading programs with stacks and to carefully execute the program on the stage in the workbook. In the first case, Emil will turn the lights on only in one house, located in the top right corner of the stage. In the second case, he will turn the lights on in the whole top row of five houses.

The pupils will have a chance to further check and develop their solutions in task **X10** in the software.

6 ***WB: If the cards had not been stacked, the program on the right will have seven places. Draw them here:***
Without stacking, the program would have ... places.

The opposite of the procedure in task **4**: the pupils need to calculate the number of places that each of the programs would need if it did not utilize the feature of stacking cards and double cards.

7 ***WB: How many times will Emil use each command? Count and write them into the table:***
And now?

Another task that practices the reading of a given stack-based program. The pupils need to carefully count the number of times each of the command is used in the program — and to write down the resulting counts in the table.

Group discussion

(task 1) *What does the first double card do? Does it make any sense?* (it only takes Emil one step left and back. However, if we used it for a number of times at the beginning of the program and then completed the task using other steps and double steps, it would be harmless despite making no sense) *Can you complete the task using the second double card? How many times would you use it? What about the third double card?*

(task 2) *How can we solve the task using the first pair of double cards? What about the second pair? What about the third one?*

(task 3) *If Emil starts at the blue house and uses the first double card (**right** and **down**), how many times can he repeat it? Three times? Three-and-a-half times or four times? If he starts at the red house, where does he finish and how many times can he use the zigzag double card? And if he starts at the green one?*

(task 4) *How many places on the panel does your program with stacks occupy?*

(task 5) *How many houses remained unlit on the stage after Emil executed the first program? How many times did Emil use the right arrow? How many houses were left unlit after Emil executed the second program? Which arrow did he use most often?*

(task 6) *How many places would the first program occupy without stacking? What about the second one? What about the third one?*

(task 7) *How many times did Emil use the right arrow in the first program? How many commands in total did Emil use in the second program?*

Emil the Keeper • H

Learning objectives

- To discover how **triple cards** are created and how they are grouped in stacks when repeated.
- To read a program with stacks of cards, double cards and triple cards from the workbook, to build it in the computer and to execute it.
- To decide which of the given triple cards suits our solution of a given problem.
- To consider whether a given task cannot be programmed using **stacks of double cards instead of a stack of triple cards**.

Computing-specific content

In this unit of tasks, the pupils deepen their understanding of the **significance of repeating a small group of commands** (this time, even three or four) in a program.

Teacher support and commentaries

H1

S: Help Emil paint all the houses the same colour and turn the lights on. Connect three cards in one.
WB: How to merge three cards into one:
Try these solutions: Solves the task? Yes No
Do not forget you can delete cards on the panel.

The pupils will learn to join even three commands in one card. When completing this task, it will prove useful to them, although the workbook extension lets them think and try several other solutions, e.g. using stacks of double cards. In that case, however, they need to use the eraser to erase the pre-written three steps on the panel.

H2

S: Collect all the washing. Complete the task in the workbook.
WB: Collect the washing.
Which of these triple cards will you use?
Try to find another solution. Did you find one? Yes No

Another task to create a program with a stack of triple cards. This time, the extensions in the workbook do not offer various other (correct or incorrect) solutions, but three different triple cards only. We suggest that the pupils decide whether they can solve the task using these triple cards as well. Although the first option looks promising, it will not be possible to solve the problem this way as we would need one more place to be able to create the second and third triple card of the same type. The third option looks promising as well, provided that we begin at the blue house with Emil. However, if we move him there, we will lack the necessary places to create the triple cards.

H3

S: Help Emil water the blooming cherry trees and collect the cherries. Complete the task in the workbook.
WB: Use the triple card in the solution:
Find a solution that does not use any triple cards. Did you find one? Yes No

Using the triple card from the workbook to solve the problem is relatively simple. The pupils then look for another solution that will make to with stacks of single and double cards. On the right side, we see a solution which utilizes double cards.

H4

S: Follow the task in the workbook.
WB: Now Emil needs to turn on all the lights and light the campfires.
Can you solve this task with quad cards? ... with triple cards? ... with double cards? Yes No

In the final task, the pupils will create a quad card by generalizing their previous experience, or they will look for an alternative solution for which triple or double cards will suffice. In fact, the task can be completed using two stacks of

triple cards; however, we would need one more place on the panel. Given that the whole task is built around the "zigzag", we cannot solve it using stacks of double cards.

Group discussion

(triple cards) *Who was able to join three cards? When is it useful to join them like this?* (when there are several repetitions of three commands in our programs) *In which order did you click on the cards?* (it does not matter at all — for example, we can create a double card, click on it again and then click on the third one. An interesting approach: we click on the first card of the three, then on the third card, and, finally, on the middle card) *Can you split the triple card? Can you cancel it?*

(H1) *Which of the given programs completes the task correctly? How do these programs differ? Which one do you like the most? Why?*

(H2) *Did you complete this task using the first triple card from the workbook? What about using the second one? What about using the third one? If not, why?* (the task could be completed using the third triple card as well; however, we would need two more places on the panel in order to create the second and third triple card of the same kind. Be sure to try it.)

(H3) *How many empty places were there on the panel after you completed the task using triple cards? Did anyone complete the task without using triple cards?* (perhaps someone used two different double cards, see the solution above)

(H4) *Did you complete the task successfully using a stack of quad cards? How many remaining places did you end up with on the panel? Did anyone try to complete the task using triple or double cards? What kinds of triple cards did you use? What approach did you take? Were you successful? If not, why?*

Emil the Keeper • X

Learning objectives

- To use the computer for an interactive exploration and check of the solutions to some of the tasks in the **after…** units of tasks.
- To extend some of the assignments by own, similar assignments intended for classmates.
- To work on extended, more difficult or otherwise changed variants of various tasks from Emil's second world.

Computing-specific content

In these extensions, all computational skills, concepts and constraints presented in the second world are summarised in a varied order and combinations. Now, pupils need to identify them and make use of them when working on similar, but often more difficult, tasks.

Teacher support and commentaries

X1 ***S: Check your solution of the task 1 on page 19.***

The pupils can check whether their ideas from task **after B1** were correct.

X2 ***S: Find an alternative solution to task 4 on page 19.***

In this task, the pupils will look for a different solution to task **after B4**, i.e. a different procedure that will guide Emil through each position on the stage, arriving in the woods. There are several solutions, given the fact that the number of places on the panel is large enough.

X3 ***S: Check your solution of the task 5 on page 20.***

The pupils can check whether their ideas from task **after B5** were correct.

X4 ***S: Check your solution of the task 6 on page 20.***

The pupils can check whether their ideas from task **after B6** were correct.

X5 ***S: Check your solution of the task 1 on page 22. Then start again and try to pick up even more mushrooms.***

The pupils can check whether their ideas from task **after D1** were correct. Then, we suggest in the assignment that they navigate Emil to collect even more mushrooms. In the solution to task **after D1** in the workbook, Emil collected seven mushrooms (all that were available on the stage). If the pupils remember the trick from task **B4**, they may be able to collect even more on this stage.

X6 ***S: Check your solution of the task 4 on page 22.***

The pupils can check whether their ideas from task **after D4** were correct.

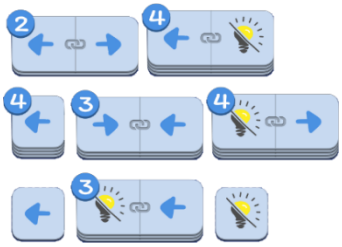
X7 ***S: With Emil recolour all laundry to green.***

[Do not assign this task before the pupils complete the **H** tasks.]

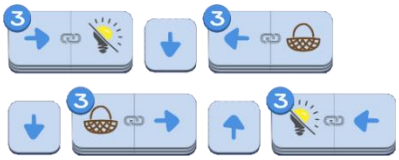
This is a tricky task because the pupils probably have not figured out that they can use the watering can to water the washing as well — which removes its colour and allows us to colour it anew.

X8 ***S: For each double card in the task 1 on page 27 build a program which will use it and solve the problem.***

In the assignment, we suggest that the pupils return to task **after G1** and attempt to build a program to solve the task for each of the given double cards. The most straightforward solution is probably to use the third double card. However, we can create a program for Emil even with the first double card — which is obviously useless, but to do the actual "work", we use another, useful double card — see the top and middle solutions on the right side. The bottom solution using the second given double card is interesting as well and is worth mentioning or discussing later.



X9 ***S: Explore A, B and C in task 2 on page 27.***



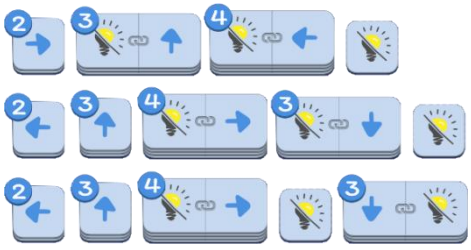
[Do not assign this task before the pupils complete the **after G** tasks.]

The pupils can check whether their ideas from task **after G2** were correct. Whilst options A and B are relatively clear (see the solutions to the right), option C, and, most importantly its second double card, is completely meaningless and useless. (However, there is a very particular situation in which these two tools could be used immediately after one another — if we turn the lights on at a fir tree with cones, it will turn the lights on like a Christmas tree. Then, we can use the basket to collect both the cones and the lights from the fir tree.)

X10 ***S: Check your solution of the task 5 on page 28. Then start again and turn lights on in each house.***

[Do not assign this task before the pupils complete the **after G** tasks.]

The pupils can check whether their ideas from task **after G5** were correct. Then, we suggest in the assignment that they navigate Emil to turn the lights on in every house. The task has several solutions — the pupils need to think carefully about the commands that they merge in double cards; there are several solutions on the right side. Let us notice that in each of them, the use of the light bulb functions as a single command that cannot be attached to other double cards. (If you want extra challenge, try to think about whether there is a solution in which the light bulb is used only on a double card.)



X11 ***S: Pick up mushrooms so that only three are left altogether in each row and each column.***

An amusing task that works as a small version of the magic square. Let us notice that there is no mushroom on Emil's starting position. Given that a total of only three mushrooms needs to remain in the top row, Emil may not collect any mushroom in the top left position...

X12 ***S: Once more: Pick up mushrooms so that only three are left altogether in each row and each column.***

This is a more difficult variant of the previous task. Its solution requires good logical thinking. There are two different solutions to this task.

X13 ***S: Pick either blue, green or red and light up each house of that colour.***

[Do not assign this task before the pupils complete the **H** tasks.]

An interesting task that lets the pupils try out everything that they have learnt in the second world, together with their mathematical and logical thinking since it relies on the fact that we notice certain pattern in the distribution of all houses that share the same colour — and that we correctly choose the double or triple cards that we will create.

Extensions

(task 10) *Find a solution in which you use each light bulb as a part of a double card only (never as a separate card).*

(task 12) *Fid two different solutions to this task. Then, create a similar task on paper, using a stage of 4 x 4 positions.*

(task 13) *Build a program that will make Emil turn the lights on in as many houses as possible.*